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Acute Effect of Novel Mind-Body Exercise on Heart Rate Variability in Older Adults

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ABSTRACT

Liu G, Premsri N, Tong-un T, Sespheng A, Teparak C, Nonsa-ard R, Aneknan P, Tunkamnerdthai O, **Leelayuwat N.** Acute Effect of Novel Mind-Body Exercise on Heart Rate Variability in Older Adults. **JEPonline** 2022;25(2):51-69. This study examined the acute effect of Khon Kaen University (KKU) Qigong exercise, novel mind-body exercise, on heart rate variability (HRV) in older adults. The subjects (66 ± 4.20 years of age) were randomly divided into two groups (n = 12 each): KKU Qigong Group (KQG); and Control Group (CG). Subjects in the CG read a book while sitting. The KKU subjects performed one 30-minute session of exercise/reading. HRV was determined before, during, and after the session of exercise/reading. KKU Qigong increased heart rate and respiratory rate that indicated a pattern of moderate physiological activation. Although the exercise did not change other HRV variables over the baseline, it had a lower parasympathetic activity and a higher stress than reading. This study indicates that moderate physiological activation of the KKU Qigong exercise increased HR without any effects on other HRV variables in older adults.

Key Words: Autonomic Nervous System, Cardiovascular Disease Risk Factors, Older Adults, Qigong, Stress

INTRODUCTION

The aging population is increasing worldwide and has been shown to have an impaired autonomic nervous system (ANS) function (10,32), which can result in a detrimental effect on cardiovascular function that is costly for the health systems (7). Thus, it is worth searching for a remedy to improve the function of the ANS and decrease cardiovascular risk factors. One of the remedies that is appropriate for older individuals is mind-body exercise (35) or meditative movement (21,28), such as Yoga and Qigong. Both represent a group of practices characterized by combining movement, patterns of breathing, and mental activity. A review article by Dong and Bergren (4) reported that Qigong may be an effective way of improving health outcomes in older adults. However, the psychophysiological mechanism underlying Qigong exercise via the examination of changes in the ANS function, and cardiovascular risk factors including stress in older adults remains unclear (3,8,30).

Heart rate variability (HRV) is used to determine the psychophysiological mechanism, which is the variation in time between consecutive heart beats (i.e., RR-intervals) (31). HRV provides quantitative information on autonomic control mechanisms. It is also shown to be associated with cardiovascular disease risk and cardiovascular mortality (9,20). Theoretically, it is attributed to the synergistic action of the two branches of the ANS, which are the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The HRV is reported as time and frequency domains. For time domain, an increase in the square root of the mean squared differences of successive NN intervals (RMSSD) determines parasympathetic activity. For frequency domain, an increase in low frequency (LF)/high frequency (HF) are generally considered to reflect a shift to sympathetic dominance; whereas, an increase in HF and a decrease in LF/HF generally correspond to parasympathetic dominance. It is now known that both the SNS and the PNS can be active simultaneously. The effect of the intervention on HRV depends on net result of both actions. Furthermore, HRV is also used to indicate cardiovascular risk factors such as stress resistance, fatigue index and electro-cardiac stability. Previous studies (2,22,23) have reported that HRV is increased, and cardiovascular risk factors are alleviated by meditative movement practices, such as Gigong (2,22,23), which is a combination of specific active movement patterns with mental techniques for reaching a meditative state of mind.

We created an alternative mode of Qigong exercise called Khon Kaen University (KKU) Qigong for the older adults. Its novelty is based on a new idea of a combination of two cultures, that is, Chinese (Baduanjin and Wu qin xi Qigong) and Thai (Wai Khru). We believe that this novel mind-body exercise may be attractive enough to motivate the older adults to perform the exercise. Regarding the literature, Xiao et al. (36) indicated that Baduanjin is one of the most common forms of Chinese Qigong. It is a dynamic Qigong that is an aerobic exercise combined with breathing and deep relaxation (37). Another style of Qigong exercise, Wu qin xi, is based on the theories of yin and yang, five kinds of animals (deer, monkey, bear, bird, and tiger). We chose three of them, i.e., bird, monkey, and tiger because of their beautiful and varied movements. The third style of exercise called Wai Khru is a ritual performed by participants before fighting in a traditional Thai martial art sport (Muay Thai) (14). Wai Khru can be a warm-up for Muay Thai competition, especially since it increases concentration that leads to mind readiness for the competition. Until now, no previous studies have shown HRV and cardiovascular risk factors including state of stress as responses to Baduanjin, Wu qin xi, or Wai Khru in sedentary older adults.

To our understanding, there is no research on both the acute and the long-term practice of KKU Qigong exercise on the mentioned variables of this study. However, before performing training of KKU Qigong exercise, a response to acute KKU Qigong exercise is necessary. No previous research has demonstrated the acute effect of KKU Qigong exercise on variables in older adults. Only a few previous studies (3,8) have explored physiological and psychological effects of one to two sessions of Qigong exercise in middle-age and older adults. Goldbeck and colleagues (8) examined the responses of two 20-minute sessions of Baduanjin Qigong on HRV and subjective state. The authors found Baduanjin Qigong increased HR with a decrease in parasympathetic modulation and an increase in subjective calmness; whereas, Chun-Yi et al. (3) reported an improvement in ANS balance and anxiety towards the end of an hour-Chinese Bioenergy Qigong.

