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Effects of Qigong combined with Muay Thai on cardiorespiratory responses and exercise intensity in sedentary older participants

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ABSTRACT

Khon Kaen Qigong (KKQ) is a new type of exercise that combines Qigong (Baduanjin and Wuqinxi) with Muay Thai. No studies have demonstrated its effects on exercise intensity and cardiorespiratory responses. We aimed to investigate the intensity of the exercise using the cardiorespiratory responses in sedentary older adults. This was a randomized, controlled, pre-and post-test parallel-group study. The participants were randomly assigned to one of the two groups (n=30 each): the exercise or the control group. There were three phases (30 min each) for each activity, including before (baseline), during, and after (recovery) reading a book in the control group or performing KKQ in the exercise group. Heart rate and blood pressure were measured before, immediately after, and 30-min after the activities. Expired gas was collected to measure the respiratory responses and ventilatory efficiency throughout the experiment. Compared with reading, KKQ increased heart rate (p-value < 0.05) and respiratory responses and decreased ventilatory efficiency (All were p-value < 0.01). Markers indicating exercise intensity indicated very low-intensity exercises. This study suggests that a single bout of KKQ can be classified as a very light-intensity exercise according to very low increased cardiorespiratory responses in sedentary older participants. It also decreases ventilatory efficiency, which is related to cardiovascular risk factors. Further studies on KKQ training may confirm its impact on cardiovascular disease interventions.

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Introduction

The world's population is aging; the number of older people aged ≥60 years will soon exceed the younger population, and the proportion of older people will reach 21% by 2050[1]. Aging leads to an increased incidence of cardiorespiratory disease, as well as increases in morbidity and mortality[2,3]. Therefore, exploring interventions to prevent these diseases is crucial to promote the health of older adults. Exercise-based rehabilitation programs prevent comorbidities and decrease mortality[4,5].

We invented a novel exercise called Khon Kaen Qigong (KKQ) for sedentary older adults. This could be an interesting choice for them because it is modified from two popular cultural exercises: traditional Qigong (Baduanjin and Wuqinxi) and Muay Thai (Wai Khru session)[6]. Both Qigong types are the most widely practiced types of traditional Chinese Qigong, which are mind-body exercises, whereas Wai Khru is a pre-session of Muay Thai, the most popular martial sport in Thailand[7-9].

Both Qigong and Wai Khru provide meditation and gentle and smooth movements, which are appropriate for the older population[7-10]. Taken together, the popularity and modified beautiful movements of the KKQ may motivate older people to adhere to KKQ practice. Our previous study demonstrated that acute KKQ in sedentary older adults led to sympathetic dominance, as evidenced by increasing heart rate (HR) and respiratory rate (RR)[6]. However, this previous study was a pilot trial requiring further investigation with more participants and cardiorespiratory variables to explore more knowledge of acute KKQ before exploring the training effect.

Exercise intensity is an important component of exercise prescriptions. This is indicated by cardiorespiratory responses. Literature reporting the responses to each component of KKQ documented that only one study was done investigating Baduanjin in older participants and found an acute increase in oxygen consumption (VO_2) and a moderately increased HR[11]. However, the participants were patients with chronic heart failure and cardiac dysfunction, and their hearts worked harder than those of healthy people as shown in the report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines[12]. Thus, healthy older adults without heart disease may yield different results. Data on the effect of the KKQ and its components on exercise intensity as indicated by cardiorespiratory variables in healthy, sedentary older people are not yet available.

Therefore, this study aimed to determine the intensity of the KKQ and its single-session effects on cardiorespiratory variables in sedentary older adults. For the response to a single bout of KKQ, we chose reading a book as the control activity because a 30-min reading was reported to have no stimulation on the cardiopulmonary responses[6]. Thus, compared to reading, the effect of a single bout of KKQ on the cardiopulmonary responses should be clearly observed. We hypothesized that a single bout of KKQ is a low-intensity exercise, as indicated by the low response of the cardiorespiratory system in sedentary older participants.

Materials and methods

Participants

This study was conducted from June 2021 to February 2022 in the Khon Kaen Province, Thailand. Participants aged 60–75 years were recruited. Participants received verbal and written explanations before signing the consent form. They were screened through body composition, anthropometry, physical examinations, electrocardiography, blood chemistry, baroreceptor reflex, and questionnaires for health status and readiness to exercise (using the Physical Activity Readiness Questionnaire, PAR-Q). Participants who had no kidney, liver, or cardiac disease, obesity, and exercise limitation were recruited. Moreover, those who had no regular (longer than 1 hour/week) long-term (>2 years) experience with meditation, Qigong, or other types of exercise were included. However, participants with these diseases or chronic infection were excluded. Ethical approval was obtained from the Ethics Committee of Khon Kaen University (HE641163).

