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ORIGINAL PAPER

Modulation of Heart and Brain Function by Surah Al-Rehman Recitation Among Distressed Diabetic Patients in Pakistan

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Abstract

Distress causes psychophysiological alterations that affect autonomic function. The current study explores psychophysiological modulation in diabetic distress in response to Surah Al-Rehman recitation. A single-group experimental study with before and after intervention assessments was conducted during April 2018 to February 2019 in which participants ($n = 10$) listened to Surah Al-Rehman recitation. Blood pressure, blood glucose, cortisol, ECG and EEG were recorded before and after recitation. Significant reduction in systolic blood pressure, increase in low frequency and absolute alpha power at Fp2 were observed. Heartbeat evoked potentials (HEP) were also significantly modulated at Fp1, Fp2 and F4. These findings suggest that Surah Al-Rehman modulated baroreflex activity thereby reducing sympathetic activity and improved heart brain coherence as reflected by HEP.

Keywords Distress · Religious therapy · Autonomic function · Psychophysiology · Meditation

Introduction

Distress is related to comorbidities which is increasing with a rise in the prevalence of chronic metabolic disorders (Dunbar et al., 2008; Roohafza et al., 2014). Diabetic patients are even more prone to stress, because of their strict treatment regimen and their emotional vulnerability (Kreider, 2017). Diabetes leads to metabolic stress (Pansuria et al., 2012; Vogel, 2006) which together with psychological stress worsens the disease state. HPA axis is altered in diabetes (Chan, 2003; Yokoyama

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et al., 2015) leading to hypertension in diabetes. Altered hypothalamic–pituitary axis (HPA) leads to impaired cortisol levels in diabetes (Joseph & Golden, 2017). Cortisol is a stress state marker and reflects a dominant sympathetic state (Bozovic et al., 2013). Distress is also associated with altered brain function (Newson & Thiagarajan, 2018; Srivastava et al., 2010) and impaired cardiac function (Hartmann et al., 2018; Vaccarino et al., 2008). It has been shown that distress affects frontal activity in the brain (Arnsten, 2009). As emotional distress increases sympathetic tone that results in hypertension, it thereby affects cardiac function too and is known to alter heart rate variability measures (Park et al., 2018). While conventional treatment strategies utilize polypharmacy for diabetes and other comorbidities, following strict treatment regimen poses a great challenge to the patient both physiologically and emotionally, ultimately leading to distress associated with diabetes.

It has been observed in our community that people show reluctance toward conventional medicines for disorders like diabetes and distress, as they may make a person vulnerable to adverse effects (Polonsky & Henry, 2016; Shams et al., 2016). This results in people approaching religious communities as the belief in the healing power of Allah (one and only absolute deity in Islam) is very strong and people tend to rely on alternative and sunnah (prophet's teachings)-based medicine more than conventional therapies (Hussain et al., 2018; Shaikh & Hatcher, 2005). Numerous scholars suggest religious therapies for treatment of both diabetes and distress; however, they have not been empirically evaluated. Even though listening to recitation of Quran has been shown to improve health outcomes (Frih et al., 2017; Ghiasi & Keramat, 2018; Saquib et al., 2017) and reduce anxiety (Ghiasi & Keramat, 2018), their mechanisms remain unknown. This renders scientific community critical about the impact of recitations in improving health outcomes.

Surah Rehman is a well-known and frequently recited Surah in Muslim communities, mostly for its anticipated spiritual strength. A previous study has shown that Surah Rehman reduces depression (Rafique et al., 2019). In the current study, we have explored the physiological and neurocardiological parameters including blood pressure, morning cortisol, absolute brain power of theta, alpha, beta and gamma bands, heart rate variability measures (HRV) and heartbeat evoked potentials (HEP), to assess their modulation in response to listening to Surah Al-Rehman recitation.