The purpose of this study was to examine the acute effects of KKU Qigong on standard HRV parameters in the time and frequency domain. Reading a book as a relaxation condition was used as the Control Group (17). We hypothesized that in older adults, acute KKU Qigong exercise would show sympathetic dominance and reduced stress. Furthermore, the acute Qigong exercise would attenuate the cardiovascular disease risk factors.

METHODS

Participants

From June to December 2021, the participants were recruited from the areas of Khon Kaen province. Their age range was 60 to 75 years. The participants were physically sedentary healthy with no diabetes, cardiovascular diseases, psychiatric issues, and/or other diseases that might affect the exercise activity and not taking medications. They had no long-term (>2 years) experience with regular practice of meditation, yoga, and/or any type of Qigong before. The participants had no regular moderate-intensity exercises. Ethical approval was obtained from the Ethics Committee of the Khon Kaen University in accordance with The Declaration of Helsinki (HE641163). The participants received oral and written explanation, and they signed the consent form before participation in this study. The recruitment was done via advertising on the Khon Kaen University e-mail lists, Facebook.com, and by word-of-mouth in the Khon Kaen University and Khon Kaen area.

Research Design

This research is a randomized controlled, parallel group study. Randomization was simple and performed by computer-generated random allocation sequence using research randomizer (15). It was carried out by another researcher from Khon Kaen University who was not involved in the recruitment of subjects to ensure allocation concealment. The random assignment occurred after completion of baseline physical examination and questionnaires.

Protocols

The participants were screened by physical examination and health questionnaires. The questionnaire included health questions and Physical Activity Readiness Questions (PAR-Q) to assess readiness to exercise. Also, the participants' anthropometry, body composition, and baroreceptor reflex were measured. After passing the screening, they were randomly divided into two groups: (a) the KKU Qigong Group (KQG, n = 12); and (b) the Control Group (CG, n = 12).

Intervention Group

The participants in the Intervention Group visited the laboratory two times. During their first visit, the familiarization day, the participants arrived at the laboratory at 8:00 am and performed KKU Qigong exercise (Figure 1) for 30 minutes to familiarize them with the exercise. During the second visit, two days later, they arrived at the laboratory at 8:00 am to measure the cardiovascular risk markers at rest by SA3000P (Medicore, Korea) for 5 minutes before (baseline) and after the KKU Qigong exercise (recovery). To measure HRV, Polar heart rate chest belt and monitors (RS 800 CX, Polar Japan, Tokyo, Japan) were used to continuously collect HR data for 5 minutes at rest in the supine lying position before and after, and during the 30-minute KKU Qigong under the guidance of professional coach.

Figure 1. Postures of Khon Kaen University Qigong Exercise.

Descriptions of the KKU Qigong Exercise

The KKU Qigong exercise consists of 12 movements (Figure 1): (1) ready position: adjusting the breath; (2) pay homage and archer shooting; (3) the tiger paws; (4) tiger walks; (5) abdominal massage; (6) swinging the head and lowering; (7) bird exercise; (8) monkey picking the fruit; (9) thrusting the fists; (10) punch; (11) raising and lowering the heels with purse lip breathing; and (12) closing form with purse lip breathing. These movements were repeated two to three times very slowly with purse lip breathing. They consisted of stretching, twisting, and bending that involved the whole body.

Control Group

The participants in the Control Group arrived at the laboratory at 8:00 am. They performed the same as the Intervention Group except the exercise bout was replaced with 30 minutes of reading a Dhamma book in the sitting position.

Study Measures

Anthropometric and Body Composition Measurement

The participants' body height and weight were measured using a stadiometer (DETECTO, Missouri**,** USA). A tape measure was used to measure waist and hip circumferences. Body compositions were measured by a Dual-Energy X-Ray Absorptiometry (DXA) (Lunar Prodigy whole body scanner, GE Medical System, USA).

Heart Rate Variability (13)

Time Domain

The square root of the mean squared differences of successive NN intervals (RMSSD), of which the measures estimate high-frequency variations in heart rate in short term NN recordings that reflect an estimate of the parasympathetic regulation of the heart. RMSSD is measured in milliseconds.

Standard Deviation of the NN Intervals (SDNN)

The SDNN is mathematically equivalent to the total power of spectral analysis. Hence, it reflects all cyclic components of the variability in the recorded series of NN intervals. SDNN is measured in milliseconds.

Frequency Domain

Total Power (TP)

TP estimates the total power of the power spectral density in the range of frequencies between 0 and 0.4 Hz. This measure mainly reflects sympathetic activity. TP is calculated in milliseconds squared (ms^2) or log.

Low Frequency (LF)

The frequency band of LF is 0.04 - 0.15 Hz. Generally, it is a strong indicator of sympathetic activity. Parasympathetic influence is represented by LF when respiration rate is lower than 7 breaths·min^{-1} or during taking a deep breath. Thus, when the subject is in the state of relaxation with a slow and even breathing, the LF values can be very high which indicates an increase in parasympathetic activity rather than an increase in sympathetic regulation. The LF band is calculated in milliseconds squared (ms^2) or log.

High Frequency (HF)
The frequency band of HF is 0.15 to 0.4 Hz. This measure reflects parasympathetic (vagal) activity. It is also known as a 'respiratory' band because it corresponds to the NN variations caused by respiration. This phenomenon is known as respiratory sinus arrhythmia (RSA). Heart rate is increased during inhalation and is decreased during exhalation. The HF band is calculated in milliseconds squared (ms^2) or log.