Sample size calculation was calculated by G*Power 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) based on a previous study[11] of the therapeutic effect of Qigong on the VO_2 with effect size of 0.53, a power of 80%, and an alpha of 5%. The sample size in each group was 30 (including a dropout rate of 20%).

Research design, randomized allocation, and blinding

This was a randomized, controlled, pre- and post-test, study. To maintain and guarantee blinding, the outcome adjudicators and data analysts were blinded by using participants' code. However, participants and the researcher who collected gas sample were not blinded because both knew the intervention. Nonetheless, participants were blinded to group allocation. The randomized allocation sequence (1:1) was performed using computer-generated random numbers and kept in sequentially numbered, opaque, sealed envelopes. However, a researcher who gave an envelope to the participant for group allocation is not the one who prepared the envelope.

Protocols

Participants who passed the screening were randomly allocated to one of the two groups (n=30 each): the KKQ group (KKG) and the control group (CG).

The KKG visited the laboratory three times at 8:00 am after an overnight fast. During the first visit, they performed the KKQ (Supplementary Figure S1)[6] for 30 min to familiarize themselves with the exercise. Two days later, they visited the laboratory to collect the expired gases during three phases (30 min each), including resting in a supine position before (baseline), during and after KKQ (recovery in supine position), to measure RR, ventilation rate (V_E), VO_2, and carbon dioxide production rate (VCO_2). HR, BP, rating of perceived exertion (RPE), and dyspnea (RPD) were recorded immediately before and at the end of the KKQ and recovery. The room temperature and humidity were recorded throughout the experiment. Two days later, they again came to the laboratory to measure peak VO_2 ($VO_{2,peak}$) by 6-min walk test (6MWT)[13].

The CG participated during a single visit. They performed the same experimental procedure as during the second visit to the KKG, except that the KKQ was replaced by reading a Dhamma book while sitting. The Dhamma book was the same for all participants in this group.

Participants' measurements of all anthropometry, body composition, and cardiovascular outcomes were assessed as described in a previous study[14]. Furthermore, all respiratory outcomes were collected and analyzed with a gas analyzer (Oxycon CareFusion 234 GmbH, Höchberg, Germany). Then percentage of maximal HR (%HRmax) and $VO_{2,peak}$ (%$VO_{2,peak}$), RPE[15], and RPD[16] were used to indicate exercise intensity. In addition, V_E, VO_2, and VCO_2 were used to calculate ventilatory efficiency[17].

Statistical analysis

All statistical analyses were performed using SPSS version 26.0 (IBM, Armonk, NY, USA). The Kolmogorov-Smirnov test was used to test the normality of the data. The independent t-test was used to compare continuous variables of characteristics with a normal distribution between groups. Repeated-measures ANOVA was used to compare continuous variables with a normal distribution within and between groups. The Bonferroni test was used as a post hoc test. The Mann-Whitney U test was used for ordinal data or unpaired samples that were not normally distributed. A *p*-value of < 0.05 was considered statistically significant. Results were expressed as mean ± standard deviation (SD) or stated elsewhere.

Results

Of the 90 eligible participants, 66 were included in this study (Supplementary Figure S2). The remaining participants were unable to participate because they did not meet the inclusion criteria (n=10), declined to participate (n=10), or for other reasons (n=4). They were then randomly allocated to one of the two groups: the KKG or the CG (n= 33 each). Thirty participants (28 females and two males in each group) completed the experiment. In the KKG, two female participants left the study for family reasons, and one male participant dropped out due to physical discomfort. In the CG, three female participants dropped out of the study for physical reasons. The room temperature and humidity were 24.9±0.9°C and 59.4±4.7%. There were no significant differences in all characteristics and cardiorespiratory outcomes between groups at baseline (Table 1, Figure 1-3).

