Research Article

Science, Engineering and Health Studies
https://li01.tci-thaijo.org/index.php/sehs
ISSN (Online): 2630-0087

Alteration in cardiac autonomic activity during listening to Thai classical music in male subjects

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***Received**: 20 June 2023*
***Revised**: 13 September 2023*
***Accepted**: 25 September 2023*
***Published**: 29 December 2023*

***Citation**:*
Butsen, O., Wannamool, P., Phoglin, M., Changsap, B., and Bangsumruaj, J. (2023). Alteration in cardiac autonomic activity during listening to Thai classical music in male subjects. Science, Engineering and Health Studies, 17, 23050018.

ABSTRACT

Relaxing music, such as classical music, could improve autonomic nervous system function by reducing sympathetic activity and increasing parasympathetic activity, as indicated by an increase in heart rate variability (HRV). However, it is unknown whether Thai classical music, which is considered to be relaxing music, could induce autonomic alterations. This study investigated the effects of classical, heavy metal, and Thai classical music on cardiac autonomic activity, as determined by HRV, using a crossover design methodology. All subjects were exposed to the three music stimulations. Electrocardiograms (ECGs) were recorded before, during, and after music listening. The results showed that the standard deviation of normal-to-normal R-R intervals (SDNN) and low frequency (LF) power were significantly decreased during listening to Thai classical music. The decreased SDNN might be due to a reduction in parasympathetic activity, as indicated by the reduction in root mean square successive difference (RMSSD) and percentage of subsequent R-R intervals with a duration difference longer than 50 ms (PNN50). However, the decrease in parasympathetic activity was not large enough to induce autonomic imbalance as shown by an insignificant change in high frequency (HF) power. A positive correlation between LF power and HF power was also observed during listening to Thai classical music. This suggests that HF power functioned to counterbalance the change in LF power during the listening session. In conclusion, only Thai classical music affected cardiac autonomic function by decreasing sympathetic activity without altering cardiac autonomic balance.

Keywords: music listening; cardiac autonomic nervous system; heart rate variability

1. INTRODUCTION

Stress is a known risk factor for many diseases, including cardiovascular disease, the leading cause of death worldwide (Steptoe and Kivimäki, 2012). Increased sympathetic activity, an imbalance in autonomic nervous system activity, is a known trigger for cardiac syndromes in humans and animals and is likely a contributory mechanism for stress-related cardiac diseases (Malpas, 2010; Thayer et al., 2010). Autonomic imbalance can manifest as increased sympathetic tone, decreased parasympathetic tone, or both (Floras and Ponikowski, 2015). It can be indicated by a reduction in heart rate variability (HRV) (Chevalier and Sinatra, 2011). Stress can change HRV, as shown in humans through a 6-min speech task (Hall et al., 2004) and in rats through 15 min of forced restraint (Carnevali et al., 2014). Both tasks are associated with reduced HRV.

Music has a significant power in reducing stress and anxiety (Iwanaga and Moroki, 1999; Lee et al., 2004), which may help to prevent cardiac syndrome. However, the effect of music on mental and physiological responses is inconsistent, depending on the type or tempo of music (Bernardi et al., 2006). Previous studies have shown that sedative music decreases heart rate, while excitative music increases heart rate (Iwanaga and Moroki, 1999). Sedative music is characterized by simple repetitive rhythms, predictable dynamics, and is described as melodious, delicate, harmonic, and romantic (Iwanaga et al., 2005; Lee et al., 2005). In contrast, excitative music is characterized as loud, dynamic, and rhythmic which elicited excitement (Iwanaga et al., 2005). Previous research has demonstrated that a popular Taiwanese song, named "He is our treasure" (Chuang et al., 2010), and Japanese music with easy rhythms can increase parasympathetic activity (Kurita et al., 2006). On the contrary, heavy metal music with its fast rhythms decreased parasympathetic activity (da Silva et al., 2014). It can be concluded that slow or easy rhythms improve autonomic function, while fast or complex rhythms induce arousal, resulting in impaired autonomic function. Therefore, we are interested in understanding whether Thai classical music, which is likely to be relaxing music, could induce any cardiac autonomic alterations. This study aimed to investigate the effects of listening to music, including classical, heavy metal, and Thai classical music, on cardiac autonomic activity.