LF/HF Ratio
A higher number of LF/HF ratio indicates an increase in sympathetic activity or a decrease in parasympathetic activity. Higher values reflect an increase in the sympathetic system, while lower values indicate an increase in the parasympathetic system.

Before the measurement, all participants were asked to avoid caffeine, smoking, and/or eating breakfast for at least 2 hours. They were provided time to adjust the new environment and resting state. The participants' HRV was measured in the morning during 7:30 and 10:30 am in a quiet, dark, and comfortable environment. Room temperature and humidity were kept constant at 25°C and 55%, respectively.

All participants did not talk, move, close the eyes, or fall asleep, and did not breathe intentionally slowly because respiration rates below 7 $breaths \cdot min^{-1}$ affect HRV. They were asked to coordinate their breathing with their bodily movements during the KKU Qigong. After the data collection, time and frequency domains were conducted using the Kubios HRV Version 2.1 software package (Biosignal Analysis and Medical Imaging Group, University of Eastern Finland, Finland).

Cardiovascular Disease Risk Factors
Cardiovascular disease risk factors including stress resistance, stress index, fatigue index, electro-cardiac stability, ectopic beat, differential pulse wave index (DPI), eccentric constriction (EC), and arterial elasticity (AE) were measured by SA3000P (Medicore, Korea). The SA-3000P Software (Medicore, Korea) was developed to meet the standards of measurement and physiological interpretation as well as bio-signal processing algorithms built by the task force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology (1996) (31).

Statistical Analyses

Statistical analysis was performed using the SPSS 10.0 (SPSS Inc., Chicago, IL, USA). Normality of the data sets was tested using a Kolmogorov-Smirnov Test. If the data had non-normal distribution the difference was tested by Man-Whitney U Test. If the data had normal distribution, the difference was tested by a one-way repeated measured ANOVA. Whenever the ANOVA indicated the existence of a significant difference (overall $P<0.05$), *post-hoc* pairwise comparisons were carried out using Bonferroni correction. A two-sided test was used in this study. Values of $P<0.05$ were considered statistically significant. All values are presented as mean ± standard deviation (SD).

We conducted this pilot study since we aimed to primarily identify the changes in HRV according to a single bout of KKU Qigong exercise with safety concerns. In this regards the sample size was suggested to be 12 per group to detect an event of this frequency in the active group with 80% power (34).

RESULTS

Figure 2 shows the flow of participants through the study. Of 27 participants, 24 participants (2 men and 22 women) aged 66 ± 4.20 years were recruited. Three participants were not recruited because two of them did not meet the inclusion criteria and the other one declined to participate. Then, 24 participants were randomly allocated into the 2 Groups (12 in each Group); CG and KQG and all of them were analysed for the results.

