Complementary Therapies in Medicine 33 (2017) 39–45

Contents lists available at ScienceDirect

Complementary Therapies in Medicine

journal homepage: www.elsevier.com/locate/ctim

# Effect of Qigong exercise on cognitive function, blood pressure and cardiorespiratory fitness in healthy middle-aged subjects

Suphannika Ladawan[a,b], Kultida Klarod[a,c], Marc Philippe[a], Verena Menz[a], Inga Versen[a], Hannes Gatterer[a], Martin Burtscher[a,*]

[a] Department of Sport Science, Medical Section, Faculty of Psychology and Sport Science, University of Innsbruck, Innsbruck 6020, Austria
[b] Department of Physical Therapy, School of Allied Health Sciences, University of Phayao, Phayao 56000, Thailand
[c] Department of Physical Therapy, Faculty of Allied Health Sciences, Burapha University, Chon Buri 20130, Thailand

ARTICLE INFO

*Keywords:*
Qigong
Cognitive function
Blood pressure
Cardiorespiratory fitness

ABSTRACT

*Objective:* To investigate effects of Qigong exercise on cognitive function, blood pressure and cardiorespiratory fitness in healthy middle-aged subjects.

*Methods:* Study part 1 examined the effects of Qigong exercise in 12 subjects (5 males, 7 females, aged 52.2 ± 7.1 years) who performed Qigong for 8 weeks (60 min sessions, 3 times/week). Study part 2 evaluated the detraining effects 12 weeks after cessation of Qigong. Cognitive function (Digit Span Forward and Backward Test, Trail Making Tests part A and B), blood pressure, and exercise performance were determined at baseline, immediately after the training programme, and after the detraining period.

*Results:* Qigong exercise showed a significant improvement of Trail Making Tests part A ($p = 0.04$), systolic blood pressure ($p = 0.001$), diastolic blood pressure ($p = 0.005$), mean arterial pressure ($p < 0.001$), and maximal workload ($p = 0.032$). Twelve weeks after cessation, Trail Making Tests part A, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and maximal workload had returned to baseline ($p = 0.050$, 0.007, 0.001, 0.001, and 0.017, compared to after the training, respectively).

*Conclusion:* These results suggest that Qigong exercise effectively improved attention, brain processing speed, blood pressure and maximal workload. However, these improvements disappeared 12 weeks after cessation of Qigong. Consequently, performing Qigong regularly is important to maintain related health effects.

## 1. Introduction

Cognitive impairment is one of the major public health concerns today. Progression of cognitive decline may impact on everyday functional abilities, such as driving, banking, shopping and medication administration.[1,2] Current literature has suggested that cognitive impairment has been associated with high systemic arterial blood pressure. A 10 mmHg increase in systolic blood pressure increased the risk for both intermediate and poor cognitive function.[3] Likewise, an increment of 10 mmHg in diastolic blood pressure was also related to higher risk of cognitive impairment.[4] A review of the relationship between blood pressure and cognitive function documented that hypertension and other vascular risk factors were associated with a decline in the ability to perform attention and executive function tests.[5]

It is well established that regular exercise has positive effects on physical performance. Furthermore, exercise has also been suggested as an important strategy for the prevention and treatment of hypertension.[6,7] and improving cognitive function.[8,9] Additionally, it was suggested that exercise training increases cerebral blood flow, resulting in memory improvements.[10] There are several physiological factors influencing cerebral blood flow, such as partial pressure of oxygen and carbon dioxide in the arterial blood, cerebral metabolism, and neural activity.[11,12] Interestingly, a double-blind study showed a significant reduction in systemic arterial blood pressure and a significant increase in cerebral blood flow followed by the administration of prazosin (α1-adrenergic blockade) in hypertensive patients.[13] Ogoh and colleagues reported that during recovery from acute hypotension, decreases in the cerebral vascular conductance index were mediated by increases in arterial blood pressure and sympathetically mediated cerebral vasoconstriction,[14] and Mueller suggested reductions in sympathetic outflow after exercise training.[15] Therefore, exercise training may alter autonomic nervous system function resulting in improved cerebral blood flow and cognitive function.