Methodology

Participants and Duration of Study

The study was approved by Institutional review board, Jinnah Sindh Medical University, as defined by National Bioethics Committee of Pakistan (NBC) (Approval No. JSMU/IRB/2017/-90). Written and informed consent was obtained from all individual participants prior to the study. Participants were gifted a pack of anti-diabetic medication for their participation. A total of ten participants diagnosed for type II Diabetes mellitus with HbA1c levels greater than 5.7% and elevated distress scale score of more than 3 on diabetic distress scale (DDS-17) were included in the study.

Table 1 Sociodemographic characteristics of study participants

Variable	Frequency (*n*)	Percentage (%)
Gender		
Male	6	60
Female	4	40
Marital status		
Married	10	100
Unmarried	0	0
Occupation		
Semi-skilled labor	1	10
Waged employee	5	50
Home makers	4	40
Socioeconomic status		
Upper	1	10
Middle	3	30
Lower	6	60
Type of diabetic distress		
Emotional stress (ED)	7	70
Physician-related stress(PD)	4	40
Regimen-related stress (RD)	6	60
Interpersonal distress (ID)	5	50
Duration of diabetes (years) (mean ± SD)	8 ± 1.2	
Age (years) (mean ± SD)	50.7 ± 2.2	

The sociodemographic factors of the study participants are mentioned in Table 1. The study was conducted during April 2018 to February 2019.

Selection Criteria

Participants with known HbA1c levels greater than 5.7 and scoring more than 3 on DDS on its sub-domains were included in the study. Participants with education lower than intermediate, low socioeconomic status, those with any other diagnosed psychotic disorders and those who refused to participate were excluded. Intermediate level education was a requirement for the study because participants had to listen to surah Al-Rehman for which they must be able to understand Arabic accent, while participants with low socioeconomic status were excluded because people with low socioeconomic status do not regularly follow treatment regimen due to heavy cost, which could affect their scores on regimen-related distress.

Study Design and Sampling Technique

We conducted a single-group experimental study with before and after intervention assessments design, where participants'physiological readings before listening to

Surah Al-Rehman served as control. A sample of ten participants was recruited as we were interested to explore the psychophysiological mechanisms that could have been modulated by Surah Al-Rehman. One participant refused for any blood tests but was interested in EEG and ECG measures so we present data for physiological parameters from nine participants. We used non-probability convenience sampling for recruiting participants.

Physiological Parameters, EEG, HRV and HEP

Data on systolic and diastolic blood pressure, RBS and cortisol were obtained prior to and after the participants listened to Surah Al-Rehman. Participants listened to eight min long recitation of Surah Al-Rehman. EEG was recorded on 4 channels including AF7, AF8, TP9 and TP10 initially with Muse headband at sampling frequency of 500 Hz. However, due to consistent data loss from TP9 and TP 10 channels for three participants, we replaced the equipment with eprobe version 8.0.8 from Sciencebeam, China, through which we recorded Fp1, Fp2 F3 and F4 along with ECG at a sampling rate of 1000 Hz. Therefore, the absolute powers presented in the results are from pre-frontal regions only. Four EEG electrodes were placed according to 10–20 International system of electrode placements.

Heart rate variability measures were extracted from ECG obtained by eprobe version 8.0.8. HRV measures were processed through Kubios HRV developed by (Tarvainen et al., 2014). We obtained time domain measures including standard deviation of NN intervals (SDNN) and root mean square of standard deviation (RMSSD), frequency-domain measures including low frequency (LF) and high frequency (HF) and stress index. Artifact correction was performed using medium filter of Kubios HRV as indicated by (Alcantara et al., 2020).

Offline EEG data were pre-processed by EEGLAB version 14.1.2b. Data were downsampled at 256 Hz, re-referenced to common average and band pass-filtered at 1 and 30 Hz. Muscular artifacts were removed by visual inspection. For HEP analysis, R-peak detection was performed using HEPLAB, an EEGLAB plugin, developed by Prof. Pandelis Perakakis (Perakakis, 2019) for extracting cardiac events. Pan-Tompkin algorithm was applied on ECG data for extracting R-peaks. Data sets were segmented to −200 to 800 ms epochs as described in (Gentsch et al., 2019; Terhaar et al., 2012). HEP were calculated by averaging time domains across trials. HEP occur from 100 to 600 ms time-locked to R-peak and have been studied in three-time windows during this period (Terhaar et al., 2012). We, therefore, assessed all possible time periods for HEP in all channels of interest.