CONSORT
TRANSPARENT REPORTING of TRIALS

CONSORT 2010 Flow Diagram

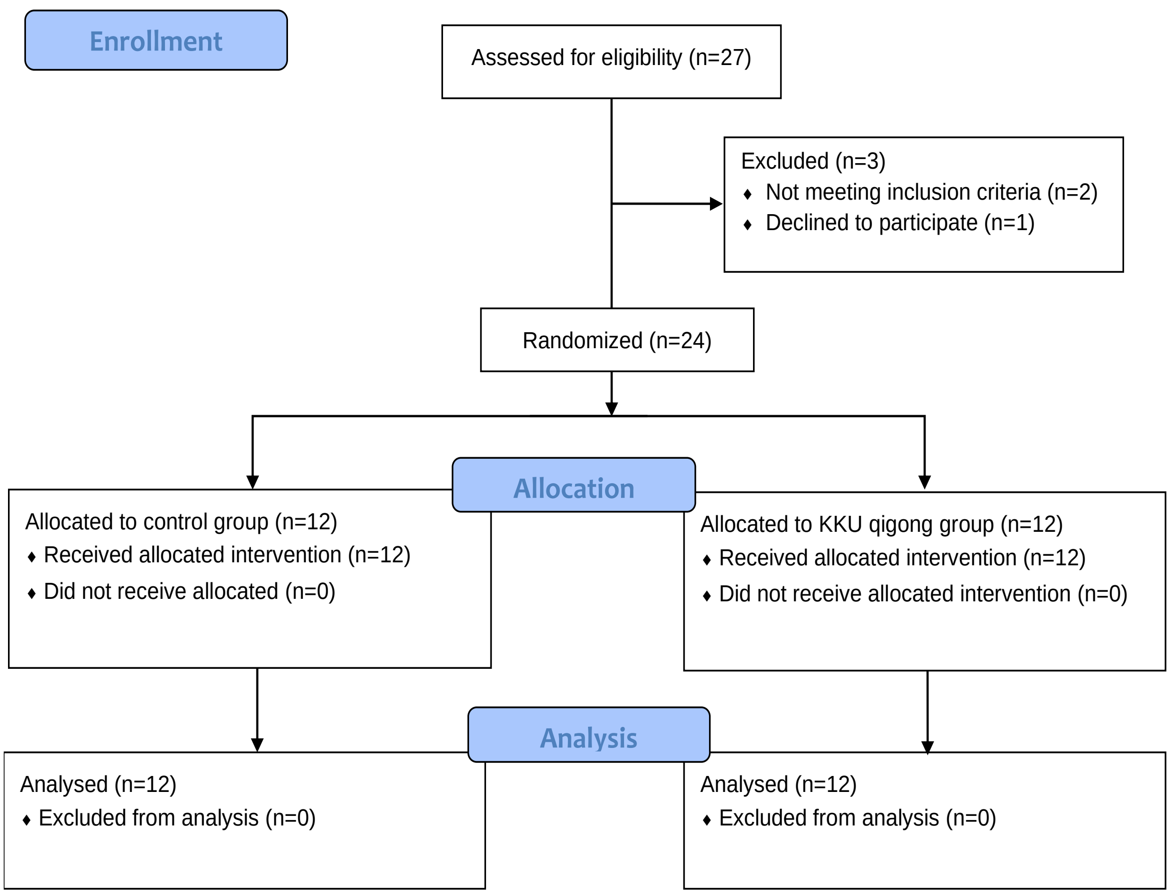

Figure 2. Flow Diagram of this Study.

Characteristics of the Participants

Both groups had similar baseline characteristics except body height that was significantly higher in the KQG than the CG (P<0.05) (Table 1). All participants were non-obese, physically healthy, with no acute or chronic disease that might affect the exercise activity. They had no regular moderate-intensity exercise. There were no significant differences in HR and BP between the Groups (Table 2).

Table 1. Anthropometry and Body Composition of the Participants.

Variable	Total (n = 24)	CG (n = 12)	KQG (n = 12)
Gender: n (%)			
Female	22(92)	10(83)	12(100)
Male	2(8)	2(17)	0(0)
Age (yrs)	66 ± 4.20	65 ± 2.99	68 ± 4.84
Weight (kg)	58.8 ± 8.88	58.6 ± 10.45	59.0 ± 7.45
Height (cm)	153.4 ± 6.34	156.4 ± 6.71	150.5 ± 4.51
Body Mass Index ($kg \cdot m^{-2}$)	25.0 ± 3.52	24.0 ± 4.02	26.0 ± 2 .75
Waist Circumference (cm)	85.5 ± 12.7	84.5 ± 15.62	86.4 ± 9.59
Hip Circumference (cm)	99.2 ± 6.97	98.7 ± 8.04	99.7 ± 6.02
Waist/hip Circumference	0.88 ± 0.06	0.89 ± 10.54	0.86 ± 0.07
Body Fat (%)	33.3 ± 6.57	31.4 ± 6.27	35.2 ± 6.55
Fat Mass (kg)	20.2 ± 5.52	18.9 ± 5.83	21.6 ± 5.06
Lean Body Mass (kg)	58.3 ± 9.53	57.5 ± 11.0	59.1 ± 8.24

Data are expressed as mean ± SD. Abbreviations: **CG** = Control Group; **KQG** = Khon Kaen University Qigong Group

Table 2. Hemodynamic Data of the Participants.

Variable	Total (n = 24)	CG (n = 12)	KQG (n = 12)
Heart Rate (beats·min^{-1})	68 ± 9.00	70 ± 10.54	66 ± 8.98
Systolic Blood Pressure (mmHg)	137 ± 17.46	133 ± 20.90	140 ± 12.97
Diastolic Blood Pressure (mmHg)	97 ± 9.17	78 ± 9.95	82 ± 8.40

Data are expressed as mean ± SD. Abbreviations: **CG** = Control Group; **KQG** = Khon Kaen University Qigong Group

Effects of Intervention on Outcome Measures

Respiratory Rate (RR)

Post-hoc tests revealed that RR was significantly higher during the KKU Qigong exercise than during reading (Figure 3). In the exercise Group, RR was significantly increased during exercise and decreased at recovery, but it did not return to baseline (All were P<0.01). In Control Group, RR was not changed throughout the experiment. There were no significant differences between the Groups in RR at baseline and recovery.

