Research Article

The Effect of Islamic Praying on Heart Rate Variation in Adult Muslims

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ABSTRACT

Introduction: The flexibility of the heart is important for cardiovascular health. The heart rate variation (HRV) is a metric of heart flexibility. Muslims perform praying (Namaz) which has some significant effects on general health regularity. The study aimed to assess the impact of real Namaz on HRV.

Materials and Methods: Eighty-two participants who performed Namaz daily were categorized into three groups, including more minor, more than, and equal to the normal cortisol level range based on salivary cortisol. The electrocardiography was recorded before, during (divided into standing, bowing, prostration, and sitting positions), and after a four-cycle Namaz around noon. The linear and non-linear features of HRV were extracted.

Results: The two-way analysis of variance showed that the standard deviation $(SD)_1$ and SD_2 of the Poincare plots of all groups increased after Namaz ($P<0.0001$). During Namaz, the indexes of sympathetic tone decreased in the prostration and bowing compared to the sitting and standing positions ($P<0.00001$). The SD of the mean of the R peaks interval, SD_1, and SD_2 of the Poincare plot also increased in those comparisons ($P<0.00001$). In addition, the spectral entropy was decreased in the bowing and prostration compared with standing and sitting positions ($P<0.001$).

Conclusion: Namaz significantly increased the performance of the cardiovascular system and decreased the effect of daily stress on it.

Keywords:
Praying, Islam; Heart rate; Complexity

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Introduction

Stress is a feeling that people experience when they are overloaded and struggling to cope with daily demands. It becomes chronic if a stressed-out person does not have enough time to cope with the stress or if it repeatedly occurs. Chronic stress, or constant stress experienced over a prolonged period, may lead to long-term heart and blood vessel problems and increase the risk of hypertension, heart attack, or stroke [1]. Due to stress, many neurological and hormonal changes may also occur in each organism. The stress response is generated by the hypothalamus-pituitary-adrenal axis, releasing cortisol hormone, and the sympato-adrenal axis, releasing epinephrine and norepinephrine [2]. Stress also activates the sympathetic nervous system (SNS) and inhibits the parasympathetic nervous system activity. The activation of SNS impacts the organs participating in blood pressure regulation, such as the adrenal glands, kidneys, and cardiovascular system. Once the acute stress is removed, the body returns to its normal state. Several methods, such as relaxation and meditation, are recommended to return the stress system to a normal state. In this regard, Muslim praying (Namaz) has a lot of potential to do this.

Namaz is an essential Islamic duty, and Muslims perform daily physical and mental practice five times a day. It should be noted that Namaz has some unique features that make it different from meditation techniques. The positions of standing (Giyam), bowing (Rokoo), prostration (Sajdeh), or sitting are repeated two or four times and differ depending on the time of day, which includes morning, around noon, evening, and night. This Islamic prayer is performed in the particular sacred direction, Qibla, and several prerequisite actions, such as ablution and wudu [3, 4]. Although each Namaz usually takes between 1 and 7 minutes, several significant effects of Namaz have been detected on the brain and cardiovascular function. These effects have returned the stress system to an optimal state [5], increasing the parasympathetic tone during prostration and decreasing systolic and diastolic blood pressure [6, 7]. The increase in parasympathetic tone was correlated with the relative α band of brain activity during Namaz [7].

Recently, the assessment of heart rate variability (HRV) has been considered a valid and reliable method to measure the autonomic system, especially in stressful situations [8, 9]. Heart rate and sympathetic tone increase during stress. Although the heart rate returns to baseline after stress, several heart activity aspects do not return to normal [9]. When the sympathetic tone increases and the parasympathetic tone decreases, the heart beats more regularly. Then, based on HRV metrics, the standard deviation (SD) of the mean interval time of peaks of R in electrocardiography (ECG) signal (R-R), SD_1 or SD_2 of Poincare plot, sample and spectral entropy of HRV decrease, and its low frequency (LF)/high frequency (HF) ratio of HRV increases [10, 11]. These changes increase a person's susceptibility to arrhythmia and heart disease [12]. Therefore, interventions that restore the autonomic system to a normal state play an essential role in cardiovascular health. In this regard, meditation has been studied for many years, but there are rare studies about Namaz. According to several studies on meditation [13], meditation helps to remove perceived tensions and psychological pressures [14, 15]. As proven, there is no doubt about a mind-heart solid connection. Such mental health problems explain the critical nature of the connection between heart and brain function as stress-induced cardiomyopathy. The ECG and cardiac biomarkers change with the heightened cardiovascular risk associated with depression and post-traumatic stress disorder [16]. It is believed that many of these interactions are mediated by the autonomic nervous system and, according to the evidence, might be influenced by meditation [13]. Therefore, understanding how cardiovascular function is influenced could help guide non-pharmacologic treatments of hypertension and other cardiovascular and psychological disorders. A specific type of vipassana meditation enhances parasympathetic activity and reduces the LF/HF ratio, implying the establishment of the proper sympathovagal balance, which takes 10 hours per day [17]. Otherwise, other meditations focusing on the object increase the heart rate and sympathetic tone [18, 19]. The same results in some parameters of the autonomic system obtained from Namaz were also reported during and after automatic self-transcending (AST) and vipassana meditation [20]. Nevertheless, the time of each Namaz is significantly shorter than that of meditation training [20].

