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Article

Effect of slow breathing exercise on heart rate variability in tension-type headache female patients: A time domain analysis

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Abstract

Background: Tension-type headache (TTH), the most frequently occurring primary headache is associated with autonomic dysfunction. Time domain analysis of heart rate variability (HRV) is a popular tool to detect changes in cardiac autonomic nerve function (CANF) in TTH patients. Slow breathing exercise (SBE) can significantly improve HRV in patients with cardiovascular disorders. **Objective:** To observe the effect of SBE on HRV by time domain analysis in TTH female patients. **Methods:** This quasi-experimental study was conducted from March 2021 to February 2022 in the Department of Physiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka on 60 female TTH patients aged 20-45 years. Thirty patients performed SBE every morning and evening for 30 minutes in addition to receiving conventional treatment and 30 patients continued only conventional treatment without any exercise for 90 days. Thirty age, sex and BMI matched apparently healthy control were enrolled who did not perform SBE or any other exercise. All subjects were assessed at baseline and also after 90 days. Time domain HRV parameters were recorded by Power Lab 8/35 AD Instruments, Australia. One way ANOVA followed by post-hoc test and Paired sample t-test were performed for statistical analysis and $p<0.05$ was considered as statistical significance. **Results:** Mean heart rate (HR) was significantly higher ($p<0.001$) and SDRR (Standard deviation of all RR interval); CVRR (Coefficient variation of RR interval); SDSD (Standard deviation of successive RR interval differences between adjacent RR intervals); RMSSD (Square root of mean of squared differences of successive RR interval) and pRR50% (Proportion of RR interval with duration > 50ms) were significantly lower ($p<0.001$) in TTH female patients compared to control at baseline. Significant decrement of mean HR ($p<0.001$) and increment of all other time domain parameters ($p<0.001$) was observed after 90 days of SBE. Again, significantly decreased SDRR, CVRR, SDSD, RMSSD and pRR50% ($p<0.001$, $p<0.01$) was observed in the patients who did not perform SBE. **Conclusion:** SBE may effectively improve cardiac autonomic dysfunction in TTH female patients.

Keywords: HRV, SBE, Tension-type headache, Time domain analysis.

Introduction

Headache is one of the most frequent painful condition. Headache affects working ability of people resulting in absence in working place, poor mental focus on work and associated health economy. In clinical practice the most frequent cases encountered by clinicians is the patients with tension-type headache (TTH)which is associated with autonomic dysfunction.[1-2]

The exact pathophysiology of TTH is not clearly understood. It has been revealed that multiple factors are involved which include central and peripheral mechanisms, environmental factors and psychological factors such as stress, anxiety.[3-4]

Heart rate variability (HRV) analysis is one of the most promising novel techniques based on variability of RR interval which is a non-invasive, highly reproducible method used for detailed and sophisticated analysis of the activity of autonomic nervous system (ANS) on the sinus node of heart. The analysis of HRV is a more sensitive method, which can discover subclinical forms of autonomic dysfunction.[5-7]

Among various measurements, time domain methods are the simplest and easiest methods for measuring HRV. In this method, values of RR interval during a 5 minute ECG are displayed by a tachogram showing the RR interval plotted against the time scale from which various time domain indices are calculated[5]. Among time domain parameters, mean heart rate (HR) reflects the overall interaction of both sympathetic and parasympathetic nerve activity at resting condition whereas, mean RR interval represents the variation of resting cardiac vagal activity[5]. SDRR, also known as SDNN is the simplest variable to calculate, denotes standard deviation of all RR interval from sinus origin expressed in millisecond (ms).[5] The square root of the mean squared differences of successive RR intervals (RMSSD) is a measure of parasympathetic activity[5]. Coefficient variation of RR interval (CVRR) is used to compare relative variability of RR interval among different groups.[8] Standard deviation of differences between adjacent RR intervals (SDSD) is a marker of parasympathetic modulation on beat to beat variability in time and also correlated with HF power in frequency domain.[5] Number of RR interval differing >50 ms from adjacent intervals divided by the total number of all RR intervals (pRR50%) represents parasympathetic modulation to heart.[2,5]

Low HRV is associated with risk of adverse cardiac events and sudden deaths in patients with various disease conditions.[5,9] Contrary, high HRV reflects good adaptability and well-functioning autonomic control.[10]

Breathing exercise is a technique where air is inspired or expired in a selective way which has remarkable influence on maintaining good physical health. Rhythmic breathing can play a significant role in determining our physical as well as emotional well-being. Mental peace or agitation has profound effect on breathing pattern.[11]