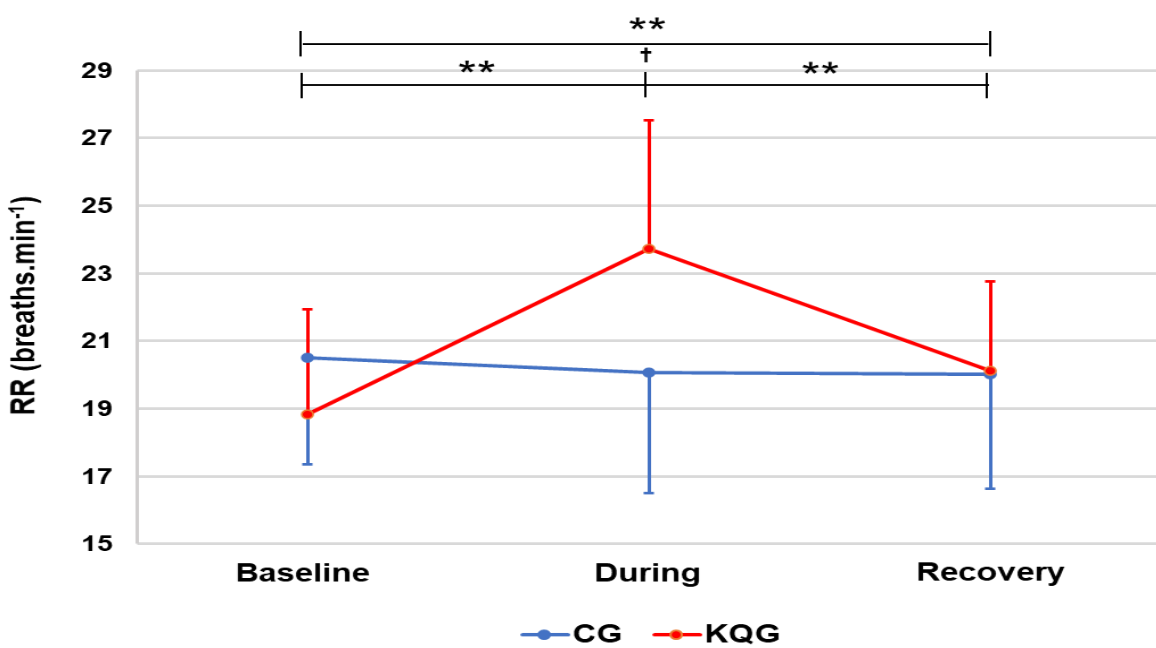

Figure 3. Respiratory Rate (RR) (breaths·min^{-1}) before (Baseline), during, and after (Recovery) Exercise (red line)/reading (blue line). Data are expressed as mean ± SD (n = 24; 12 in each Group). **Significantly different within Group (P<0.01), †Significantly different between Groups at the same time point (P<0.05). Abbreviations: **CG** = Control Group; **KQG** = Khon Kaen University Qigong Group

HRV
Time Domain
The *post-hoc* tests revealed that HR was significantly higher (P<0.01) during the KKU Qigong exercise than during reading (Figure 4). Specifically, in the Intervention Group, HR was significantly increased during exercise but returned to baseline during the recovery (both were P<0.01). Both RMSSD (P<0.05) and SDNN (P<0.01) were increased after reading with the former was tended to be lower (P<0.07) and the latter was significantly lower (P<0.01) after exercise than during reading. There were no significant differences between the Groups in RMSSD and SDNN at baseline and recovery (Table 3). There were no changes in RMSSD and SDNN in the exercise Group.

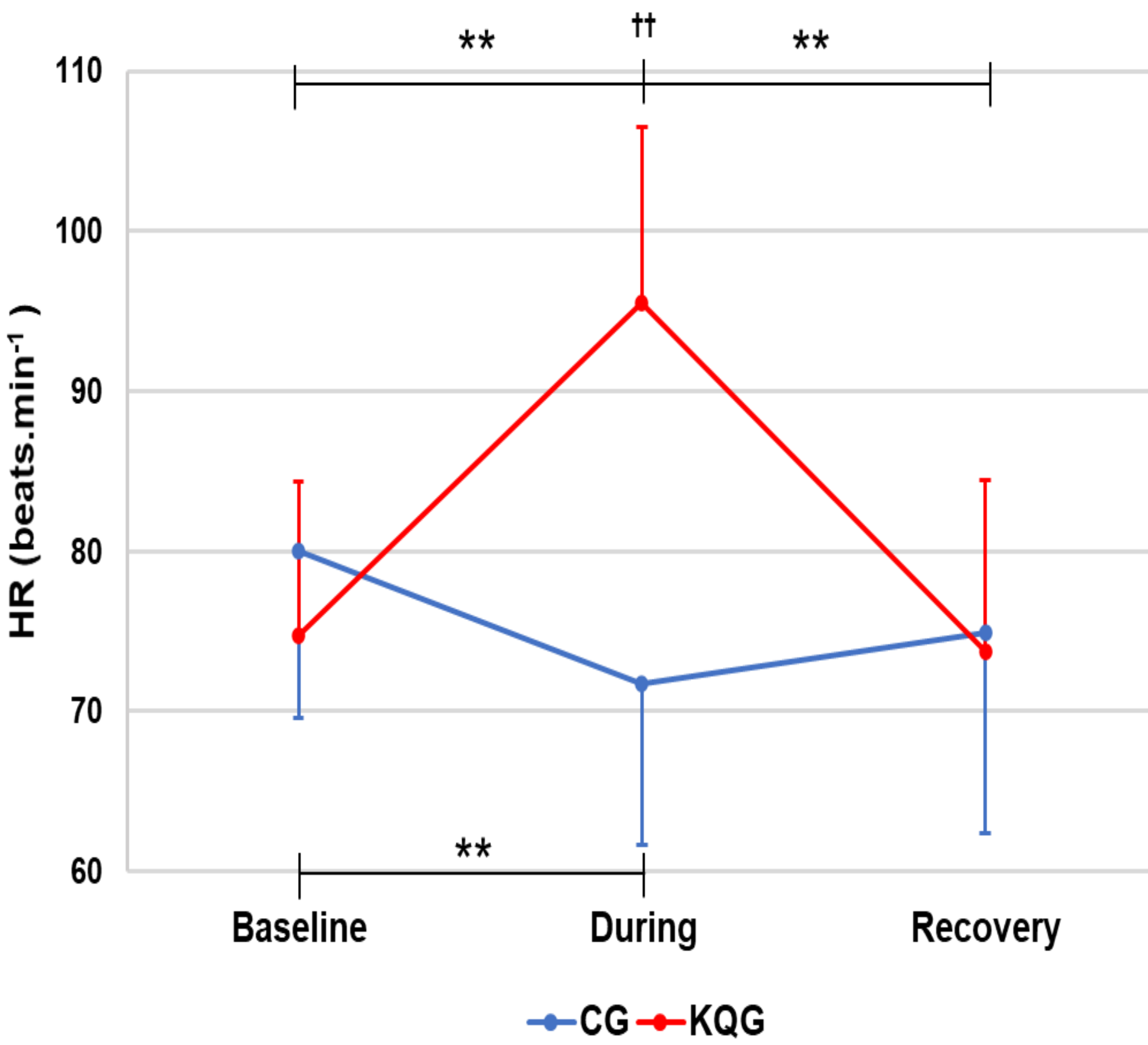

Figure 4. Heart Rate (HR) (beats·min^{-1}) before (baseline), during, and after (Recovery) Exercise (red line)/Reading (blue line). Data are expressed as mean ± SD (n = 24; 12 in each Group). **Significantly different within Group (P<0.01), ††Significantly different between Groups at the same time point (P<0.01), Abbreviations: **CG** = Control Group; **KQG** = Khon Kaen University Qigong Group

Table 3. Time Domain of HRV of Participants.