2. MATERIALS AND METHODS

2.1 Subjects

This study was conducted on 12 healthy subjects (6 male and 6 female), aged 20–49 years, selected from our institution. All volunteers were informed about the study procedures and objectives and signed an informed consent form after agreeing to participate. All study procedures were approved by the Research Ethics Committee of Huachiew Chalermprakiet University (Approval number อ. 1262/2565). Exclusion criteria included auditory disorders, diabetic neuropathy, cardiac arrhythmia, or other cardiovascular diseases, as well as undergoing treatments that could affect cardiac autonomic regulation. Volunteers were required to abstain from consuming alcohol or caffeine for 24 h before the evaluation.

2.2 Experimental procedures

The experiment was conducted in a room, where the temperature was maintained between 21 °C and 25 °C, with a relative humidity of 50–60%. To prevent the disturbance of circadian rhythm, data were collected individually between 8 AM and 12 PM. Before starting the experiment, subjects completed the questionnaire. Subsequently, they sat on a comfortable chair and rested alone in a designated room for 10 min. After the resting period, baseline blood pressure and heart rate were measured, and a 5-min ECG recording was obtained to establish baseline values. Immediately following the baseline measurement, subjects listened to music through earphones, and a 5-min ECG recording was conducted. After the music played for 5 min, blood pressure, heart rate, and ECG were recorded again. All subjects were exposed to three different music stimuli: Western classical (WC, Air on the G String, Suite No. 3, BWV 1068), heavy metal (HM, Hard-Rock music instrumental compilation 205–150 BPM), and Thai classical (TC, Khamen Saiyok- Instrumental music). This exposure followed a crossover design with a 5-min washout period between conditions. The experimental procedures are illustrated in Figure 1.

2.3 ECG recording and HRV measurements

To assess HRV, ECG was recorded using a BIOPAC MP150 data acquisition system (Biopac Systems, Goleta, CA, USA). The recorded ECG traces were analyzed using LabChart 8 (ADInstruments, Castle Hill, NSW, AU). All analyzed segments were 5 min in duration and met the quality assurance criteria of stationarity and a lack of ectopic beats. The parameters used to evaluate HRV were categorized into time domain and frequency domain. Time domain parameters were derived from the RR interval, representing the reciprocal of heart rate. In this study, we examined several time domain parameters, including the standard deviation of all normal RR intervals (SDNN), the root mean square of successive differences (RMSSD), and the percentage of subsequent R-R intervals with a duration difference longer than 50 ms (PNN50). SDNN represents total variability, while PNN50 and RMSSD specifically quantify parasympathetic activities. Frequency domain parameters were derived from power spectra, obtained through Fourier transformation as previously described, using a window size of 256 and a Hamming window (Malik, 1996). These parameters were analyzed in terms of total power, very low frequency (VLF), low frequency (LF) and high frequency (HF) powers. In this study, VLF, LF and HF powers were calculated within the frequency ranges of <0.4 Hz, 0.04–0.15 Hz, and 0.15–0.4 Hz, respectively (Malik, 1996). All frequency domain parameters were presented in units of ms^2. Total power, VLF, LF and HF represent the variance of all normal RR-intervals, renin-angiotensin system, sympathetic and parasympathetic activity, respectively. The ratio of LF to HF indicates the changing relationship between sympathetic and parasympathetic nerve activities, known as the sympathovagal balance. During data analysis, one subject was excluded due to abnormalities in the ECG pattern.

2.4 Statistical analysis

All data are presented as means and standard errors of the mean (mean±SEM). The HRV parameters were analyzed using two-way repeated measures ANOVA followed by Bonferroni's post hoc test. Additionally, Pearson correlation analysis was conducted to assess the relationship between HRV parameters. Statistically significant differences were considered at $p<0.05$.

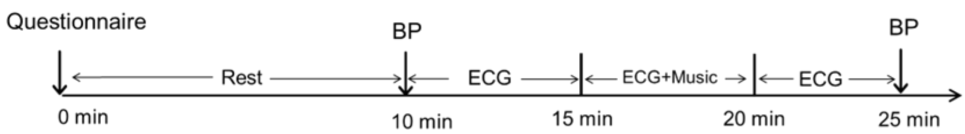

Figure 1. An overview of the experimental time course for music listening and ECG recording

3. RESULTS

3.1 Demographic data

The characteristics of the subjects in this study are shown in Table 1. The subjects consisted of 11 healthy volunteers, both male and female, aged 20–49 years. Most of the subjects had a normal body mass index (BMI), while only one subject had a high BMI value of 26.56 kg/m^2. Approximately half of the subjects always enjoyed exercise. The majority of them did not drink coffee, and none of the subjects had ever smoked or taken any medication. Most preferred listening to Western classical and rock music.