Data Analysis

Data were analyzed using SPSS version 21. Results are reported as mean SD. Paired t-test was performed for the analysis of physiological parameters, brain wave absolute powers and HRV measures. Mean of absolute powers were obtained from muse monitor and eProbe version 8.0.8. Heart rate variability measures were derived from Kubios HRV standard version. For assessing changes in HEP amplitude before and

after listening to Surah Al-Rehamn, we performed paired difference statistics, using EEGLAB.

Results

Effect of Surah Al-Rehman on Sympathetic Tone

Stress has been shown to be associated with increased in sympathetic tone (Won & Kim, 2016). Numerous studies have reported increased sympathetic tone in stress. This has been identified by increase cortisol and increased blood pressure (Anderson et al., 1991; Ayada et al., 2015; de Looff et al., 2018; Fisher et al., 2009). Surah Al-Rehman reduced the sympathetic tone by decreasing systolic blood pressure by 11.77 mmHg ($t=2.82$, $df=8$). Even though a slight reduction of 4.1 mmHg in diastolic blood pressure ($t=1.42$, $df=8$) and in RBS by 9 mg/dl ($t=1.5$, $df=8$) was observed, the differences were not statistically significant ($P>0.05$). Also, there was no difference in the cortisol levels after listening to Surah Al-Rehman recitation ($t=0.08$, $df=8$).

Effect of Surah Al-Rehman on Absolute Brain Power in Different Frequency Bands

Meditation practices have previously been shown to modulate brain functions (Braboszcz et al., 2017; Hata et al., 2019; Kaur & Singh, 2015), which can be useful for treating various mental conditions. Therefore, we assessed brain wave power in theta, alpha, beta and gamma band frequency range. It is now known that pre-frontal theta and alpha activity is reflective of mental relaxation (Lin & John, 2006). Surah Al-rehman recitation increased the overall activity in the right pre-frontal cortex (Table 3) with 2.41 µv increase in theta power ($t=0.69$, $df=9$), 2.98 µv increase in alpha power ($t=1.47$, $df=9$), 2.5 µv increase in beta power ($t=1.5$, $df=9$) and 0.78 µv in Gamma Power ($t=0.49$, $df=9$) at Fp2. We also observed minute reduction in all frequency ranges in left pre-frontal cortex where there was a 0.58 µv reduction in theta band power ($t=1.6$, $df=9$), 0.21 µv reduction in alpha band power (0.79, $df=9$), 0.64 µv reduction in beta band power ($t=1.04$, $df=9$) and 0.67 µv reduction in gamma band power ($t=1.29$, $df=9$) at Fp1. The changes in the absolute band power in both the regions after listening to Surah Al-Rehman were not significantly different ($P>0.05$). However, after removing outliers, we observed a significant difference in alpha band power ($t=2.59$, $df=6$, $P<0.05$), while no significant change was observed in beta, theta or gamma band power (Table 3).

Effect of Surah Al-Rehman on Heart Rate Variability Measures

Since, we identified a significant reduction in the systolic blood pressure of the participants consistent with previously reported anti-anxiety and anti-depressive effects of Surah Al-Rehman therapy (Babamohamadi et al., 2017; Ghiasi & Keramat, 2018;

Rafique et al., 2019), we assessed if it also improved autonomic tone in the study participants. After adjusting for outliers, we observed time–frequency measures where there was 2.9 ms statistically insignificant increase in the SDNN component ($t=1.42$, $df=5$) and 0.06 ms statistically insignificant increase in RMSSD component ($t=0.10$, $df=5$). For frequency-domain measures, we observed 0.01 Hz, statistically significant increase in the LF component ($t=2.5$, $df=5$) and 0.03 Hz insignificant decrease in HF component ($t=1.57$, $df=5$). We also observed 7.47 index statistically significant decrease in stress index ($t=3.66$, $df=5$) of the participants after they listened to Surah Al-Rehman recitation.