Table 1 Baseline demography, anthropometry, body composition, hemodynamics, and blood chemistry of participants in both groups

	CG (n=30)	KKG (n=30)
Age (yr)[a]	68±4.6	70±6.04
Sex (male/female)	2/28	2/28
BM (kg)[a]	57.2±9.47	58.8±8.82
BMI (kg/m^2)[a]	24.6±3.54	25.5±3.05
W (cm)[a]	85.5±12.15	87.7±8.65
H (cm)[a]	98.3±7.35	99.3±6.47
W/H[a]	0.89±0.06	0.87±0.06
BF (%)[a]	33.6±4.98	35.2±4.05
FM (kg)[a]	19.1±5.8	21.1±4.3
LBM (kg)[a]	35.9±8.8	36.9±6.2
HR (/min)[a]	74.6±11.3	70.9±8.3
SBP (mmHg)[a]	132.5±15.8	125.9±14.4
DBP (mmHg)[a]	79.4±11.7	72.1±8.9
MAP (mmHg)[a]	98.1±13.9	87.1±12.8
FBG (mg/dL)[a]	112.6±37.2	104.1±31.4
TC (mg/dL)[a]	212.2±35.2	227.9±47.2
TG (mg/dL)[a]	151.6±78.0	148.6±91.4
HDL-c (mg/dL)[a]	51.3±17.4	50.4±14.0
LDL-c (mg/dL)[a]	136.1±34.6	151.5±43.7
Cr (mg/dL)[a]	0.84±0.18	0.83±0.12
SGPT (U/L)[a]	19.3±18.6	15.2±5.79

Note: The data are presented by mean ± SD. [a]The independent t-test was used to compare continuous variables with normal distribution between groups.

Abbreviation: BM, body mass; BMI, body mass index; W, waist circumference; H, hip circumference; BF, body fat; FM, fat mass; LBM, lean body mass; FBG, fasting blood glucose; TC, total cholesterol; TG, triacylglycerol; HDL-c, high-density lipoprotein cholesterol; LDL-c, low-density lipoprotein cholesterol; Cr, creatinine; SGPT, serum glutamate pyruvate transaminase.

Cardiovascular outcomes

HR

Compared with baseline, HR significantly increased immediately after KKQ and reading and recovery, with a greater value immediately after KKQ compared with reading (All were *p*-value < 0.05) (Figure 1A).