Because many people are Muslim in the world and perform Namaz several times daily and there are rare studies on the effect of Namaz on HRV as an indicator of stress and the cardiovascular system, this study aimed to assess the effect of performing a four-Rakat Namaz, which lasts for a maximum of seven minutes, on the linear and non-linear features of HRV.

Materials and Methods

Participants

The type of study was cross-sectional. The population of the study was not recruited by randomization but by using an available sampling method. All 82 adult Muslims (forty-five men and thirty-seven women) who participated in our study performed Namaz regularly. The inclusion criteria were no history of systemic diseases and cardiovascular disease, no history of craniocervical surgery, no opioid addiction, no use of mental health medication, cigarette use, and routine physical training. The exclusion criteria were the non-cooperation of the participant in completing the test session. Before the study, all participants completed and signed an informed consent form following the ethics approved by Baqiyatallah University of Medical Sciences.

Procedure

The study procedure was conducted between 12:00 and 13:00. The participants were asked to sleep well the night before, perform ablution, wash their mouths, and have no stress before the test. They had not eaten anything one hour before the test. First, saliva samples (minimum 0.5 cc) were taken to measure the baseline salivary concentration of cortisol. The electrocardiogram (ECG) was then recorded for 2 min in the relaxed position while sitting on the chair before and after Namaz. The ECG was also recorded while performing Namaz in four-cycle cycles (Rakat). Namaz was performed in its actual form, toward the Qibla direction. Each Rakat was segmented into four parts: Standing, bowing, prostration, and sitting for analysis [21].

Salivary cortisol

The saliva samples were transferred to a refrigerator and kept at a temperature of -80°C. The human saliva cortisol enzyme immunoassay (EIA) kit from ZellBio Company made in Germany was used, and the procedure was done based on the kit's instructions. According to the optical density adjusted on the logarithmic curve, the cortisol level was assessed in each sample [22]. The participants were categorized based on their baseline concentrations of salivary cortisol. The normal range reported by the salivary cortisol kit used in this study was between 5 and 15 ng/mL from 10:00 to 16:00. The following three groups were defined: Group 1 with a cortisol level of less than 5 ng/mL, group 2 with a cortisol level of 5-15 ng/mL, and group 3 with a cortisol level of more than 15 ng/mL.

Heart rate recording

The heart rate was recorded with an ECG wireless instrument designed by Liv Intelligence Technology Company from Iran. The specifications of the instrument are A/D:24 bit, sample rate: up to 500 Hz, and input range: 5000 µV p-p. Three electrodes were used in this study. One electrode was attached to the left midclavicular line above the heart position. Then, the second one was attached to the right lower quadrant of the abdomen, and the third one was attached to the left sternal border below the heart position. The cables of the lids were fixed to the body with a belt [23]. Heart-rate recordings were done 2 minutes before and after Namaz and during four Rakat of Namaz in the following positions. The signals were relayed to an analog-to-digital converter with a sampling rate of 256 Hz. The HRV was analyzed using HRV software (HRVAS) created by John T. Ramshur (2010) in MATLAB [24]. First, the HRV was extracted from ECG signals by appropriate filtering and finding the peaks during the analysis. Since ECG signals are band-pass filtered in the range of 5 to 20 Hz, R peaks could be estimated by setting up the amplitude threshold and the minimum time interval between successive peaks. The linear features extracted from the respiration rate (RR) series in the time domain were heart rate (HR), Mean±SD of the RR interval. In the frequency domain, HF power (0.15-0.5 Hz), LF power (0.05−0.15 Hz), very low-frequency power (0-0.04 Hz), and, the ratio of LF/HF components were analyzed [25]. The non-linear features extracted were SD_1 and SD_2 of the Poincare Plot [26], α_1 of detrended fluctuation analysis (DFA) [27], and spectral entropy [28]. Figure 1 shows the extraction of the HRV signal from the ECG signal by selecting R peaks during the four Rakat of Namaz.