Various prayanamic techniques have been found to have very good impact on cardiorespiratory health. Among these techniques, Nadisuddhi pranayama, known as slow breathing exercise (SBE) or alternate nostril breathing has earned much popularity because of its procedural simplicity. This technique composed of inhalation and exhalation through alternate nostrils.[12] In this SBE, oxygen consumption requirement is decreased. In addition, heart rate and blood pressure are also decreased to maintain a good cardiopulmonary function.[13] SBE also plays a crucial role for improving our autonomic function.[11-12,14-15]

TTH patients are vulnerable to adverse cardiac events due to their association with autonomic dysfunction. Therefore, it was important to sort out an easily approachable, safe and economic measure to improve cardiac autonomic nerve function (CANF) for protecting these group of patients from cardiovascular mortality and morbidity. We hypothesized that SBE would enhance parasympathetic tone and reduce sympathetic tonic activity in TTH patients. The aim of this study was to observe the effect of SBE on autonomic function in female patients with TTH by analysis of time domain parameters of HRV.

Methods

Setting & study participants

This quasi-experimental study was conducted in the Department of Physiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka from March 2021 to February 2022, after obtaining ethical approval by the Institutional Review Board. A total of 107 female subjects with 20-45 years of age were selected for this study.[16] Seventy five (75) diagnosed frequent episodic (FETTH) and chronic (CTTH) subtype of TTH patients constituted the study group and 32 apparently healthy subjects with similar age, sex and BMI constituted control group. Among 75 FETTH and CTTH patients, 38 patients practiced SBE for 90 days (SBE Group) along with usual treatment. Remaining 37 patients without SBE continued usual treatment only and were followed up after 90 days (NSBE Group). Control group did not practice slow breathing exercise. On the basis of data recording SBE_0 and SBE_{90} constituted pre and post SBE group whereas $NSBE_0$ and $NSBE_{90}$ represented pre and post follow up group without SBE at day 0 and day 90 respectively. After 90 days, 6 patients of SBE group and 7 patients of NSBE group did not appear for follow up. Additionally, data of 2 patients of SBE group and 2 subjects of control group were discarded due to technical errors. Finally, data of 30 patients of SBE group, 30 patients of NSBE group and data of 30 controls were analyzed and compared among the groups after 90 days of follow up.

Exclusion criteria

Subjects with infrequent episodic tension-type headache (IETTH), smokers, alcoholics, pregnant women and history of medication or illness affecting autonomic functions were excluded.

Sampling

Purposive sampling procedure was followed to select the patients as well as the control subjects. The study group was selected from Neurology OPD, BSMMU, Shahbag, Dhaka seeking for medical follow up who were diagnosed as FETTH and CTTH. Selected patients were motivated and interviewed with the cooperation from the attending physician. Age, sex and BMI matched apparently healthy female subjects were selected from different areas of Bangladesh through personal contacts.

Intervention

A training session on SBE was organized in the Department of Physiology. The steps of SBE (alternate nostril breathing) were thoroughly demonstrated to the study group on that training session by the researcher and asked them to do. They continued training till they were confident enough to perform it at home. They were advised to perform SBE every morning and evening for 30 minutes for a period of 90 days.

Data collection Procedure

After selection procedure, informed written consent was taken from all participants. A detailed medical history and anthropometric measurements were taken. Then a thorough clinical examination was done. Preparation for the test was explained to them. For HRV recording, the subject took their meal by 9:00 pm and had a sound sleep in the previous night. From previous night up to the time of examination, they were requested not to undergo any physical or mental stress, and also avoid taking any sedatives or any other drugs that could affect central nervous system[5]. The participants were requested to take light breakfast but no tea or coffee in the morning and then report to the Department of Physiology, BSMMU between 8-9 am on next day for HRV recording.

The short term (5 minutes) recording of HRV measures was done by 8 active channels, Power Lab 8/35 (AD instrument, Australia), in the Autonomic Nerve Function Laboratory of the Department of Physiology, BSMMU in relaxed supine position, keeping eyes closed, refraining from talking, body movements, mental exercise and even sleep with a normal respiratory rate for 15 minutes both at base line and at the end of 90 days. HRV recording was obtained in the morning between 9 to 11 am with dim light, keeping the room temperature at 25^0 C and noise free and then time domain measures of HRV were automatically analyzed by in-built Labchart software.