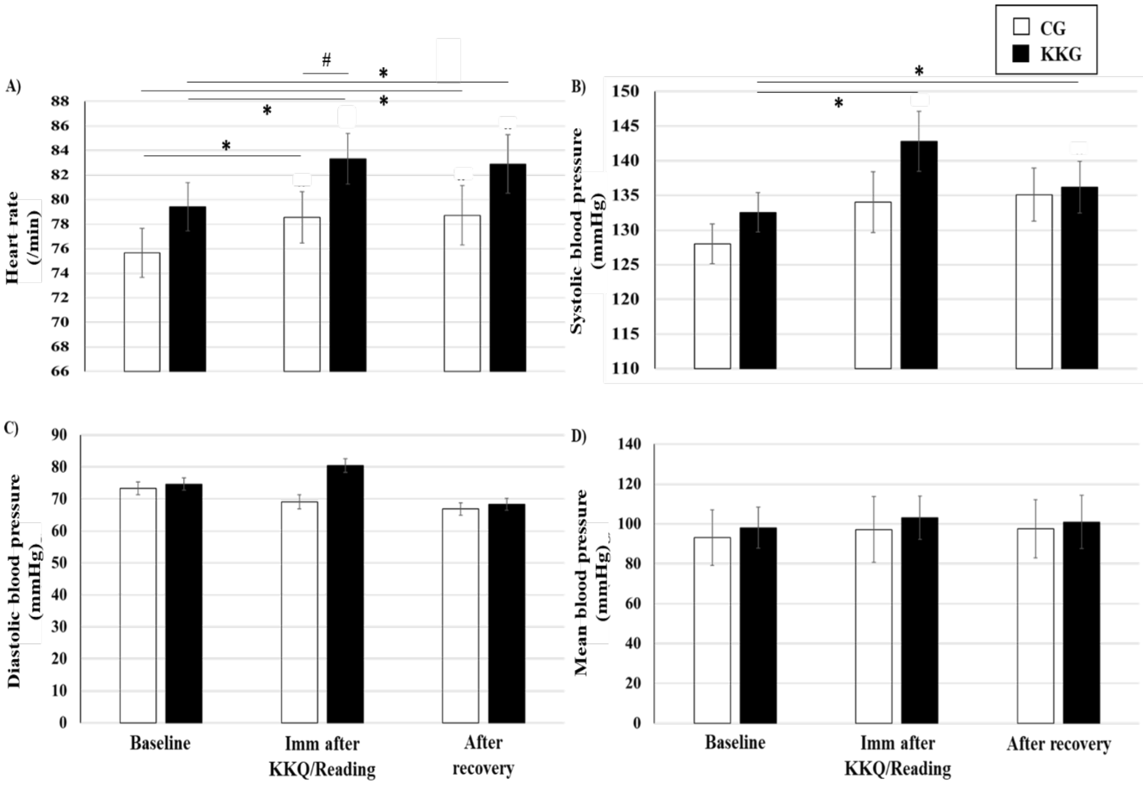

Figure 1 (A) Heart rate (/min), (B) Systolic blood pressure (mmHg), (C) Diastolic blood pressure (mmHg), and (D) Mean arterial pressure (mmHg) at baseline, immediately after KKQ/Reading, and at the end of recovery.

Note: Data are presented as mean±SE (n=30 each group). * within the group (*p*-value < 0.05); # between groups (*p*-value < 0.05).

Abbreviation: CG, control group; KKG, Khon Kaen Qigong group.

BP

Compared to baseline, SBP significantly increased immediately after KKQ and recovery (Both were *p*-value < 0.05) in the KKG (Figure 1B), but no changes were found in the CG. No significant differences in SBP were observed between the groups. Furthermore, no significant differences in DBP and MAP were found within or between the groups (Figure 1C and 1D).

Respiratory outcomes

RR

Compared with the baseline, the RR was significantly increased from 10 to 30 min during KKQ, with greater values in the KKG than in the CG for 20-30 min (All were *p*-value < 0.01) (Figure 2A). Furthermore, the RR was greater than baseline at 5- and 15-min during recovery from KKQ. The RR decreased during the KKQ throughout recovery and returned to baseline during the last 10 min (All were *p*-value < 0.01). However, there were no significant changes in RR throughout the experiment in the CG.

V_E

Compared with baseline and CG, V_E were significantly greater throughout the KKQ (5-30 min) (All were *p*-value < 0.01) (Figure 2B). Then, the KKG had decreased V_E from during KKQ throughout recovery and returned to baseline during the last 10 min of recovery (All were *p*-value < 0.01). V_E was significantly greater during KKQ than reading at 5-10 min (*p*-value < 0.05) of recovery. V_E did not change throughout the entire experiment in the CG.

VO_2

Compared with baseline and the CG, VO_2 was significantly greater throughout the KKQ (5-30 min) until 5 min into recovery (All were *p*-value < 0.01) (Figure 2C). The KKG had a lower VO_2 during recovery than during KKQ (*p*-value < 0.01) and returned to baseline during the last 25 min of recovery. VO_2 did not change throughout the entire experiment in the CG.

VCO_2

Changes of VCO_2 were the same as those of VO_2, except the KKG had a greater VCO_2 than baseline 15 min into recovery (All were *p*-value < 0.05). VCO_2 did not change throughout the entire experiment in the CG (Figure 2D).