3.2 Effect of listening to music on blood pressure

Systolic and diastolic blood pressure were not affected by listening to music including the main effect of time (before and after music listening) [F(1, 67) = 0.445, P = 0.510; F(1, 67) = 0.453, P = 0.506], musical types [F(2, 67) = 0.083, P = 0.921; F(2, 67) = 0.098, P = 0.907], or interaction between factors [F(2, 67) = 0.164, P = 0.850; F(2, 67) = 0.898, P=0.418] as shown in Table 2.

3.3 Effect of listening to music on HRV

RR interval and HR were not affected by listening to music including the main effect of time (baseline, during, and after music listening) [F(2, 89) = 1.007, P = 0.372; F(2, 89) = 1.393, P = 0.257], musical types [F(2, 89) = 0.077, P = 0.926; F(2, 89) = 0.0814, P = 0.922], and interaction between factors [F(4, 89) = 0.987, P = 0.422; F(4, 89) = 0.957, P = 0.439] as shown in Figure 2.

For the HRV analysis, time domain parameters including SDNN, RMSSD, and PNN50 are displayed in Figure 3. SDNN was influenced by Thai classical music [F(2, 89) = 4.905, p = 0.011]. It was significantly decreased during listening, compared to baseline (p = 0.010), and became significantly increased after the music ceased (p = 0.038). No significant effect of Western or heavy metal music on SDNN were observed. Regarding RMSSD and PNN50, two-way repeated measure ANOVA revealed insignificant main effects of time (before, during and after listening) [F(2, 89) = 0.970, P = 0.386; F(2, 89) = 0.710, P = 0.494 for RMSSD and PNN50, respectively], treatment (types of music) [F(2, 89) = 0.122, P = 0.886; F(2, 89) = 0.079, P = 0.925], or interaction between factors [F(4, 89) = 0.404, P = 0.805; F(4, 89) = 1.460, P = 0.227].

The frequency domain parameters of HRV including total power, VLF, LF, HF power and LF/HF ratio are presented in Figure 4. The total power was not influenced by musical types [F(2, 89) = 0.813, P = 0.454], time [F(2, 89) = 2.493, P = 0.092], and interaction between factors [F(4, 89) = 1.265, P = 0.295]. VLF showed a similar result to total power, two-way repeated measure ANOVA revealed insignificant main effects of musical types [F(2, 89) = 0.544, P = 0.586], time [F(2, 89) = 0.732, P = 0.486], and interaction between factors [F(4, 89) = 0.906, P = 0.467]. Moreover, HF was also not affected by musical types [F(2, 89) = 0.141, P = 0.869], time [F(2, 89) = 2.156, P = 0.126], and interaction between factors [F(4, 89) = 0.474, P = 0.755]. For the LF/HF ratio, a two-way repeated measure ANOVA revealed a significant main effect of time [F(2, 89) = 3.292, P = 0.045], and an insignificant effect of musical types [F(2, 89) = 0.123, P = 0.884], with no interaction between factors [F(4, 89) = 0.584, P = 0.675]. However, within-group comparisons showed that the LF/HF ratio were not significantly different between baseline, during or after listening in all types of music although main effect of time was significantly different. For LF power, the LF was affected during listening to Thai classical music [F(2, 89) = 5.526, P = 0.007]. However, there were no significantly different main effects of Western and heavy metal music F(2, 89) = 1.004, P = 0.379] nor interaction between factors [F(4, 89) = 0.558, P = 0.673]. The within-group comparison demonstrated that during the Thai classical music listening period, the LF power was significantly decreased from baseline (P = 0.038) and trended to increase after the music ceased (0.072) (Figure 4C).