The signals of HRV were segmented during Namaz into 18 positions consisting of four different positions, including standing (4 repetitions), bowing (4 repetitions), prostration (8 repetitions), and sitting (2 repetitions). The event marker (getting in position) was used to name positions. The motion artifact was very low because we did not consider the transitional movements between the positions. To make the time lengths equal, those long positions like standing and sitting were compartmented into sub-segments, including bowing and prostration. Then, the mean of sub-segments was calculated to be considered for long positions.

Statistical analysis

The participants were categorized based on their baseline concentrations of salivary cortisol. The normal range reported by the salivary cortisol kit used in this study was between 5 and 15 ng/mL from 10:00 to 16:00. The following three groups were defined: Group 1 with a cortisol level of less than 5 ng/mL, group 2 with a cortisol level of 5-15 ng/mL, and group 3 with a cortisol level of more than 15 ng/mL.

Regarding the variables with normal distribution such as mean values of HR, RR interval, and percentage of frequency band power, a two-way mixed model analysis of variance (ANOVA) was used to compare them before and after Namaz in three groups. A two-way ANOVA was used to compare the mean values of outcome measures in different positions of Namaz in all three groups. The Bonferroni test was also used for the pairwise comparison in the following test for both analyses. For the variables without normal distribution such as SD of the RR interval, SD_1 and SD_2 of the Poincare plot, and LF/HF ratio, the non-parametric Wilcoxon test was used to compare mean values of outcome measures of three groups before and after Namaz and Mann-Whitney to compare them in different positions of Namaz. SPSS software, version 22 was used for analysis and a $P<0.05$ was considered significant.

Results

As mentioned in the statistics part, all participants were classified into three groups. Group 1 (with the level of their cortisol less than 5 ng/mL) included nineteen (11 men, 8 women), group 2 (with the level of their cortisol between 5-15 ng/mL) had forty-nine (23 men, 26 women) and group 3 (the level of their cortisol more than 15 ng/mL) included fourteen participants (11 men, 3 women). The total duration of Namaz was 3 to 6 minutes.

Comparison of heart rate variability before and after Namaz

According to our results, a significant interaction effect was only observed in the HR and RR intervals. Only group 1 showed a decrease in the RR interval or HR increase (interaction effect of time×group: $P<0.05$) after Namaz. The between-group comparison independently showed that the HR of group 1 was lower than that of group 2 ($P<0.05$). The Mann-Whitney test demonstrated that SD of RR interval ($P<0.05$), SD_1 ($P<0.05$), and SD_2 ($P<0.05$) of the Poincare plot, were significantly higher after Namaz compared to before Namaz, independent of the level of cortisol (Figure 2).

Comparison of linear features of HRV between positions of Namaz

The two-way ANOVA with Bonferroni pairwise comparison showed that the mean RR interval increased in the bowing, prostration, and sitting position compared to the standing position ($P<0.05$). The maximum increase occurred in the prostration, significantly more than bowing and sitting ($P<0.05$). The RR interval of the bowing position was also significantly higher than that of the sitting position ($P<0.05$). These changes were observed in all three groups, although the RR interval of group 1 was significantly higher than that of group 2 ($P<0.05$), and this difference is reduced in other positions (Figure 3A). Since the HR is precisely the inverse of the RR interval, its result was the same as the RR interval, which is not reported here.

Figure 3B shows that the SD of RR intervals in prostration and bowing positions were more than in standing and sitting positions ($P<0.05$). The increase was higher in group 3 than in group 2 ($P<0.05$).

The percentage of the very low and low frequencies of HRV decreased in the bowing, prostration, and sitting positions compared to the standing position and in the bowing and prostration positions compared to the sitting position ($P<0.05$). These results were obtained reversely for the percentage of the high frequency of HRV. These differences were also observed between sitting and standing positions ($P<0.05$). Then the LF/HF ratio decreased in bowing and prostration positions compared to the sitting position ($P<0.05$) and in the prostration position compared to the sitting position ($P<0.05$) (Figure 4).