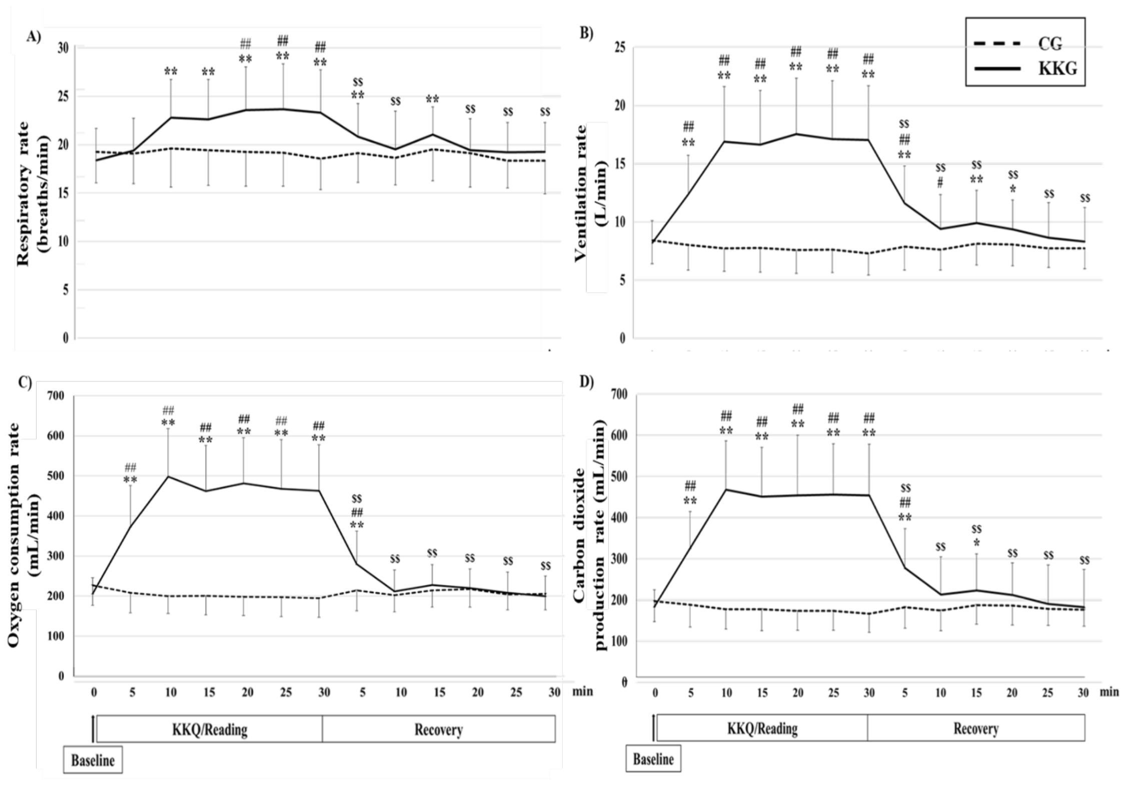

Figure 2 (A) Respiratory rate (breaths/min), (B) ventilation rate (L/min), (C) Oxygen consumption rate (mL/min), (D) Carbon dioxide production rate (mL/min) at baseline, during KKQ/Reading, and recovery in both groups.

Note: Data are presented as mean±SE (n=30 each group). *,** Different from baseline within the group (*p*-value < 0.05, 0.01), $$ different from that during the KKQ within the KKG (*p*-value < 0.01), #,## different between groups at the same time point (*p*-value < 0.05, 0.01).

Abbreviation: CG, control group; KKG, Khon Kaen Qigong group.

V_E/VO_2

Compared with baseline, V_E/VO_2 was significantly decreased during KKQ (5-25 min) (All were *p*-value < 0.01 except at 25 min (*p*-value < 0.05)) and increased at 10 min into recovery (*p*-value < 0.01) (Figure 3A). Compared with the CG, V_E/VO_2 in the KKG was significantly lower at 10 min during KKQ (*p*-value < 0.01) and greater at 5-20 min into recovery (All were *p*-value < 0.01). In the KKG, V_E/VO_2 during recovery was greater than during KKQ (All were *p*-value < 0.01). V_E/VO_2 did not change throughout the entire experiment in the CG.

V_E/VCO_2

Compared with baseline and the CG, V_E/VCO_2 was significantly lower throughout KKQ (5-25 min) (All were *p*-value < 0.01, except at 5 min compared with CG (*p*-value < 0.05) (Figure 3B). V_E/VCO_2 of the KKG returned to baseline at 25 min of KKQ until the end of recovery. V_E/VCO_2 did not change throughout the entire experiment in the CG.