Table 1. Participant demographic, and behavioral characteristics (n = 11)

	Value (percent)
Sex (female: male)	5:6
Age (years)	
- 18–30	6 (54.55%)
- 31–50	5 (45.45%)
Body weight (kg)	57.05±2.97
Body mass index (kg/m^2)	21.82±0.91
Exercise (times/week)	
- Never	5 (45.45%)
- 2–3	4 (36.35%)
- ≥3	2 (18.18%)
Smoking (persons)	
- Never	11 (100%)
- Ex-smoker	0
- Current	0
Caffeine consumption (persons)	
- No	8 (72.73%)
- Yes	3 (27.27%)
For binary stratification, only 1 (yes) can be presented	
Alcohol consumption (drinks/week)	
- Never	11 (100%)
- ≤1/week	0
- ≥2/week	0
Medical condition	
- No	11 (100%)
- Yes	0
For binary stratification, only 1 (yes) can be presented	
Music preference	
- Western classic	4 (36.6%)
- Rock	4 (36.6%)
- Thai classic	2 (18.18%)
- Thai folk song	1 (9.09%)

Table 2. Blood pressure before and after listening to music (n = 11)

	Blood pressure (mmHg)		
	Western classic	**Heavy metal**	**Thai classic**
Systolic			
Before	107.91±4.33	111.82±4.04	113.18±3.55
After	108.36±4.76	108.36±4.16	108.36±4.23
Diastolic			
Before	73.36±3.75	76.18±2.89	79.91±3.18
After	77.00±3.42	72.91±2.93	72.91±2.97

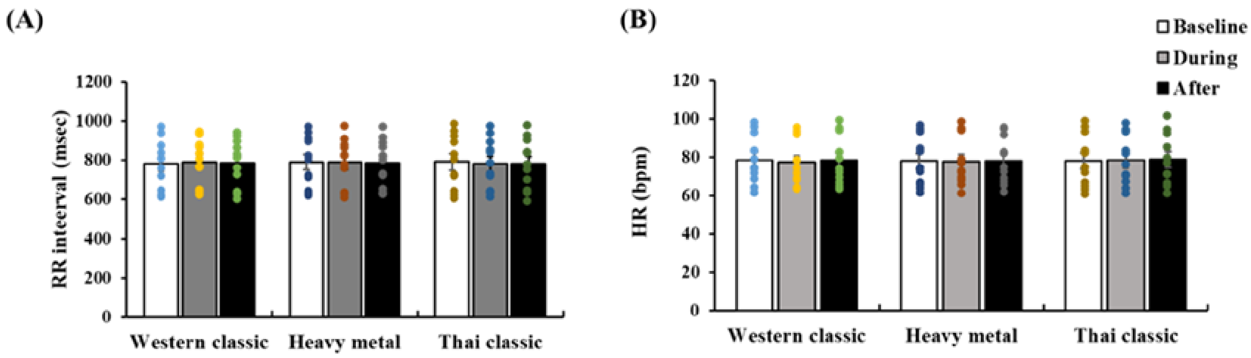

Figure 2. RR interval (A) and HR (B) in baseline, during, and after music listening
Note: Data are presented as mean±SEM; n = 11