Comparison of non-linear features of heart rate variability in the positions of Namaz

The most significant changes were detected in group 2, with a standard range of cortisol levels. Figure 5A shows that the SD_1 and 2 Poincare plots of group 2 increased in bowing, prostration ($P<0.05$), and sitting positions ($P<0.05$) compared to the standing position. The prostration position increased more than the sitting position ($P<0.05$). Also, the bowing position showed a greater increase in SD_1 in comparison with the sitting position ($P<0.05$). Groups 1 and 3, with less and more cortisol concentration than the normal range, showed more variation than group 2 because of the lower amount of data. However, groups 2 and 3 showed the same trend as group 2. Significant differences between SD_1 and SD_2 of the Poincare plot were observed between prostration and standing positions in group 1 ($P<0.05$) and group 3

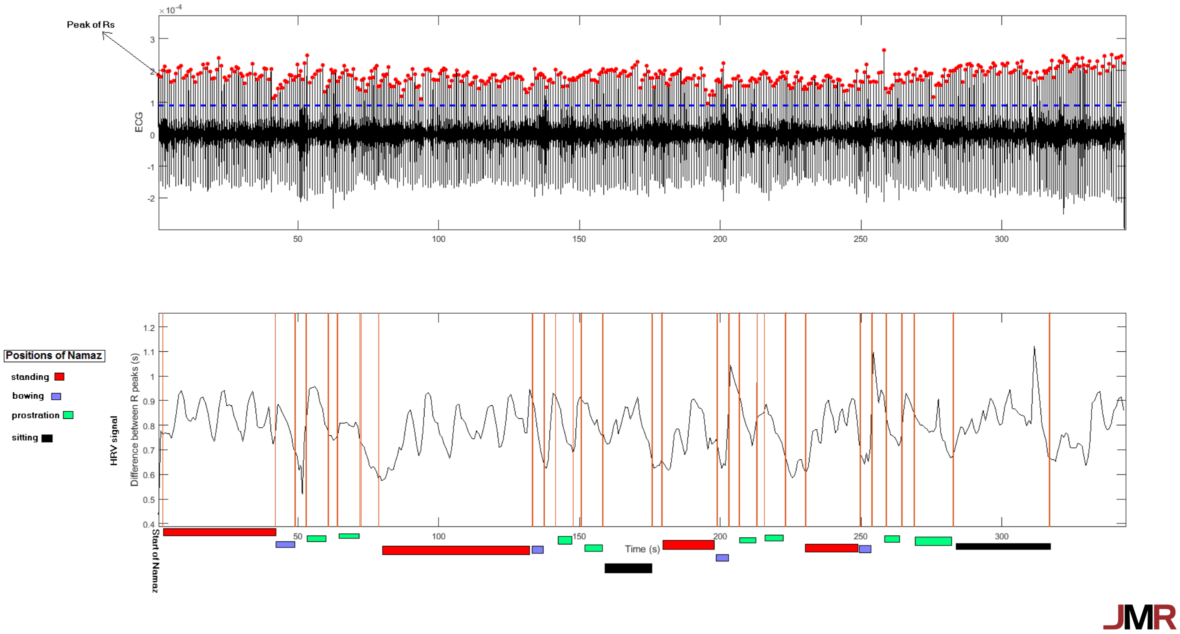

Figure 1. The process of extraction of heart rate variability signal from electrocardiogram signal during four Rakat of Namaz
Note: The parts of Namaz are marked with trigger lines.

(P<0.05). The SD_1 of group 3 significantly differed between the prostration and sitting positions (P<0.05). SD_1 and SD_2 of groups 1 (P<0.05) and 3 (P<0.05) were higher than group 2 in the standing position. SD_1 of group 3 (P<0.05) in the prostration position and SD_2 of group 1 (P<0.05) in the sitting position were more than those of group 2.

The α_1 of the DFA was inversely changed in group 1 compared to groups 2 and 3 in the bowing position (P<0.05). Bowing, prostration, and sitting reduced the α_1 DFA compared to the standing position in group 2, with a standard range of cortisol (P<0.05). Group 3 followed the changes of group 2 only in the bowing position (P<0.05). The α_1 of the DFA in group 1 was significantly different in the bowing and sitting positions (P<0.05) (Figure 5B). The spectral entropy decreased in the bowing and prostration positions compared to the standing (P<0.05) and sitting (P<0.05) positions in all groups.