Moreover it was reported that older adults with a higher

* Corresponding author.
*E-mail address:* Martin.Burtscher@uibk.ac.at (M. Burtscher).

http://dx.doi.org/10.1016/j.ctim.2017.05.005
Received 4 October 2016; Received in revised form 25 April 2017; Accepted 24 May 2017
Available online 13 June 2017
0965-2299/ © 2017 Elsevier Ltd. All rights reserved.

cardiorespiratory fitness (maximal oxygen consumption:$VO_{2max}$) had significantly greater brain activation in cortical regions such as the middle frontal gyrus, superior frontal gyrus, and superior parietal lobules associated with attentional control.[16] These findings suggest that cardiorespiratory fitness may influence cognitive performance by impacting on brain activation.[16,17] Several studies showed that $VO_{2max}$ significantly increases after exercise training and decreases subsequently within 2–4 weeks after the cessation of training.[18,19] Other investigations on the effects of detraining reported that physical activity adaptations were lost between 6 and 12 weeks of detraining.[19–21]

Qigong exercise is one type of mind-body exercise which originated in China. Qigong has been defined as meditative movement (MM) representing a new category of exercise involving 4 essential elements: movement, focus on breathing, meditative state of mind, and relaxation.[22,23] The typical movement of MM is slow, relaxed and flowing, but the range of movement may include high level of dynamic movement to static posture, prescribed or spontaneous free movement. Focus on breathing during MM may bring the mind to a restful state and oxygenation and/or energy to the body. There is a specific breathing pattern such as inhaling during arms slowly raising and exhaling during arms slowly lowering. The breathing may be slow, fast or be hold for various time periods.[22] Altering the breathing pattern may be associated with changing of the autonomic nervous system (ANS) function.[24,25] There are several patterns of meditation forms, for example, focus awareness on the breath or the present movement.[22] The mind is used to direct the movement of Qi (life energy or breath).[23,26] MM requires both deep state of physical as well as mental relaxation during practice. Deep relaxation is the suggested goal of MM.[22] Each element may evoke several health benefits. However, the combination of all 4 elements may generate more benefits than a single element.

Previous studies showed positive effects of Qigong exercise, such as improved self-reported cognitive function in cancer patients,[27] reduced blood pressure in hypertensive patients,[28–30] stabilization of the autonomic nervous system,[28] improved ventilatory function,[28] and cardiorespiratory fitness ($VO_{2max}$)[31] reduced mental stress,[32] depression,[33] and anxiety.[34] Moreover, Qigong is low joint-impact exercise, easy to practice and needs no special equipment. Breathing exercise combined with mental concentration and relaxation during Qigong practice may help to improve cardiorespiratory and autonomic nervous system functions, which then might contribute to better brain function and improved cognitive performance.

The present study aimed at investigating the effects of Qigong exercise on cognitive function, blood pressure and cardiorespiratory fitness in healthy middle-aged subjects. In order to evaluate the effects of Qigong exercise, we compared main outcomes between baseline, immediately after the end of the 8-week Qigong training period, and 12 weeks after stopping training. We hypothesized that immediately after the end of training cognitive function, blood pressure and cardiorespiratory fitness would be improved with a subsequent decline to baseline after cessation of training.

## 2. Methods

### 2.1. Study protocol

This study has been divided into 2 parts: the first part examined the effects of Qigong exercise on cognitive function, blood pressure, and cardiorespiratory fitness. After the baseline measurements (T1), all participants performed Qigong exercise for 8 weeks and then they performed the first post-test (T2). The second part evaluated the effects after cessation of Qigong exercise in subjects who volunteered to return to previous habits and not to do Qigong exercise for the next 12 weeks (T3, after 12 weeks).

### 2.2. Sample size and participants

Blood pressure parameter was used for sample size estimation. The alpha level and power of test were set at 0.05 and 0.80 respectively. Based on previous study that investigated the effects of qigong on reducing stress and anxiety and enhancing body–mind well-being,[35] standard deviation was set at 10.56. Tsivgoulis et al. found that an increment of 10 mmHg in diastolic blood pressure was related to higher risk of cognitive impairment,[4] thus we expected this change to occur between pre-test and post-test. Based on this assumption the calculated sample size was 9. As a drop out rate of about 30% was expected 12 participants were recruited. Since 2 participants dropped out after training cessation, there were 12 participants in the first part of the study and 10 in the second part.

Participants were recruited at the University of Innsbruck (Austria) using flyers and e-mail. All of them were aged between 45 and 66 years and well-educated (higher education level or third level education). Exclusion criteria were any medical condition, such as cardiovascular diseases, respiratory diseases, orthopaedic problems, neurological disorder and infectious conditions, not compatible with performing Qigong exercise safely. None of the participants performed regular exercise or took part in physical training at an athletic level for at least 3 months prior to enrolling in the study. They were also asked to maintain their usual activities of daily living and dietary behaviour throughout the study period.

Before signing the consent form for participation, subjects were informed about the experimental protocol and possible risks. Ethical approval was obtained from the review board of the institute of sport science and the ethics committee of the University of Innsbruck; protocol number 11-2015.