Effect of Surah Al-Rehman on Heartbeat Evoked Potentials

HEP have been hypothesized to reflect cortical processing of cardiac activity (Kern et al., 2013; Schandry & Weitkunat, 1990; Schandry et al., 1986). HEP peak during 524–620 ms has been shown to reflect interoceptive attention (Petzschner et al., 2019). Figure 1 shows significant positive HEP amplitude on Fp1 at 400–450 ms and 550–570 ms ($P<0.05$). Fp2 showed a significant positive HEP amplitude at 100–180 ms (Fig. 1) as compared to C4 in previous studies, reflecting good heartbeat perception (Yuan et al., 2007). However, we observed no statistically significant difference in HEP amplitude at F3 in baseline or after Surah Al-Rehman recitation. A significantly strong HEP amplitude at 200 ms (N200) at F4 was observed (Fig. 1) after Surah Al-Rehman recitation, which has previously been observed in resonant breathing states (MacKinnon et al., 2013).

Discussion

Diabetic distress poses two major challenges; (1) metabolic stress that constantly affects the body, (2) psychological stress of living with a very challenging treatment regimen of diabetes throughout lifetime. It is likely to get overwhelmed by the treatment regimen, frequent visits to consultants and the cost of therapy (Shams et al., 2016). Also, diabetic patients have been reported to have a higher sympathetic tone (Yokoyama et al., 2015), which in turn is reflective of chronic stress.

Conventional treatment for distress includes anti-depressants and selective serotonin re-uptake inhibitors (Ferguson, 2001); however, they pose risk of dependency and may add to the cost of therapy. Since ages, people have been using alternative medicine approaches and in Islamic world, the impact of Surah Al-Rehman on health is well acknowledged by religious communities. It has previously been shown that Surah Al-Rehman recitation is effective for treating depression (Rafique et al., 2019). We, therefore, were interested in identifying the physiological mechanisms underlying this effect to exclude the possibility of the religious biases. The study was hence designed to assess acute physiological changes that may take place after listening to Surah Al-Rehman. The anti-anxiety effects of Surah Al-Rehman recitation were evident especially on systolic blood pressure of the participants (Table 2). We also observed a decrease in diastolic blood pressure in the participants