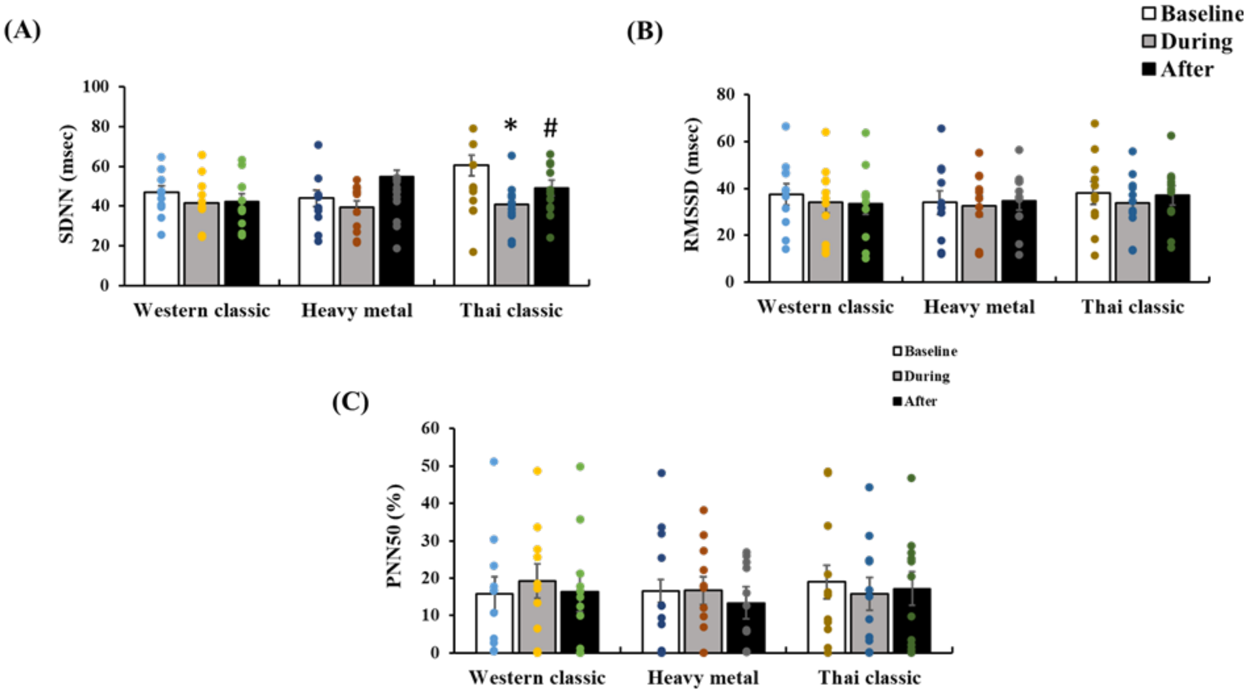

Figure 3. Time domain analysis of HRV at baseline, during, and after music listening
Note: Data are presented as mean±SEM, *p<0.05 vs. baseline of Thai classic group, #p<0.05 vs. during music listening of Thai classic group; analyzed using two-way repeated measures ANOVA followed by Bonferroni's post hoc test; n = 11