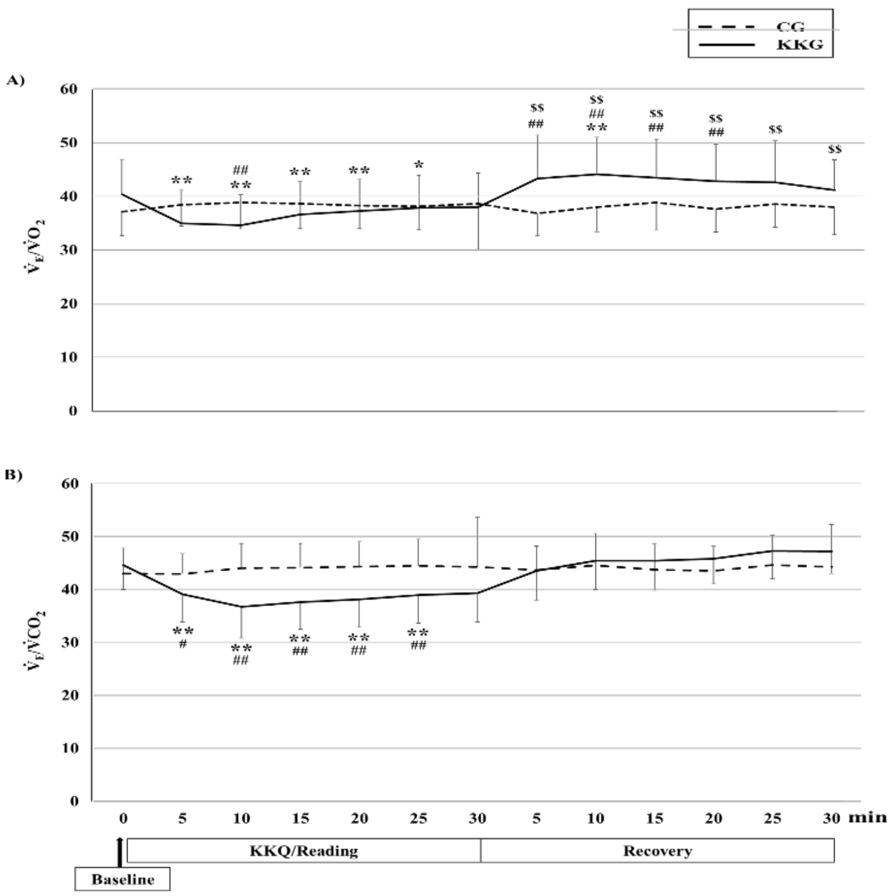

Figure 3 Ventilatory efficiency at baseline, during KKQ/Reading, and recovery in both groups. Data are presented as mean±SE (n=30 each group).

Note: *,**Different from baseline within the group (*p*-value < 0.05, 0.01), $$ different from that during the KKQ within the KKG (*p*-value <0.01), #,## different between groups at the same time point (*p*-value < 0.05, 0.01).

Abbreviation: CG, control group; KKG, Khon Kaen Qigong group; V_E/VO_2, ventilatory efficiency relative to VO_2; V_E/VCO_2, ventilatory efficiency relative to VCO_2.

Intensity of exercise[16,18]

%HRmax indicated that KKQ was a very light-intensity exercise (Table 1). Furthermore, the $VO_{2,peak}$ of the participants in KKG was 32.2±4.34 mL/kgBM/min. The $\%VO_{2,peak}$ determined that KKQ was a very light-intensity exercise. The highest $\%VO_{2,peak}$ was during the first round of KKQ (Supplementary Figure S3). The RPE and RPD also increased to a very light to light level of exertion during the KKQ. No participants complained of any discomfort or injury from KKQ.

Table 2 Exercise intensity of KKQ of participants

Variable	Mean±SD	Reference values	Exercise intensity
%HRmax	54.1±9.5	<57	Very-light
$\%VO_{2,peak}$	20.9±5.0	<37	Very-light
Rating of perceived exertion	10.6±1.8	9-11	Very light-fairly light
Rating of perceived dyspnea	2.8±1.6	2-3	Light

Note: The data are presented by mean ± SD (n=30).
Abbreviation: KKQ, Khon Kaen Qigong group; %HRmax, percentage of maximal heart rate; $\%VO_{2,peak}$, percentage of peak oxygen consumption rate.

Discussion

To the best of our knowledge, this is the first study to provide evidence that a single bout of KKQ is a very light-intensity exercise, as indicated by very low responses of the cardiorespiratory system in sedentary older participants. Furthermore, KKQ reduced ventilatory efficiency, whereas the reading was confirmed as resting status.

Unexpectedly, the cardiorespiratory responses determined that KKQ was a very light-intensity exercise. Only two subjective indicators i.e. RPE and RPD indicated it as very light- to light-intensity exercise. Together with the other indicator i.e. %HRmax, $\%VO_{2,peak}$ which is a gold standard indicator of exercise intensity[19] classified it as a very light-intensity exercise. The increase in HR compared to the reading group is consistent with a previous study in our laboratory[6] (a pilot study). We found that KKQ increased HR along with a trend towards an increased low frequency/high frequency ratio of heart rate variability. This reflects the sympathetic dominance induced by KKQ. Sympathetic activity stimulates cardiac frequency, increasing HR[20]. However, it is surprising that KKQ did not increase BP compared with the reading group. The unaltered change in SBP caused by the KKQ was consistent with the response to cycling during low-intensity exercise in a study by Boonthongkaew et al[14]. The increased HR but not SBP may be due to the sinoatrial node, which generates HR and is more sensitive to exercise-induced sympathetic activity or hormonal stimulation than the left ventricular muscle, which increases SBP[20]. In addition, the unchanged DBP may be explained by the fact that KKQ may not stimulate sufficient vasodilators, such as nitric oxide.