Statistical analysis

Data were expressed as Mean±SD and analyzed at baseline and also at the end of 90 days of intervention or follow up using SPSS version 16. Data were found normally distributed. One way ANOVA followed by post-hoc Bonferroni test and Paired sample t-test were performed. $p<0.05$ was considered as statistically significant.

Results

At baseline, resting pulse rate was found significantly higher in both patient groups compared to control. Data of general characteristics, resting pulse rate and BP of both patient groups at baseline were similar (Table I).

Again, mean HR was significantly higher ($p<0.001$) and all other time domain parameters were significantly lower ($p<0.001$) in both patient groups compared to control at baseline (Table II).

In addition, mean HR significantly decreased ($p<0.001$) and all other time domain parameters significantly increased ($p<0.001$) after 90 days of intervention in the patient group who practiced SBE, whereas mean HR and mean RR interval were similar but rest of the time domain parameters significantly decreased ($p<0.001$, $p<0.01$) in the group who were followed up at the end of 90 days without intervention (Table III).

Furthermore, the mean HR was significantly lower ($p<0.001$) and rest of the time domain parameters were significantly higher ($p<0.001$; $p<0.01$) in post exercise group compared to patients without SBE. All these parameters were significantly lower ($p<0.001$; $p<0.01$) in both group of patients compared to control at the end of 90 days (Table IV).

Table I: General characteristics, resting pulse rate and BP in different groups (N=90)

Parameters	SBE_0 (n=30)	$NSBE_0$ (n=30)	$Control_0$ (n=30)
Age	27.97±6.13	28.13±6.01	28.97±4.72
(Years)	(20-38)	(20-45)	(21-41)
BMI	22.65±2.32	22.78±2.13	22.62±2.03
(Kg/m^2)	(18.50-24.90)	(18.50 – 24.90)	(18.60-24.90)
Pulse rate	87.53±9.03***	85.87±10.33**	77.93±6.61
(beats/min)	(76-114)	(72-112)	(64-92)
SBP	107.83±8.68	106.67±9.59	104.17±8.72
(mm Hg)	(95-120)	(80-120)	(90-120)
DBP	72.67±7.28	74.33±7.04	71.17±7.03
(mmHg)	(60-85)	(60-85)	(60-85)

*This depicts comparison with control group, **p<0.01, ***p<0.001. Data were expressed as Mean ± SD. Values in parentheses indicate ranges; Statistical analysis was done by One-way ANOVA; BMI- Body Mass Index; SBE_0- Patients with slow breathing exercise at baseline; $NSBE_0$- Patients without slow breathing exercise at baseline; $Control_0$- Healthy control at baseline; N- Total number of subjects; n- Number of subjects in each group.

Table II: Time domain parameters in different groups at baseline (N=90)

Parameters	SBE_0 (n=30)	$NSBE_0$ (n=30)	$Control_0$ (n=30)
Mean heart rate	90.74±11.35***	88.91±13.19***	76.54±8.46
(beats/min)	(70.10-121.00)	(66.45-122.00)	(62.19-100.30)
Mean R-R	671.68±78.94***	689.14±91.72***	797.48±86.14
Interval (ms)	(496.30-857.80)	(490.90-903.90)	(604.10-966.40)
SDRR	26.55±8.05***	31.11±6.70***	59.35±14.76
(ms)	(15.66-41.87)	(14.60-39.67)	(35.85-99.18)
CVRR	0.040±0.012***	0.046±0.011***	0.075±0.020
	(0.023-0.067)	(0.020-0.074)	(0.040-0.129)
SDSD	22.43±11.23***	25.39±11.73***	62.34±20.78
(ms)	(5.12-49.76)	(6.76-58.94)	(38.37-117.10)
RMSSD	22.40±11.27***	25.37±11.74***	62.26±20.75
(ms)	(5.11-49.70)	(6.75-58.95)	(38.32-117.00)
pRR50	4.08±7.41***	6.72±8.92***	38.07±13.65
(%)	(0.00-35.49)	(0.00-36.08)	(15.06-70.77)

*This depicts comparison with control group,***p<0.001. Data were expressed as Mean ± SD. Values in parentheses indicate ranges; Statistical analysis was done by One-way ANOVA followed by post-hoc Bonferroni test. SDRR- Standard deviation of all RR interval; CVRR- Coefficient variation of RR interval; SDSD- Standard deviation of successive RR interval differences between adjacent RR intervals; RMSSD- Square root of mean of squared differences of successive RR interval; pRR50%- Proportion of RR interval with duration > 50ms; SBE_0- Patients with slow breathing exercise at baseline; $NSBE_0$- Patients without slow breathing exercise at baseline; $Control_0$- Healthy control at baseline; N- Total number of subjects; n- Number of subjects in each group.