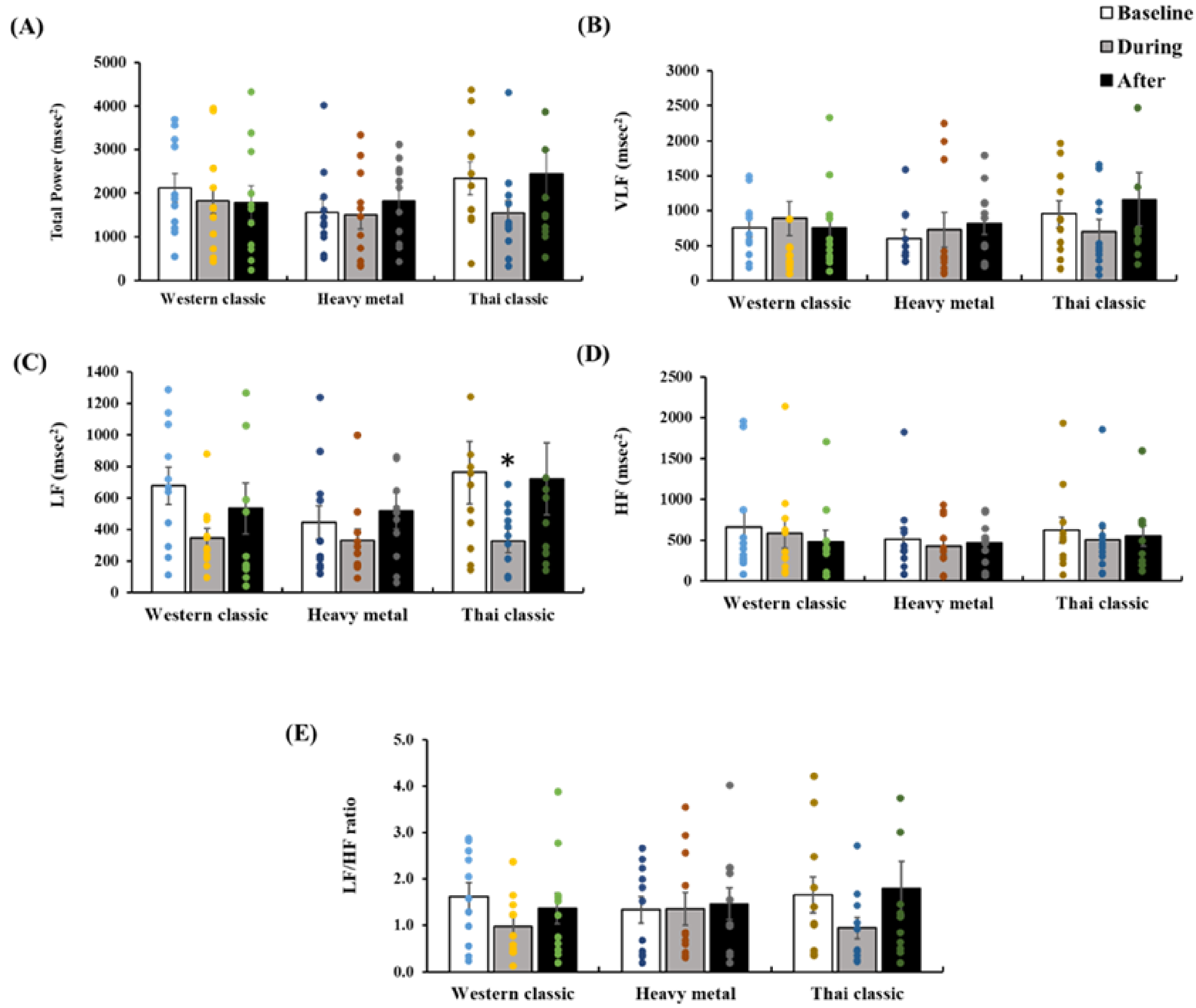

Figure 4. Frequency domain analysis of HRV at baseline, during, and after music listening
Note: Data are presented as mean±SEM, **p*<0.05 vs. baseline of Thai classic group, analyzed using two-way repeated measures ANOVA followed by Bonferroni's post hoc test; n = 11.

3.4 Correlation between SDNN, LF power and other HRV parameters

The results of correlative analyses are displayed in Table 3. Consistent with earlier findings, SDNN and LF power showed significant alterations only within the Thai classical music group. Therefore, a correlation analysis of HRV parameters was conducted to elucidate the probable cause of HRV changes in this group. As anticipated, SDNN demonstrated positive correlations with RMSSD, PNN50, total power, and HF power at before, during and after the Thai classical music listening period. In addition, SDNN showed a positive correlation with VLF power during and after the listening period.

LF power correlated with LF/HF ratio before listening. Surprisingly, during listening, LF power showed a positive correlation with both total power and HF power, suggesting that HF power counterbalanced the change in LF power. After listening, LF power correlated positively with LF/HF ratio but not with HF power.

4. DISCUSSION

This study showed that Thai classical music decreased HRV and sympathetic activity, as shown by the reduction in SDNN and LF power. This is interesting because Thai classical music was more effective than Western classical or rock music in inducing autonomic nervous system alterations, despite the majority of subjects expressing a preference for Western classical and rock music. These results imply that the type of music, rather than the individual favorite song, is the primary factor affecting HRV. These findings are in agreement with previous studies (Iwanaga and Moroki, 1999; Lynar et al., 2017).

Table 3. Correlative analysis between SDNN, LF power and other HRV parameters before, during, and after Thai classical music listening

Period	Factor 1	Factor 2	Correlation coefficient (r)	*p*-value
Before	SDNN	RMSSD	0.836	0.001**
		PNN50	0.770	0.006**
		Total power	0.925	0.000***
		VLF	0.420	0.199
		LF	0.688	0.019*
		HF	0.806	0.003**
		LF/HF	0.031	0.929
	LF	RMSSD	0.299	0.372
		PNN50	0.289	0.389
		Total power	0.598	0.052
		VLF	-0.087	0.799
		HF	0.248	0.463
		LF/HF ratio	0.643	0.033*
During	SDNN	RMSSD	0.805	0.003**
		PNN50	0.691	0.018*
		Total power	0.896	0.002**
		VLF	0.764	0.006**
		LF	0.672	0.023*
		HF	0.772	0.005**
		LF/HF	-0.223	0.511
	LF	RMSSD	0.414	0.206
		PNN50	0.317	0.342
		Total power	0.752	0.008**
		VLF	0.470	0.144
		HF	0.621	0.042*
		LF/HF ratio	0.323	0.332
After	SDNN	RMSSD	0.729	0.011*
		PNN50	0.683	0.021*
		Total power	0.884	0.000***
		VLF	0.726	0.011*
		LF	0.554	0.077
		HF	0.662	0.027*
		LF/HF	0.148	0.665
	LF	RMSSD	0.072	0.833
		PNN50	0.149	0.661
		Total power	0.694	0.018*
		VLF	0.382	0.247
		HF	0.085	0.805
		LF/HF ratio	0.793	0.004**