Discussion

The study aimed at studying the HRV during and after a four-Rakat Namaz at noon. The participants were categorized into three groups, based on their baseline salivary cortisol concentration. Group 2 consisted of subjects with a standard range of cortisol based on the kit standard report. Group 1 and group 3 cortisol levels were less and more than the normal range, respectively. Compared to the initial states before Namaz, the linear and non-linear features of HRV did not change after

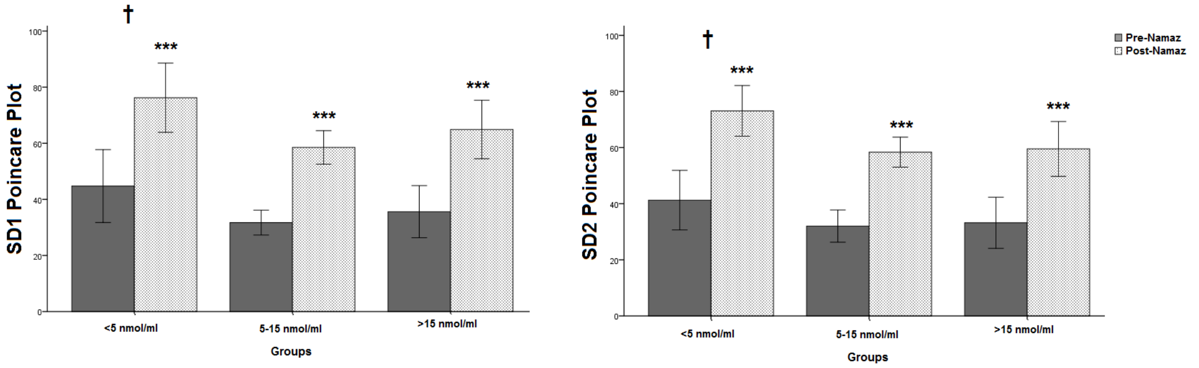

Figure 2. The SD_1 and SD_2 of Poincare plot significantly increased after Namaz independent to level of cortisol (***P<0.05), They were significantly higher in low cortisol than two other levels (†P<0.05).