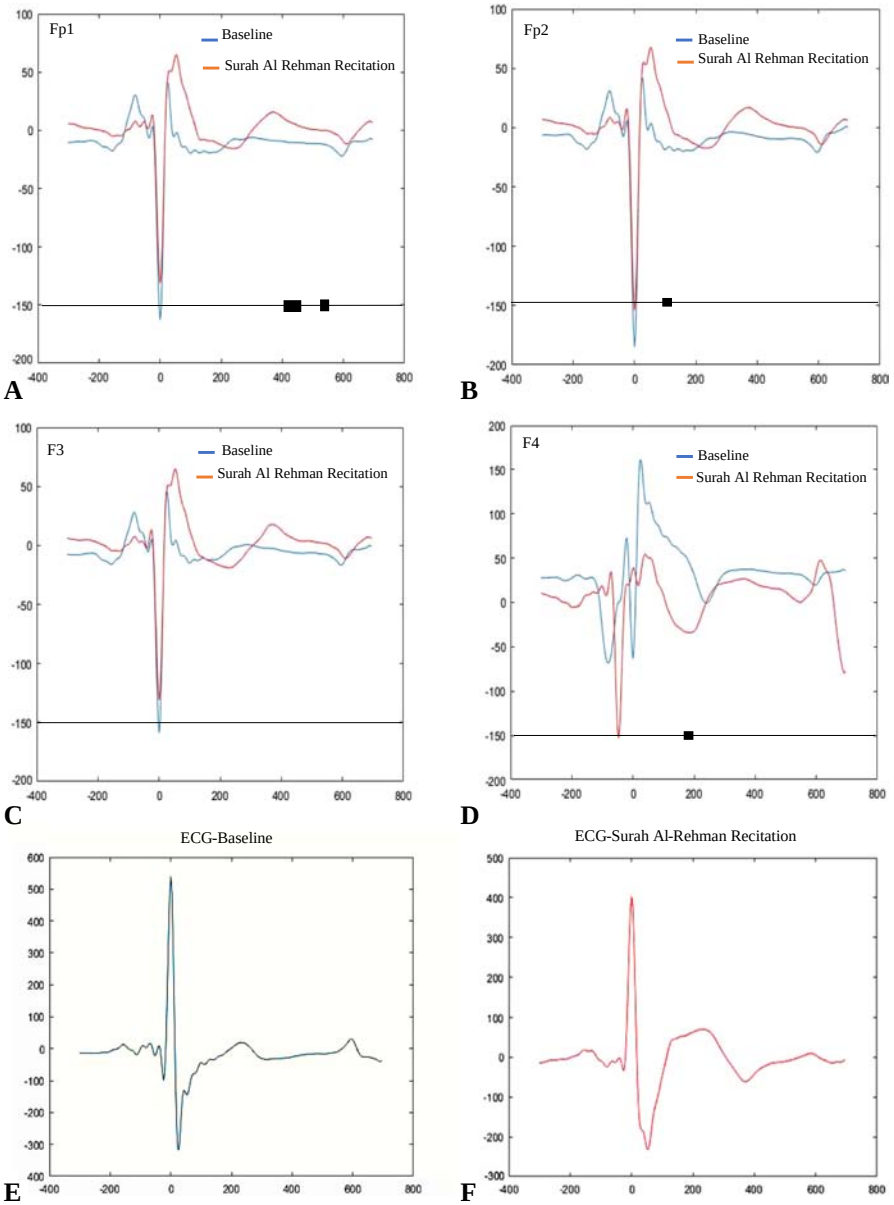

Fig. 1 HEP waveforms in baseline and after Surah Al-Rehman recitation following the onset of R-wave (at time 0ms) for (**a**) Left Frontopolar region (Fp1), (**b**) Right Frontopolar region (Fp2), (**c**) Left Frontal region (F3) and (**d**) Right Frontal region (F4). ECG was also monitored before (**e**) and after Surah Al-Rehman recitation (**f**). Black bars indicate a significant positive HEP amplitude ($P < 0.05$) during 400-600 ms at Fp1, 150 ms at Fp2 and a negative HEP amplitude at 200 ms (N200) at F4 as measured by paired statistics

Table 2 Physiological parameters before and after listening to Surah Al-Rehman

Variable	Pre-test Mean ± SD	Post-test Mean ± SD	*P* value
Systolic blood pressure (mmHg)	134.7 ± 17.2	123 ± 15.7	0.02
Diastolic blood pressure (mmHg)	83.2 ± 10.8	78.1 ± 9.01	0.25
RBS (mg/dl)	244.5 ± 78.5	235.5 ± 75.1	0.15
Cortisol (µg/dl)	13.4 ± 4.6	13.4 ± 6.2	0.93

RBS random blood sugar, *SD* standard deviation

Table 3 Pre-frontal absolute brain power in different frequency bands before and after listening to Surah Al-Rehman