Variable	CG (n = 12)	QKG (n = 12)
RMSSD (ms)		
Before	19.5 ± 8.57	24.1 ± 12.9
After	26.6 ± 10.8*	22.4 ± 7.79
SDNN (ms)		
Before	21.4 ± 9.07	27.8 ± 10.8
After	27.5 ± 9.72**	23.9 ± 6.73††

Data are expressed as mean ± SD. *Significantly different within Group (P<0.05), **Significantly different within Group (P<0.01), ††Significantly different between Groups at the same time point (P<0.01). Abbreviations: **CG** = Control Group; **KQG** = Khon Kaen University Qigong Group; **HRV** = heart rate variable; **RMSSD** = Square Root of the Mean Squared Differences of Successive NN Intervals; **SDNN** = Standard Deviation of the NN Intervals

Frequency Domain

The *post-hoc* tests revealed that TP (Figure 5A) was increased during reading and the recovery over baseline (both were P<0.05). Moreover, HF was increased during reading and then decreased during recovery (both were P<0.01), but did not return to baseline (P<0.05) (Figure 5B), and LF was increased during reading and the recovery over baseline (both were P<0.01) (Figure 5C). In contrast to the others, the LF/HF ratio during exercise was higher than during reading (P<0.05) with a trend to be higher over baseline (P=0.058) (Figure 5D). There were no differences in all the frequency domains between Groups at baseline and recovery.