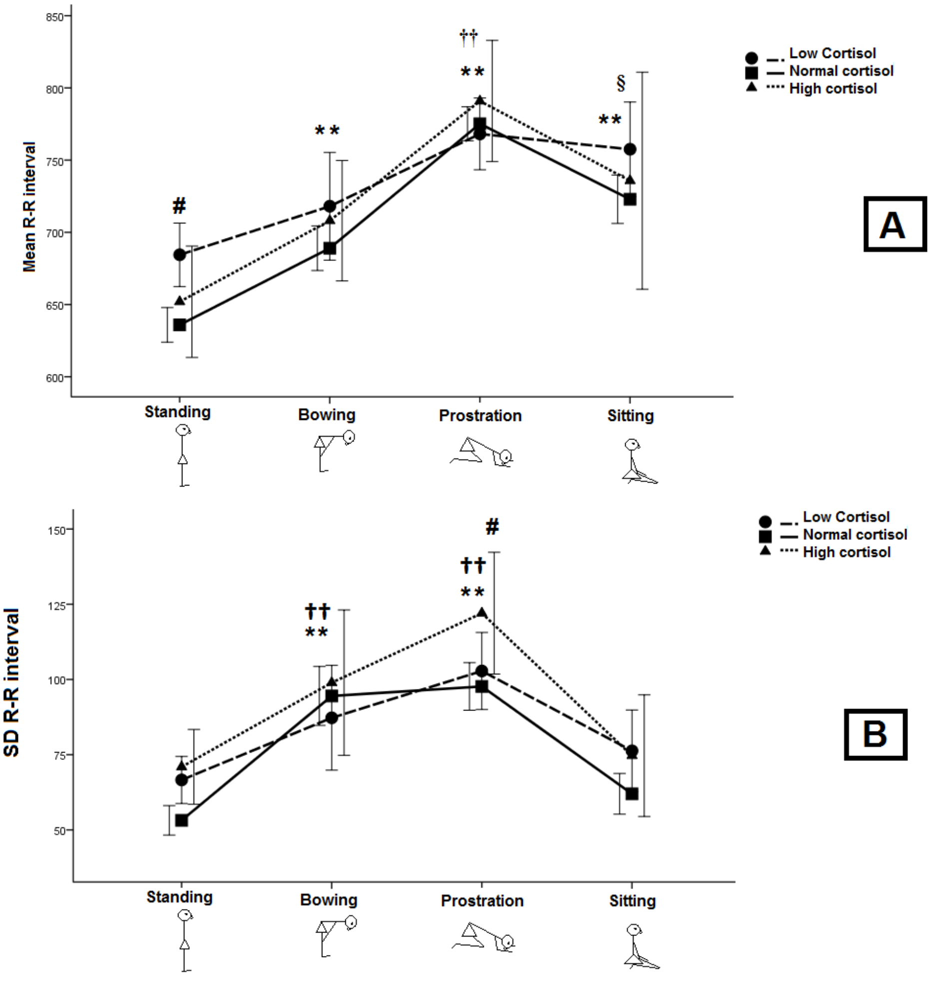

Figure 3. The RR (A) interval and the SD (B) of it of HRV in different positions of Namaz in all three groups

Note: It increased significantly to the maximum, first, in prostration, next in bowing, and finally in sitting compared to the standing position. *Significant difference between standing and other positions ($P<0.05$), †† Significant difference between prostration and bowing and sitting ($P<0.05$). §Significant difference between bowing and sitting ($P<0.01$). The RR interval of group 1 was significantly higher than that of group 2 in the standing position ($P<0.05$). The SD significantly increased in the bowing and prostration position, (** & ††$P<0.05$) in all three groups. Group 3 showed a greater increase in SD in comparison with group 2 in the prostration position (#$P<0.05$).

Namaz, except for the increase of the HR significantly in group 1, and SD_1 and SD_2 of the Poincare plot in all groups. Notably, Namaz caused group 1 to achieve the normal state of HR next to group 2 and more complexity. The complexity of HR is the marker of heart performance [29]. The previous study showed that the cortisol concentration of subjects with low cortisol levels (lower than 5 nmol/mL) increased significantly after Namaz, while it did not change in subjects with a normal range of cortisol levels (between 5-15 nmol/mL) [5]. Then, the change in the HR and cortisol concentration concurrently are affected by Namaz to reach the optimal state.

The positions of Namaz affected brain function [30, 31]. As a result, it is expected to affect HRV [7]. The prostration, bowing, and sitting positions increased the indices that are markers of parasympathetic activity. The HR, very LF, LF, and LF/HF ratio of HRV decreased, and the high frequency of HRV increased mainly during prostration compared to other positions. Prostration and bowing also increased the SD of RR interval, SD_1, and SD_2 of the Poincare plot and decreased the spectral entropy and α_1 of DFA. These changes suggested that prostration and bowing increased the complexity of HRV in the fractal dimension and decreased the complexity of HRV in the frequency and noise of the signal.

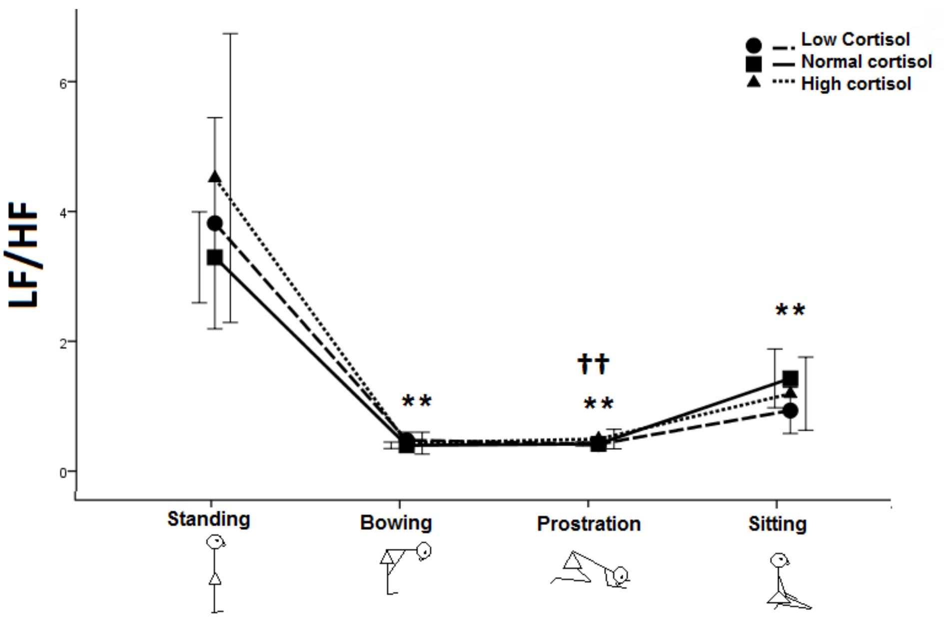

Figure 4. The LF/HF ratio of HRV in the positions of Namaz in the three groups

Note: The bowing, prostration, and sitting position made a decrease in LF/HF ratio compared to the standing position (**P<0.05). In addition, the decrease in this ratio was more in the prostration than in the sitting position (††P<0.05).