All movements of the KKQ included bending forward, backward, sideward, twisting, and walking. This provides good stretching of the chest, waist, arms, and legs. Furthermore, the KKQ included breathing exercises with pursed lips. Together with stretching in the chest area, KKQ enhances thoracic cage flexibility, resulting in increased inspiratory volumes. Therefore, it increases the concentration of inspired oxygen. The increased KKQ-induced VO_2 reflects increased aerobic metabolism possibly led to enhanced aerobic performance[21]. Furthermore, we found that V_E/VCO_2 decreased from baseline throughout the single bout of KKQ, whereas V_E/VO_2 decreased at 10 min of KKQ compared with the CG. Together with the decreased V_E/VCO_2 and V_E/VO_2 during the KKQ session, the increases in RPE and RPD confirm improved ventilatory efficiency secondary to KKQ. Importantly, it has been shown that exercise-induced decreased ventilatory efficiency are associated with decreased cardiovascular risk and mortality(22,23). Therefore, we expect that KKQ training may benefit cardiovascular risk and mortality.

Considering the importance of quality of the measurement process, we controlled them throughout. Firstly, this study design is RCT which is a good research design, and we blinded all participants and researchers except those who collected the data during KKQ/Reading. Secondly, the quality of all equipment was controlled by calibration before data collection or having quality assessment during the analysis. Thirdly, we matched all baseline characteristics of participants confirmed by results of no difference between groups (Table 1). Furthermore, the ratio of participants' underlying diseases in CG and KKG was similar (five and three participants with diabetes mellitus type 2; 18 and 17 participants with hypertension, and 27 participants in both groups with dyslipidemia). Therefore, these data were sufficient to confirm the results of this study.

First of our limitations, we did not measure autonomic activity, stress hormone concentration, or vasodilator use. This conceals the mechanism of cardiorespiratory responses to both conditions in older sedentary adults. Furthermore, we did not record the HR during KKQ/reading and recovery every 5 min. We measured the HR before and immediately after activities and recovery. Therefore, we could not show a 5-min change in HR during either activity. Therefore, the HR data were inconclusive. However, other indicators, i.e., $\%VO_{2,peak}$, RPE, and RPD, showed the very light exercise intensity nature of KKQ. In addition, although we did not have a direct measurement of $VO_{2,peak,}$ i.e., cardiopulmonary exercise test (CPET), we used other indirect indicators, i.e., calculated $VO_{2,peak}$ from 6 MWT[24], %HRmax, RPE, and RPD which are standard tools. Measuring $VO_{2,peak}$ from a 6 MWT, a moderate-intensity exercise, is safer for older individuals compared to the direct measurement, i.e., CPET, where participants need to exercise until 85%HRmax or exhaustion[25]. Lastly, most participants were female (28 females in the KKG and CG, respectively). A review article demonstrated that sex influences physiology, pathology, and treatment outcomes[26]. Thus, our results are unlikely to apply to the male population.

Based on previous studies showing beneficial effects of very low-intensity exercise on cardiorespiratory function[27-29], further studies applying KKQ training to investigate cardiorespiratory responses such as heart rate variability, respiratory muscle strength, and dynamic pulmonary functions and cardiovascular risk factors in older adults worth performing. In addition, the training research in other populations, such as male participants, elderly adults, and patients with cardiovascular and pulmonary diseases should be encouraged.

Conclusion

This study demonstrated that a single bout of KKQ is a very light-intensity exercise in sedentary older adults, as indicated by the cardiorespiratory responses to a very low level of effort. Furthermore, it decreases ventilatory efficiency, associated with cardiorespiratory risk factors. Further studies on KKQ training may confirm its impact on cardiovascular disease interventions.

Clinical implication

- Khon Kaen Qigong (KKQ) is a very light-intensity exercise indicated by increased cardiorespiratory responses to very low levels in sedentary older participants.
- KKQ decreased ventilatory efficiency, implying a reduction in cardiorespiratory risk factors.

Conflicts of interest

The authors declare no conflict of interest.

Acknowledgements

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Supplementary

Figure S1 Postures of Khon Kaen Qigong (Figure reproduced with permission from Liu et al, 2022).