Variable	Without outliers			Adjusted outliers		
	Pre-test Mean ± SD	Post-test Mean ± SD	P value	Pre-test Mean ± SD	Post-test Mean ± SD	*P* value
Theta power (µV)						
Fp1	13.2 ± 8.6	12.6 ± 8.0	0.19	16.6 ± 7.7	15.9 ± 7.1	0.28
Fp2	16.2 ± 7.2	18.6 ± 5.3	0.30	19.5 ± 3.3	20.6 ± 4.1	0.51
Alpha power (µV)						
Fp1	11.6 ± 5.8	11.4 ± 5.6	0.52	14.8 ± 2.3	14.5 ± 2.3	0.45
Fp2	12.8 ± 6.4	15.7 ± 4.3	0.17	12.5 ± 3.9	14.5 ± 4.6	0.04
Beta power (µV)						
Fp1	12.7 ± 8.9	12.0 ± 7.9	0.16	10.0 ± 6.1	9.0 ± 5.3	0.33
Fp2	14.2 ± 6.5	16.7 ± 6.4	0.18	14.6 ± 4.0	14.0 ± 4.0	0.18
Gamma power (µV)						
Fp1	7.8 ± 5.6	7.1 ± 4.7	0.31	10.9 ± 5.1	9.0 ± 4.2	0.24
Fp2	9.8 ± 4.7	10.6 ± 3.5	0.52	10.8 ± 3.6	11.2 ± 4.1	0.63

Fp1 pre-frontal electrode (left), *Fp2* pre-frontal electrode (right), *SD* standard deviation

after listening to Surah Al-Rehman; however, the lack of statistical significance was observed which may be attributed to the higher standard deviations as compared to the difference. It suggests that Surah Al-Rehman recitation holds the potential benefit in reducing sympathetic tone by reducing blood pressure which can be clinically important.

We also observed a reduction in blood glucose (Table 2), however, the difference was not significant both statistically and clinically, indicating that Surah Al-Rehman recitation may not hold similar value for control of diabetic symptoms except distress. Since stress is closely linked with HPA-axis as well, we were therefore also interested in observing cortisol levels after listening to Surah Al-Rehman. It has previously been shown that maraqba, a spiritual practice, significantly reduces cortisol levels (Azeemi et al., 2020), so we expected a similar drop in cortisol levels. However, we did not observe any significant change in cortisol levels after surah Al-Rehman recitation, which may be due to the difference of time duration

as previously, the significant drop in cortisol levels was observed after 20 min of maraqba, while the recitation was eight min long. This may also explain that Surah Al-Rehman recitation may have no effect on cortisol levels.

Distress is related to altered brain function (Al-Shargie et al., 2016). Since prefrontal cortex (PFC) holds a significant role in higher cognitive functions, we were interested to study different frequency band powers in PFC after listening to Surah Al-Rehman. We observed an overall increase in all frequency band powers including theta, alpha, beta and gamma powers after listening to Surah Al-Rehman (Table 3). The increase was mostly on the right PFC, and the highest difference was observed in alpha power range followed by theta, beta and lastly gamma wave. These changes in brain activity were not statistically significant due to higher standard deviations and the fact that recitation lasted for eight min. We suggest increasing time of the recitation for future studies in order to confirm the statistical significance of the differences.

Stress also affects cardiovascular system as reflected in HRV measures (Park et al., 2018). Heart rate variability measures have emerged as important tools for determining autonomic control. SDNN and RMSSD among the other HRV measures are used for short-term assessments of autonomic function (Shaffer & Ginsberg, 2017). Since our experimental design incorporated short-term assessment, i.e., after eight min of listening to Surah Al-Rehman recitation, we therefore assessed SDNN and RMSSD as time domain measures. Even though a slight insignificant increase in SDNN was observed (Table 4), there was no difference in RMSSD measure. It indicates that Surah Al-Rehman recitation had no direct effect on cardiac function reflected by beat to beat variability. However, there was significant increase in LF power. LF power has been shown to indicate cardiac autonomic outflow by baroreceptor reflexes (Goldstein et al., 2011; Moak et al., 2007, 2009). Together with physiological findings in study participants, we can conclude that 8 min long Surah Al-Rehman recitation modulated autonomic function through baroreceptor reflex, resulting in a significant decrease in the stress index as indicated by HRV measures (Table 4).