Any daily intervention that can deal with stress is crucial because, according to previous studies, the first cause of death is a heart attack, while a heart attack's leading risk factor is stress [32]. Acute stress generates the pathways that activate the sympathetic system [1]. Then, the HR increases and becomes more regular [33]. HRV reflects the central autonomic network's capacity to adapt to environmental demands [29] as an index of self-regulatory strength and well-being [34]. The mean RR interval of HRV is reduced in patients with cardiovascular disease. Therefore, it might act as a risk factor for mortality [35]. In this regard, some effective interventions should be adopted to decrease the cardiovascular system's harmful stress and maintain life expectancy.

Many studies have demonstrated that meditation is considered a method of stress reduction that promotes general health [15]. However, there is still a tiny amount of evidence showing that mindfulness medication increases the HRV or reduces HR as a parasympathetic dominancy marker and improves stress, distress, and mental health-related quality of life [20, 26]. Only one type of mindfulness, Vipassana, increases the parasympathetic tone and improves well-being [17]. Whereas this technique was performed for 10 hours per day in one study [17], Namaz performed a maximum of 7 min each time. Our results showed that Namaz could be considered more optimal to increase parasympathetic tone, especially during bowing and prostration, and may improve health when repeated daily.

Two main physiological reasons are suggested for the effects of Namaz positions on the HR and autonomic function. Firstly, the head relocates from higher to parallel surfaces in bowing or lower surfaces in the heart's prostration position. Therefore, the blood flow suddenly changes to baroreceptors in the carotid and aortic artery and stimulates the baroreflex. On the other hand, following bending in bowing and prostration, the volume of blood accumulated in the abdomen is drained into the vessels, and more blood flow shifts to baroreceptors. The frequency power of HRV measures the baroreflex. If the baroreflex is stimulated, the parasympathetic tone increases, the HR and LF/HF ratio decrease, and the HF increases [37, 38]. Previous studies have confirmed that HR decreased during Namaz, especially in the prostration position, and blood pressure decreased after Namaz [6]. Doufesh et al. 2012 showed the increase of α band of brain activity especially in prostration in the actual and acted form of Namaz. Although the sample size of the study was small, it demonstrated that the change of positions in the Namaz is important [21].

In addition to the change in HR and power of frequencies of HRV, the SD of RR interval and SDs of Poincare plot significantly increased in the bowing and prostration position. These features of HRV usually decrease during and after acute stress or cardiac attack [22, 23, 33, 39]. Therefore, their increase concurrently with parasympathetic tone might be a good sign of cardiovascular