Table III: Pre and post intervention/follow up values of Time domain parameters in TTH patients (N=90)

Parameters	SBE_0 (n=30)	SBE_{90} (n=30)	$NSBE_0$ (n=30)	$NSBE_{90}$ (n=30)
Mean heart	90.74±11.35	80.41±7.40$^{¥¥¥}$	88.91±13.19	88.86±8.16
rate(beats/min)	(70.10-121.00)	(61.86-98.33)	(66.45-122.00)	(67.90-107.90)
Mean R-R	671.68±78.94	754.52±73.48$^{¥¥¥}$	689.14±91.72	681.77±63.51
Interval(ms)	(496.30-857.80)	(611.80-974.60)	(490.90-903.90)	(556.70-884.10)
SDRR	26.55±8.05	36.82±9.11$^{¥¥¥}$	31.11±6.70	25.37±6.00§§§
(ms)	(15.66-41.87)	(24.22-65.89)	(14.60-39.67)	(14.60-37.85)
CVRR	0.040±0.012	0.049±0.011$^{¥¥¥}$	0.046±0.011	0.037±0.009§§
	(0.023-0.067)	(0.03-0.07)	(0.020-0.074)	(0.02-0.05)
SDSD	22.43±11.23	34.99±14.92$^{¥¥¥}$	25.39±11.73	18.96±5.87§§
(ms)	(5.12-49.76)	(17.38-95.15)	(6.76-58.94)	(10.72-35.37)
RMSSD	22.40±11.27	34.95±14.90$^{¥¥¥}$	25.37±11.74	18.94±5.87§§
(ms)	(5.11-49.70)	(17.36-95.00)	(6.75-58.95)	(10.71-35.33)
pRR50	4.08±7.41	15.22±16.37$^{¥¥¥}$	6.72±8.92	1.79±2.63§§
(%)	(0.00-35.49)	(0.55-72.08)	(0.00-36.08)	(0.00-12.55)

$^{¥}$This depicts comparison between SBE_0 and SBE_{90} group, $^{¥¥¥}p<0.001$. §This depicts comparison between $NSBE_0$ and $NSBE_{90}$ group, $^{§§}p<0.01$, $^{§§§}p<0.001$. Data were expressed as Mean ± SD. Values in parentheses indicate ranges; Statistical analysis was done by Paired sample t-test; SDRR- Standard deviation of all RR interval; CVRR- Coefficient variation of RR interval; SDSD- Standard deviation of successive RR interval differences between adjacent RR intervals; RMSSD- Square root of mean of squared differences of successive RR interval; pRR50%- Proportion of RR interval with duration > 50ms; SBE_0- Patients with slow breathing exercise at baseline; SBE_{90}- Patients with slow breathing exercise at the end of 90 days; $NSBE_0$- Patients without slow breathing exercise at baseline; $NSBE_{90}$- Patients without slow breathing exercise at the end of 90 days; N- Total number of subjects; n- Number of subjects in each group.

Table IV: Post intervention/follow up values of time domain parameters in different groups (N=90)

Parameters	SBE_{90} (n=30)	$NSBE_{90}$ (n=30)	$Control_{90}$ (n=30)
Mean heart rate	80.41±7.40$^{\#\# ØØØ}$	88.86±8.16$^{\#\#\#}$	74.26±7.66
(beats/min)	(61.86-98.33)	(67.90-107.90)	(63.85-94.74)
Mean R-R	754.52±73.48$^{\#\# ØØ}$	681.77±63.51$^{\#\#\#}$	820.34±81.94
Interval (ms)	(611.80-974.60)	(556.70-884.10)	(637.50-941.30)
SDRR	36.82±9.11$^{\#\#\# ØØ}$	25.37±6.00$^{\#\#\#}$	57.10±16.76
(ms)	(24.22-65.89)	(14.60-37.85)	(37.22-95.34)
CVRR	0.049±0.011$^{\#\#\# ØØ}$	0.037±0.009$^{\#\#\#}$	0.070±0.020
	(0.03-0.07)	(0.02-0.05)	(0.04-0.12)
SDSD	34.99±14.92$^{\#\#\# ØØØ}$	18.96±5.87$^{\#\#\#}$	62.19±22.11
(ms)	(17.38-95.15)	(10.72-35.37)	(36.82-122.50)
RMSSD	34.95±14.90$^{\#\#\# ØØØ}$	18.94±5.87$^{\#\#\#}$	62.11±22.08
(ms)	(17.36-95.00)	(10.71-35.33)	(36.77-122.30)
pRR50	15.22±16.37$^{\#\#\# ØØ}$	1.79±2.63$^{\#\#\#}$	40.62±16.36
(%)	(0.55-72.08)	(0.00-12.55)	(10.29-76.25)