Unexpectedly, SDNN decreased during the listening period of Thai classical music, which is considered sedative music. This finding aligns with a study conducted by Plassa et al. (2014), which showed that classical baroque music decreased SDNN in the group that enjoyed the music (Plassa et al., 2014). In this study, the decrease in SDNN may be attributed to a reduction in parasympathetic activity, as shown by the reductions in RMSSD and PNN50. However, the changes in RMSSD and PNN50 did not reach statistical significance. A decrease in LF power was also observed in this study, consistent with findings in numerous previous studies involving various types of music. For instance, Japanese music was found to decrease LF in elderly patients with cardiovascular disease and dementia

(Kurita et al., 2006). Chang et al. also reported that listening to popular Taiwanese songs with pleasant moderate rhythms and tempos for two hours decreased LF power of HRV compared to the control group. Conversely, some previous studies have shown that music listening can increase LF power, demonstrating increased sympathetic or decreased parasympathetic activity (Bernardi et al., 2006). For example, fast rhythm music increased the LF/HF ratio (Bernardi et al., 2006), and excitative music decreased HF power (Iwanaga et al., 2005). The characteristics of exciting music, such as a high tempo, high pitch, or increasing overtones, can stimulate the sympathetic autonomic nervous system. In contrast, tranquilizing music may enhance parasympathetic drive (John et al., 2021). This study did not show an alteration in HF power during or after listening to Thai classical music. However, HF was positively correlated with LF, suggesting that changes in parasympathetic activity were counterbalancing the alterations in sympathetic activity. This study is the first to report to a decrease in sympathetic activity (LF power) during the listening to Thai classical music. However, it's important to note that this investigation was carried out exclusively within the same institution, among individuals with similar lifestyles. Therefore, the results of this study may not be readily generalizable to real-life situations emphasizing the need for further research on this issue.

Music may alter autonomic activities by reducing neurotransmitter release, especially norepinephrine. Music listening activates the limbic system, releasing enkephalins and endorphins. Beta-endorphins decrease norepinephrine secretion, inhibiting sympathetic neuronal excitatory activity (Lee et al., 2005; Shrihari, 2019). Music listening is also associated with dopamine activity in the reward system. Dopamine is released from the nucleus accumbens, a key component of the reward system, when exposed to music. This plays a crucial role in processing rewarding stimuli and reinforcing stimuli and is associated with autonomic system activity that reflects emotional responses (Salimpoor et al., 2011). In this study, LF decreased when subjects were exposed to Thai classical music, implying that this music can induce a state of relaxation. These findings suggest that listening to certain types of music can alter autonomic activities potentially by activating the reward system.

Thai classical music attenuated the sympathetic nervous system, as indicated by reduced LF power. Additionally, LF and HF power were positively correlated during the listening period of Thai classical music.

Notably, the study did not include a passive control group, such as white noise, to account for the effects of music listening in general. Additionally, the study primarily involved younger adults from a single institution, which may limit the generalizability of the results.

5. CONCLUSION

Various types of music may have different effects on cardiac autonomic activity. Despite the similarity between Thai classical music and Western classical music, both being considered relaxing genres, their HRV responses differed. Remarkably, only Thai classical music significantly influenced cardiac autonomic function in this study, specifically by decreasing sympathetic activity without altering the cardiac autonomic balance. These findings suggest that Thai classical music may improve cardiac autonomic activity, supporting the potential of music as a therapeutic tool to not only alleviate stress but also promote healing and improve overall emotional well-being.

ACKNOWLEDGMENT

The authors would like to thank the Department of Veterinary Physiology, Faculty of Veterinary Science, Chulalongkorn University for providing the LabChart program. I would also express my thanks to Associate Professor Dr. Anusak Kijtawornrat for supporting the facilities required for ECG recording and HRV analysis, and to Mr. Martin McMurrich, for his assistance in the collecting grammatical errors in a manuscript.

REFERENCES

Bernardi, L., Porta, C., and Sleight, P. (2006). Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: The importance of silence. *Heart*, 92(4), 445–452.