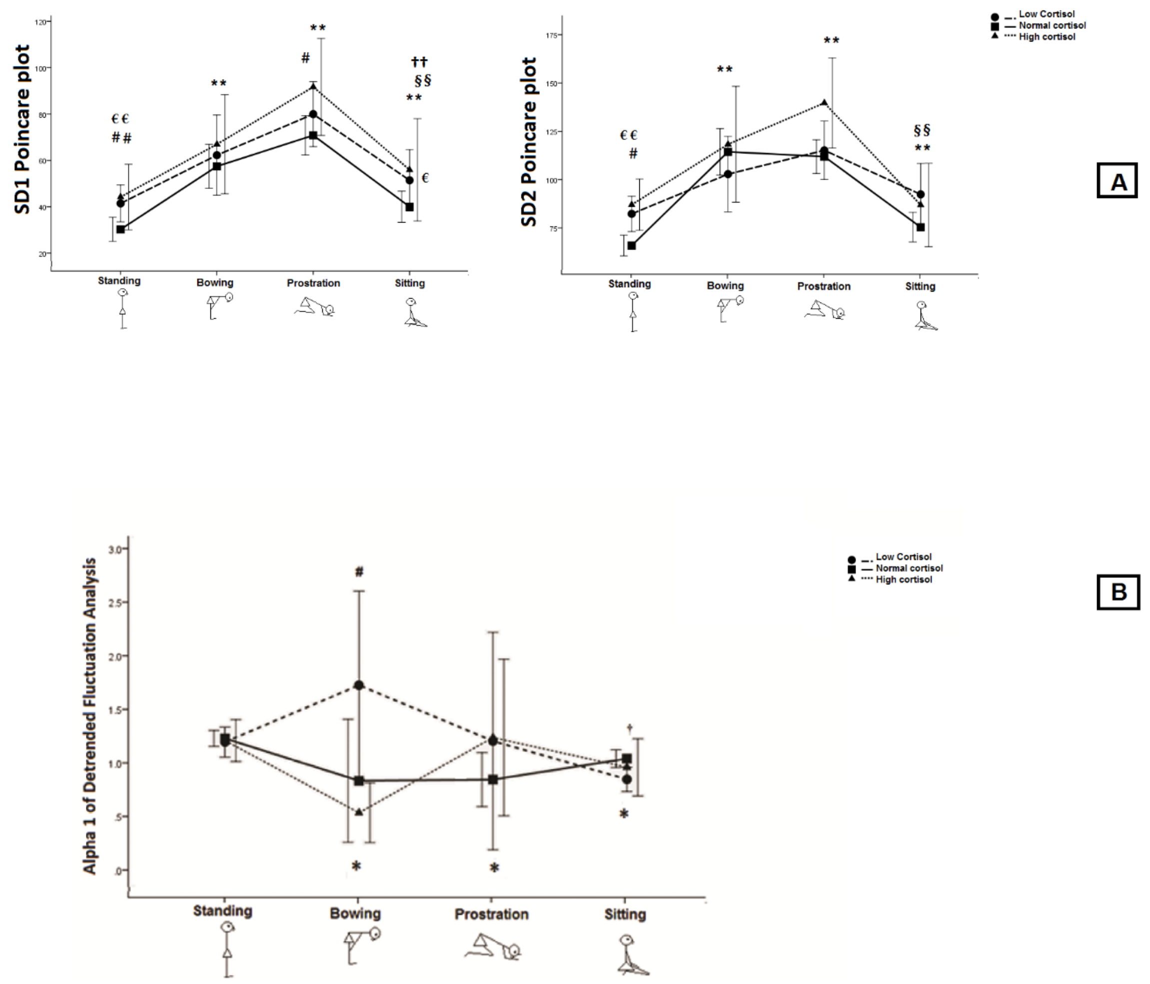

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Figure 5. The SD_1 and SD_2 of poincare (A) and the α_1 of DFA (B) of HRV in the positions of Namaz in the three groups

A) **Difference between standing and other position (P<0.01), ††Difference between bowing and sitting (P<0.05), §§Difference between prostration and sitting (P<0.01), $^{\#\#}$Difference between groups 3 and 2 (P<0.05), $^{\#}$Difference between groups 3 and 2 (P<0.05), $^{€€}$Difference between groups 1 and 2 (P<0.05).

B) *Difference between the standing and bowing, prostration and sitting position (P<0.05), †Difference between the bowing and sitting position (P<0.05), $^{\#}$Difference between groups 1 and 2 (P<0.05).

function enhancing heart performance. The α_1 of DFA showed that the HRV signal's noise decreased in the bowing and prostration position in the group with a standard range of cortisol. The subjects with a lower cortisol level than the normal range reversely showed an increase in DFA. The participants performed a real Namaz with Dhuha, while the effect of motion and Dhuha were not considered separately. Thus, this could be a limitation of the study. The lack of a control group that did not perform Namaz is another study limitation. The evaluation of Namaz at other times of the day, such as morning and night, is suggested for future studies.

The clinical note of the study is the critical role of Namaz, which is done several times daily to change the autonomic balance briefly and promote it to a better state in terms of heartbeat complexity.

Conclusion

It is concluded that a four-Rakat Namaz increased the HRV indices as markers of parasympathetic tone during the prostration, bowing, and sitting positions. The SDs of the Poincare plot increased significantly during bowing and prostration compared to the standing position and after Namaz. These changes are beneficial for pushing the stress system to an optimal state.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Baqiyatallah University of Medical Sciences (Code: IR.BMSU.REC.1397.190).

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Authors' contributions

Conceptualization: Boshra Hatef and Gila Pirzad Jahromi; Methodology: Yeganeh Shaverdi, Gholam Hossein Meftahi, Boshra Hatef, and Mohammad Shahab Sharif; Data analysis: Gila Pirzad Jahromi and Yeganeh Shaverdi; Data analysis: Gila Pirzad Jahromi and Yeganeh Shaverdi; Data collection and writing: All authors; Data curation: Boshra Hatef;

Conflict of interest

The authors declared no conflict of interest.

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