$^{\#}$This depicts comparison with $control_{90}$ group, $^{\#\#}p<0.01$, $^{\#\#\#}p<0.001$. ^{Ø}This depicts comparison of SBE_{90} with $NSBE_{90}$ group, $^{ØØ}p<0.01$, $^{ØØØ}p<0.001$. Data were expressed as Mean ± SD. Values in parentheses indicate ranges; Statistical analysis was done by One-way ANOVA followed by post-hoc Bonferroni test. SDRR- Standard deviation of all RR interval; CVRR- Coefficient variation of RR interval; SDSD- Standard deviation of successive RR interval differences between adjacent RR intervals; RMSSD- Square root of mean of squared differences of successive RR interval; pRR50%- Proportion of RR interval with duration > 50ms; SBE_{90}- Patients with slow breathing exercise at the end of 90 days; $NSBE_{90}$- Patients without slow breathing exercise at the end of 90 days; $Control_{90}$- Healthy control at the end of 90 days; N- Total number of subjects; n- Number of subjects in each group.

Discussion

In this study, higher HR and lower RR interval, SDRR, CVRR, SDSD, RMSSD and pRR50% in both patient groups prior to intervention or follow up provided evidence of substantially impaired vagal tone in TTH patients which was consistent to other reports.[1,17] A significant lower SDRR and RMSSD were noted by a group of researchers in FETTH and CTTH patients[17], but previous studies found these values lower but not significant.[1,2] In addition to this, a significantly lower pRR50% was reported in TTH patients suggesting decreased parasympathetic modulation.[1,2]

In our study after performing SBE for 90 days, decrement in HR and increment in all other time domain parameters suggested increased variability and parasympathetic activity was increased in TTH patients. This demonstrated the good impact of SBE on CANF in TTH patients.

Again, comparison of time domain parameters after 90 days from the baseline between the patients who performed SBE and who did not, showed that the value of these parameters were significantly higher in patients who were under SBE. In addition, further comparison among both group of patients and controls showed that mean HR and all other time domain parameters remained significantly different at the end of 90 days.

All these suggested that, though there was improvement of CANF after performing SBE, but it did not reach close to control value. In this study performing SBE for 90 days significantly improved CANF from the pre-exercise level but as it could not reach the control level, long duration of SBE may bring improvement to the extent of healthy subjects. It is also noteworthy that after 90 days, further deterioration of CANF in the patients without SBE, is obviously strengthening the evidence of SBE on CANF.

The exact mechanism how SBE improves CANF in TTH patients is yet to be explored. SBE was efficient to reduce autonomic dysfunction by resetting the central autonomic discharge by enhancing the vagal traffic as a result of prolonged receptor activation and increased vagal discharge. SBE exerts greater stretching on these slowly adapting pulmonary receptors, present in the smooth muscle of bronchial wall down to bronchi and also in the tracheal and bronchial segments of extrapulmonary airways, when the lungs are above tidal volume and this synchronizes cardiopulmonary centers with the central nervous system. More specifically, the increased vagal afferent impulses conveyed to nucleus tractus solitarious (NTS), ultimately activated autonomic neurons at dorsal vagal motor nucleus (DVN).[18,19] As a result of these repeated afferent stimuli which are integrated at DVN in turn strengthened vagal center which was apparently weak in TTH. Therefore, increased synchronizing discharge of vagal center directly acted on SA node of heart. In addition to this, such increased vagal trafficking to SA node also caused reciprocal sympathetic inhibition, as a result heart rate was decreased in TTH patients performing SBE.

Conclusion

Results of the study concluded that SBE, a form of yoga based relaxation techniques, may effectively improve deranged autonomic function in TTH patients. Therefore, SBE can be recommended for regular practice along with usual medication in TTH patients to improve cardiac health.

Conflict interest

Authors no conflict of interest

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