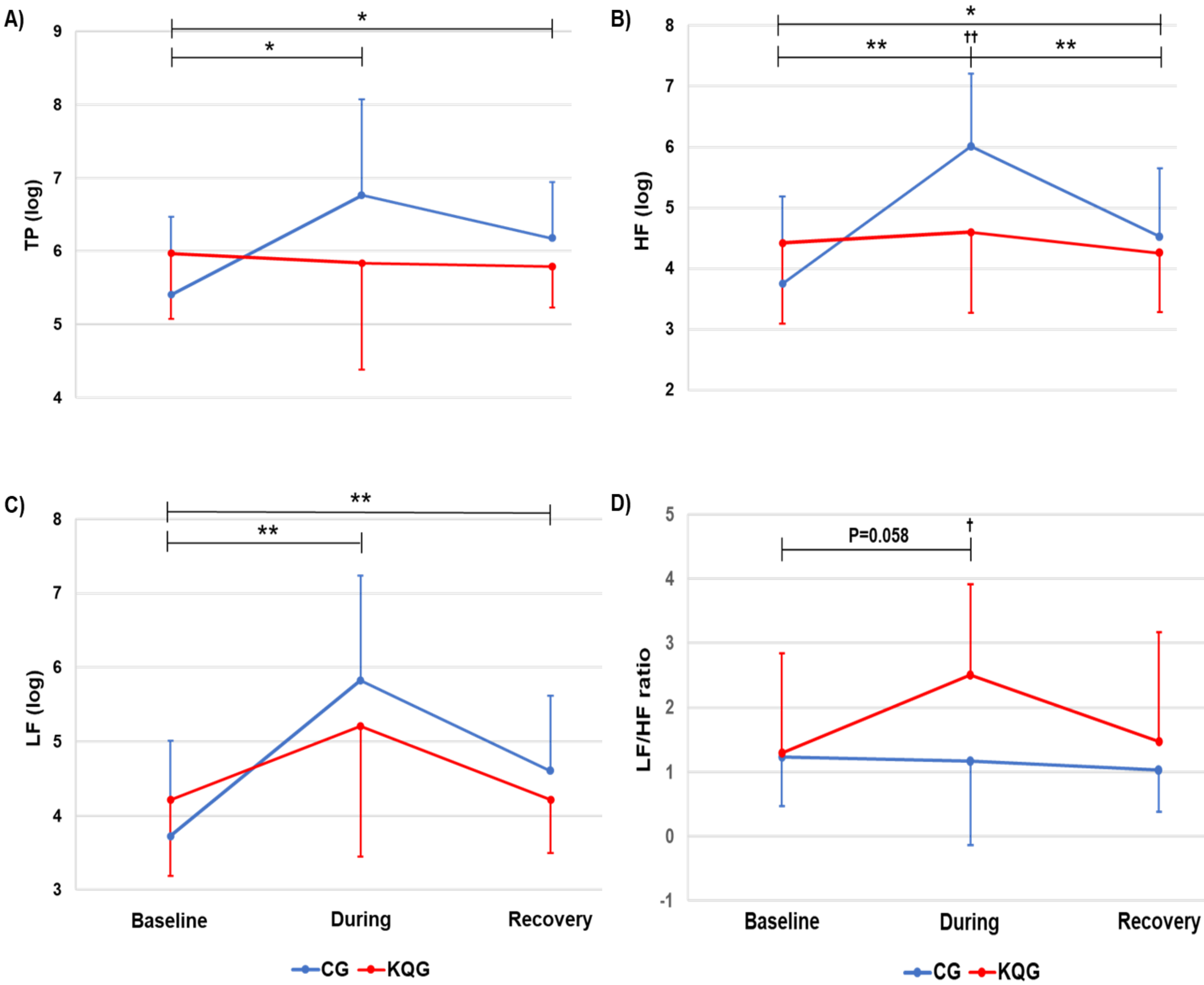

Figure 5. Total Power (TP) (log) (A), High Frequency (HF) (log) (B), Low Frequency (LF) (log) (C), and LF/HF Ratio (D) before (Baseline), during, and after (Recovery) Exercise (Red Line)/Reading (Blue Line). The data are expressed as mean ± SD (n = 24; 12 in each Group). *Significantly different within Group (P<0.05), **Significantly different within Group (P<0.01), †Significantly different between Groups at the same time point (P<0.05), ††Significantly different between Groups at the same time point (P<0.01), Abbreviation: **CG** = Control Group; **KQG** = Khon Kaen University Qigong Group

Cardiovascular Disease Risk Factors

All cardiovascular disease risk factors were not different between the Groups at baseline. Stress resistance was lower (P<0.01), while stress index (P<0.01) and fatigue index (P<0.05) were higher after the KKU Gigong exercise than during reading (Table 4). Moreover, after reading, stress resistance was higher and stress index and fatigue index were lower than before reading (all were P<0.01) (Table 4); whereas, there were no changes in stress resistance, stress index, and fatigue index after exercise.

Electro-cardiac stability and ANS activity (Both were P<0.01) were significantly increased only after reading (Table 4). There were no significant changes within and between Groups after both interventions in other cardiovascular disease risk factors including DPI, EC, and AE (Table 4).

Table 4. Cardiovascular Disease Risk Factors of the Participants.

Variable	CG (n = 12)	KQG (n = 12)
Stress Resistance		
Before	84.8 ± 16.0	92.5 ± 14.3
After	92.9 ± 14.3**	88.9 ± 11.4††
Stress Index		
Before	109.2 ± 21.1	99.5 ± 11.7
After	96.5 ± 13.8**	101.0 ± 9.85††
Fatigue Index		
Before	115.94 ± 19.8	108.4 ± 19.5
After	101.1 ± 19.0**	110.5 ± 11.04†
ANS Activity		
Before	83.5 ± 14.8	90.4 ± 16.4
After	95.1 ± 14.1**	86.5 ± 9.01††
ANS Balance Status		
Before	53.5 ± 29.2	45.3 ± 43.9
After	54.8 ± 43.4	59.2 ± 35.3
Electro-Cardiac Stability		
Before	87.2 ± 20.4	99.7 ± 26.7
After	103.4 ± 22.6**	94.2 ± 18.6
Ectopic Beat		
Before	1.42 ± 2.54	0.33 ± 0.49
After	2.58 ± 4.27	1.08 ± 2.84
DPI		
Before	-44.0 ± 28.5	-22.6 ± 32.2
After	-28.2 ± 50.0	-21.6 ± 33.6
EC		
Before	-78.0 ± 5.62	-66.5 ± 15.6
After	-70.4 ± 17.8	-66.2 ± 15.3
AE		
Before	-21.8 ± 14.4	-19.4 ± 8.56
After	-15.4 ± 20.3	-17.7 ± 13.4

Data are expressed as mean ± SD. *Significantly different within Group (P<0.05), †Significantly different between Groups at the same time point (P<0.05), ††Significantly different between Groups at the same time point (P<0.01). Abbreviations: **DPI** = Differential Pulse Wave Index; **EC** = Eccentric Constriction; **AE** = Arterial Elasticity

DISCUSSION

To our knowledge, this is the first study that provides evidence for the effects of acute KKU Gigong exercise on standard HRV parameters in the time and frequency domain. The KKU Gigong exercise resulted in sympathetic dominance, which was evident by the increase in HR and RR, and a trend to increase the LF/HF ratio without any effect on the cardiovascular disease risk factors. Whereas reading was a relaxation condition with parasympathetic dominance and a decrease in many cardiovascular diseases risk factors that include stress resistance, stress index, fatigue index, ANS activity, and electro-cardiac stability.

Regarding the importance of the physical and environment factors during the HRV measurements, we controlled them throughout the measurement. Before the measurement, we asked all the participants to avoid caffeine and smoking at least 2 hours. They were also asked to avoid breakfast, and we provided time for the participants to adjust to the new environment and resting state. All measurements were performed in the morning during 7:30 to 10:30 am in a quiet, dark, and comfortable environment. Room temperature and humidity were kept constant at 25°C and 55%, respectively. All participants did not talk, move, or fall asleep, and did not breathe intentionally slowly because RR below 7 breaths·min^{-1} affects HRV (13). In this study, the mean RR of all participants throughout the experiment was greater than 20 breaths·min^{-1}. Therefore, the HRV data are considered valid.