Heartbeat evoked potentials are reflective of interoceptive awareness and have been shown to produce enhanced amplitudes in resonant breathing. Resonant

Table 4 HRV measures before and after listening to Surah Al-Rehman

Variable	Without outliers			Adjusted outliers		
	Pre-test Mean ± SD	Post-test Mean ± SD	P Value	Pre-test Mean ± SD	Post-test Mean ± SD	*P* value
SDNN (ms)	11.2 ± 2.4	12.8 ± 3.7	0.20	11.4 ± 2.9	14.3 ± 3.2	0.20
RMSSD (ms)	10.2 ± 7.7	10.4 ± 8.1	0.75	7.3 ± 1.3	7.4 ± 2.3	0.92
LF (Hz)	0.05 ± 0.01	0.62 ± 0.02	0.76	0.05 ± 0.01	0.06 ± 0.01	0.04
HF (Hz)	0.22 ± 0.08	0.25 ± 0.07	0.50	0.23 ± 0.04	0.20 ± 0.05	0.62
Stress Index	26.3 ± 4.3	23.1 ± 8.2	0.3	26.4 ± 4.7	18.9 ± 4.7	0.02

SDNN standard deviation of RR intervals, *RMSSD* root mean square of standard deviation, *LF* low frequency component, *HF* high frequency component, *SD* standard deviation

breathing in turn is associated with HRV and reflects cardiac regulation of vagal afferents. HEP amplitude is usually observed from 100 to 600 ms. Surah Al-Rehman recitation invoked HEP amplitudes at Fp1 following a period of 450 ms (Fig. 1). Previously, focus of attention has been shown to induce HEP during 450–550 ms at Cz (Montoya et al., 1993). Sustained HEP amplitude 400 ms after R-peak has been observed in physiological coherence states (McCraty et al., 2004), we observed a similar positive HEP amplitude at Fp1, which may suggest a physiologically coherent state after surah Al-Rehman recitation. At Fp2, we observed an enhanced HEP amplitude during 100–150 ms (Fig. 1), which has been previously described as a slow wave potential observed as a grand average of different electrodes (Perez et al., 2005). On the frontal regions, only F4 produced a significant N200 HEP amplitude, which has also been shown to increase in resonant breathing. HEP have been shown to be correlated with LF and SDNN component of HRV at Cz site. In light of our findings, Surah Al-Rehman recitation increased the LF component along with increased HEP amplitudes at pre-frontal sites and an increase N200 at F4, suggestive of its effect mimicking resonant breathing states (MacKinnon et al., 2013), commonly utilized in meditation. Findings from the current study suggest three possible effects of Surah Al-Rehman on heart–brain communication; (1) increased focus of internal attention reflected by HEP amplitudes at Fp1, (2) induction of slow wave potential observed at Fp2 and (3) deep meditating state previously observed in resonant breathing by N200 HEP amplitudes.

Study Limitations

Since this study focused on mechanistic understanding of the effects of Surah Al-Rehman, we used a small sample which may lead to low power. The study was conducted in local settings with convenience sampling strategy; therefore, the generalizability of the results is likely to be restricted. Further investigations using a longer recitation time or a larger sample size with an attention control group may provide a clear insight, establishing if the effects are due to increased focus of attention during recitation or due to the acoustic properties of Surah Al-Rehman.

Conclusion

Spiritual and religious practices have previously been shown to improve health outcomes with a pronounced effect on mental health. This is the first time that physiological changes in response to listening to Surah Al-Rehman have been assessed. Surah Al-Rehman has shown the capacity to reduce autonomic burden by lowering systolic blood pressure and reducing stress index. It also improved baroreceptor reflex by increasing low frequency band power component and is effective in improving heart–brain connection as indicated by HEP waveforms observed during resonant breathing state and internal focus of attention. Incorporating spiritual healing tools like Surah Al-Rehman in therapeutic regimen for mental disorders can have a pronounced effect on the therapeutic outcomes of heart and brain health.

We recommend future studies to target modulation in time duration of Surah Al-Rehman recitation to observe a pronounced effect on brain activity and time domain measures of cardiac function.

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Declarations

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

Human and Animal Rights Jinnah Sind Medical University, Institutional Review Board reviewed and approved the study (Approval No. JSMU/IRB/2017/-90).

Informed Consent Written and informed consent was obtained from all individual participants included in the study.

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