Carnevali, L., Trombini, M., Graiani, G., Madeddu, D., Quaini, F., Landgraf, R., Neumann, I. D., Nalivaiko, E., and Sgoifo, A. (2014). Low vagally-mediated heart rate variability and increased susceptibility to ventricular arrhythmias in rats bred for high anxiety. *Physiology and Behavior*, 128, 16–25.

Chevalier, G., and Sinatra, S. T. (2011). Emotional stress, heart rate variability, grounding, and improved autonomic tone: Clinical applications. *Integrative Medicine*, 10(3), 16–21.

Chuang, C. Y., Han, W. R., Li, P. C., and Young, S. T. (2010). Effects of music therapy on subjective sensations and heart rate variability in treated cancer survivors: A pilot study. *Complementary Therapies in Medicine*, 18(5), 224–226.

da Silva, S. A. F., Guida, H. L., dos Santos Antonio, A. M., de Abreu, L. C., Monteiro, C. B., Ferreira, C., Ribeiro, V. F., Barnabe, V., Silva, S. B., Fonseca, F. L., Adami, F., Petenusso, M., Raimundo, R. D., and Valenti, V. E. (2014). Acute auditory stimulation with different styles of music influences cardiac autonomic regulation in men. *International Cardiovascular Research Journal*, 8(3), 105–110.

Floras, J. S., and Ponikowski, P. (2015). The sympathetic /parasympathetic imbalance in heart failure with reduced ejection fraction. *European Heart Journal*, 36(30), 1974–1982.

Hall, M., Vasko, R., Buysse, D., Ombao, H., Chen, Q., Cashmere, J. D., Kupfer, D., and Thayer, J. F. (2004). Acute stress affects heart rate variability during sleep. *Psychosomatic Medicine*, 66(1), 56–62.

Iwanaga, M., Kobayashi, A., and Kawasaki, C. (2005). Heart rate variability with repetitive exposure to music. *Biological Psychology*, 70(1), 61–66.

Iwanaga, M., and Moroki, Y. (1999). Subjective and physiological responses to music stimuli controlled over activity and preference. *Journal of Music Therapy*, 36(1), 26–38.

John, N., Dubey, P., and John, J. (2021). Impact of instrumental music on heart rate variability in ardent music listeners. *Research in Cardiovascular Medicine*, 10(1), 14.

Kurita, A., Takase, B., Okada, K., Horiguchi, Y., Abe, S., Kusama, Y., and Atarasi, H. (2006). Effects of music therapy on heart rate variability in elderly patients with cerebral vascular disease and dementia. *Journal of Arrhythmia*, 22(3), 161–166.

Lee, D., Henderson, A., and Shum, D. (2004). The effect of music on preprocedure anxiety in Hong Kong Chinese day patients. *Journal of Clinical Nursing*, 13(3), 297–303.

Lee, O. K. A., Chung, Y. F., Chan, M. F., and Chan, W. M. (2005). Music and its effect on the physiological responses and anxiety levels of patients receiving mechanical ventilation: A pilot study. *Journal of Clinical Nursing*, 14(5), 609–620.

Lynar, E., Cvejic, E., Schubert, E., and Vollmer-Conna, U. (2017). The joy of heartfelt music: An examination of emotional and physiological responses. *International Journal of Psychophysiology*, 120, 118–125.

Malik, M. (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *Annals of Noninvasive Electrocardiology*, 1(2), 151–181.

Malpas, S. C. (2010). Sympathetic nervous system overactivity and its role in the development of cardiovascular disease. *Physiological Reviews*, 90(2), 513–557.

Plassa, B. de O., Milan, R. C., Guida, H. L., de Abreu, L. C., Raimundo, R. D., Gonzaga, L. A., and Valenti, V. E. (2014). Cardiac autonomic responses induced by auditory stimulation with music is influenced by affinity. *Medical Express*, 1(14), 206–210.

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., and Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience*, 14, 257–262.

Shrihari, T. G. (2019). Beta endorphins-Holistic therapeutic approach to cancer. *Annals of Ibadan Postgraduate Medicine*, 17(2), 111–114.

Steptoe, A., and Kivimäki, M. (2012). Stress and cardio-vascular disease. *Nature Reviews: Cardiology*, 9, 360–370.

Thayer, J. F., Yamamoto, S. S., and Brosschot, J. F. (2010). The relationship of autonomic imbalance, heart rate variability and cardiovascular disease risk factors. *International Journal of Cardiology*, 141(2), 122–131.