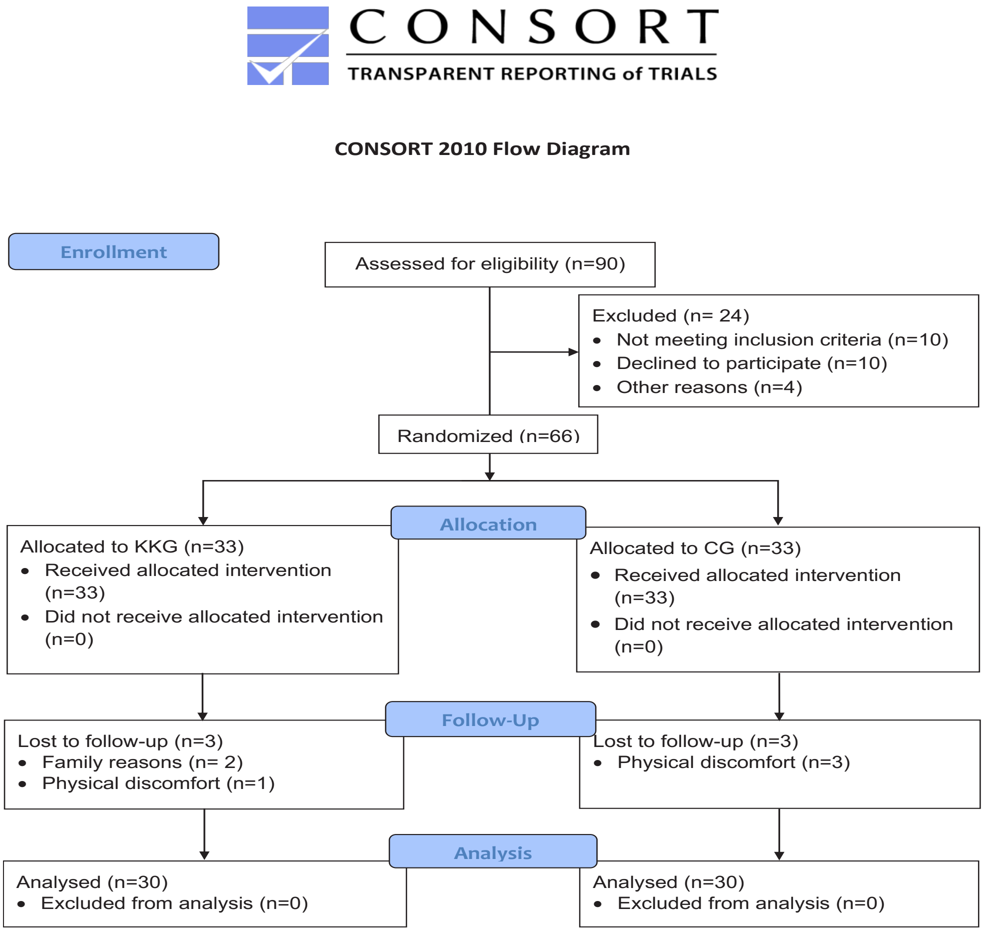

Figure S2 Consort flow diagram of this study.
Abbreviation: KKG, Khon Kaen Qigong group; CG, control group.

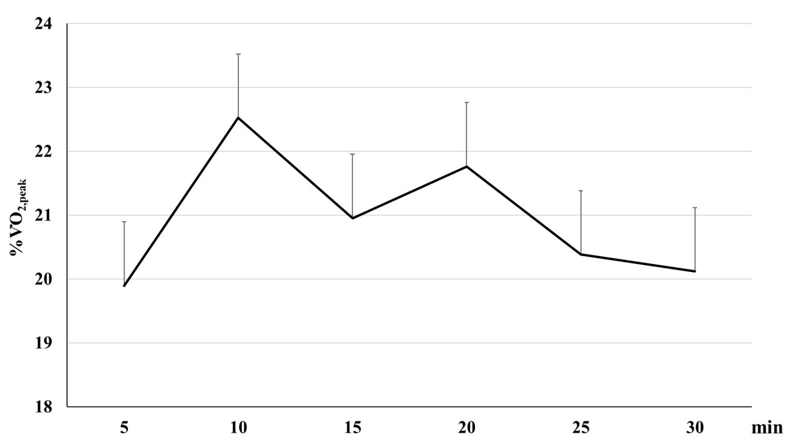

Figure S3 %VO_{2peak} during Khon Kaen Qigong.
Abbreviation: %VO_{2peak}, percentage of peak oxygen consumption rate.