In addition, in order to control the quality of time domain interpretation, having known that the longer recording is, the higher the values (13). We were aware of this fact, therefore, we compared time domain only for 5 minutes before (baseline) and after the exercise/reading (recovery). This allowed for providing a valid interpretation of the time domain. Furthermore, like nominal 24-hour long-term, the 5-minute recordings are appropriate options for both time and frequency domains (31). Only HR, one of time domain, was presented throughout the experiment though different time duration (5-minute baseline, 5-minute recovery, and 30-minute exercise/reading) because HR was presented as rate of heart beats (beats·min^{-1}). All HR data, therefore, can be compared though they were recorded during different time duration (resting and exercise).

One of our hypotheses was that in older adults, acute KKU Qigong exercise would show sympathetic dominance and reduced stress. Our results of an increase in HR and RR and the tendency for an increase in LF/HF ratio partly support the hypothesis because they confirmed that exercise contributed to sympathetic dominance without any change in stress. Our participants' mean HR during the exercise was 63% of maximal HR, which indicates that the KKU Qigong exercise produced moderate effort (i.e., 55 to 69% maximal HR for their age) (12,18). The results are consistent with a previous study, which showed that Baduanjin Qigong exercise was a moderate intensity effort (1). Apart from increasing HR, we found more results supporting our hypothesis that the KKU Qigong exercise increases RR and sympathetic dominance with a trend to increase the LF/HF ratio (P=0.058). This is reasonable since medullary sympathetic premotor neurons (stimulating HR) received efferent signals from medullary respiratory neurons that stimulate RR (5). Furthermore, we did not observe a withdrawal of parasympathetic activity such as HF, and RMSSD which should be shown at this intensity (16). The lack of parasympathetic withdrawal is possible since our participants' HR was lower than 100 beats·min^{-1}. A HR response that is higher than 100 beats·min^{-1} can be achieved only by parasympathetic withdrawal (38).

The lack of any significant changes from baseline in all HRV parameters except HR according to the KKU Qigong exercise may be due to an explanation that HRV is regulated by many factors (26,33), such as the metabolic system (e.g., glucose, insulin, and lipid in circulation), endocrinological system, hypothalamic-pituitary-adrenal axis, immunological system, and other brain regions including the association areas of the amygdala, the limbic cortex, and the prefrontal cortex (5). However, the influence of these systems is not yet clear, therefore, the exploration of these systems on the response of HRV to KKU Qigong exercise are needed. Moreover, age is also a factor affecting the HRV change. Recently, Goldbeck et al. (8) found that older participants had less pronounced changes in HRV parameters. Thus, this may be a reason for the lack of changes in HRV variables in our study, which had older adults as participants.

In addition, the increase in parasympathetic parameters such as TP, RMSSD, SDNN, HF, ANS balance activity, stress resistance, and the decrease in stress index and fatigue index confirm the relaxation status of reading. This is supported by a previous review showing that reading can decrease stress (19). In particular, the Dhamma book reading in this study seems to be similar to Heavenly books (24) or mindfulness meditation that is known to reduce physiological stress by inducing relaxation (1). In fact, mindfulness meditation has been shown to induce physiological relaxation through reductions in cardiac and respiratory rate (27). This is consistent with the decrease in HR after reading in the present study. Furthermore, given that mindfulness meditation is related to a decrease in amygdala activation, it is recognized as the emotional center of the brain (27). Therefore, the decrease in amygdala activation attenuated HR leading to relaxation. The relaxation may have led to the decrease in two of the cardiovascular risk factors, i.e., ANS activity and electro-cardiac stability after reading. However, acute KKU Qigong exercise did not affect any cardiovascular risk markers including stress. These results did not support our hypothesis on cardiovascular risk markers in response to the KKU Qigong exercise. This may be attributed to either inadequate exercise duration or the number of participants. A longer period of the acute interventions, a long-term training of the KKU Qigong exercise, or a larger sample size may disclose the beneficial effect on the cardiovascular risk markers in older adults.

The HRV variables of this study are consistent with the data by a recent literature review in old and young populations (10). Participants in this study were old and had SDNN between 11.2 and 37 milliseconds, which theoretically categorized them as very low-mid normal. This means their ANS's regulating function and coping ability ranges from a high risk of having chronic stress induced disease related to ANS dysfunction to normal.

Limitations in this Study

This study has a few limitations. First, since this is a pilot study that was designed to examine the tendency of acute effects of the KKU Qigong exercise on specific HRV variables and cardiovascular disease risk factors, we did not assess cardiac coherence to confirm the quality of the mind-body exercise of KKU Qigong regarding the adjustment of mind, body, and breath (8). Second, since most of the participants were women (2 men, 22 women), it is reasonable to conclude that findings may not apply for men. Therefore, further studies are necessary to disclose the acute effects with a larger sample size in female and male participants, and also the training effects on HRV variables are encouraged. Furthermore, additional research on the cardiac coherence during the KKU Qigong exercise should be performed. It should be mentioned that a strength of this study was the randomization design that decreased a bias of dividing the participation into the research group. Moreover, using the physiological method (i.e., HRV) to measure mental stress is appropriate because it is a quantitative result that has high reliability. Also, although the subjective method that is a qualitative method, it is appropriate on the phenomenology of the mental state achieved in further Qigong training (29).

CONCLUSIONS

This novel evidence showed that in older adults, a single bout of a 30-minute KKU Qigong exercise had moderate physiological activation that indicated sympathetic dominance but did not influence any cardiovascular disease risk factors including stress. A larger sample size should be performed to confirm this finding. Further research on the training effect of the KKU Qigong exercise on these parameters may provide additional information for older adults.

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