### 2.3. Qigong exercise

Eighteen Qigong forms or Tai Chi Qigong Shibashi were used in this study combining gentle movements with breathing, meditation and relaxation. The slow movements coordinated with breathing required focus and concentration on the movements. All participants were required to attend Qigong exercise at the institute of sports science, 3 days a week for 8 weeks. The Qigong group exercise started with 10 min warm up by general stretching. After that, they performed all 18 movements of Qigong for 40 min followed by cool down with general stretching for 10 min. Participants practiced Qigong under the guidance of an investigator who has practiced Qigong for more than 10 years. The following 18 Qigong movements, adapted from 18 movements Taiji Qigong by Robinson, were performed[36]:

Movement 1: Lift hands
Movement 2: Opening the ches
Movement 3: Rainbow dance
Movement 4: Separating clouds
Movement 5: Rolling arms
Movement 6: Rowing the boat
Movement 7: Lift the ball
Movement 8: Looking at the moon
Movement 9: Pushing palms
Movement 10: Cloud hands
Movement 11: Touch the sea, look at the sky
Movement 12: Pushing the waves
Movement 13: Flying dove
Movement 14: Punching
Movement 15: Flying wild goose
Movement 16: Rotating the wheel
Movement 17: Marching whilst bouncing the ball
Movement 18: Balancing the Chi

### 2.4. Measurements

Measurements were performed before the first Qigong session (T1), immediately after the end of the 8-week training period (T2) and after the detraining period, which lasted for 12 weeks (T3).

#### 2.4.1. Cognitive functions

Cognitive function was assessed by executive and memory function.

*2.4.1.1. Memory function.* Short-term memory and working memory were measured by the Digit Span Forward test (DSF) and the Digit Span Backward test (DSB), respectively. The DSF requires participants to memorize and repeat the numbers in the same order as they were shown on a computer screen. During the DSB test, participants had to repeat the numbers in the reverse order. The score of each test consists of the number of correctly repeated sequences until participants are no longer able to reproduce two sequences of equal length.[37]

*2.4.1.2. Executive function.* Executive function was measured by Trail Making Tests (TMT). The test is divided into Trail Making Test part A (TMT-A), which tests attention and processing speed, and Trail Making Tests part B (TMT-B), which tests mental flexibility. The TMT-A requires the participants to connect numbers from 1 to 25 that were distributed on a sheet of paper. The TMT-B is similar to the TMT-A except the participant must alternate between numbers and letters (e.g. 1, A, 2, B, 3, C, etc.). Participants were instructed to complete the test as quickly and accurately as possible. The score on each part is the amount of time required to complete the task.[38, 39]

#### 2.4.2. Blood pressure

Blood pressures were always measured in the afternoon (between 1 and 6 pm). All participants were asked to abstain from food, caffeine, and/or alcohol intake, and smoking at least two hours prior to the investigation. Systolic and diastolic systemic blood pressure were measured using an aneroid blood pressure device on the right arm in a seated position after a minimum of 5 min rest. Mean arterial pressure (MAP) was calculated from the formula:

$$MAP = [(2 \text{ x diastolic}) + \text{systolic}]/3$$

#### 2.4.3. Cardiorespiratory fitness

Each subject performed an incremental exercise test on an electrically braked cycle ergometer. The test began with warming up by cycling at 0 W, then workloads were increased by 25 W every 2 min for women and 50 W every 3 min for men until they reached the limit of exercise tolerance, could not maintain the required pedaling frequency (60 rpm).

### 2.5. Statistical analysis

At T2 of part 2 of this study, we excluded two subjects' data from statistical analysis because they did not comply with the detraining recommendations. For this reason, the sample size of part 1 was 12 while part 2 was 10. As we had two groups of different sample sizes, we decided to analyze the two study parts separately part 1: T1 vs. T2 and part 2: T2 vs T3. Normality was tested by use of the Shapiro-Wilk test and the main outcomes were compared using Paired Sample *t*-test for parametric or Wilcoxon test for non-parametric data. Pearson correlation coefficient was used to evaluate associations between outcomes. Data are presented as means ± SD. *P* value of $\leq 0.05$ was considered statistically significant. All data analysis was conducted with SPSS version 17.

**Table 1**
Baseline Characteristics.

| Characteristic | Value (n = 12) |
|---|---|
| Age (years) | 52.2 ± 7.1 |
| Gender (M:F) | 5:7 |
| Height (cm) | 172.3 ± 8.60 |
| Body mass (kg) | 73.5 ± 15.9 |
| BMI (kg/m$^2$) | 24.5 ± 3.4 |
| Waist circumference (cm) | 87.5 ± 10.7 |
| Hip circumference (cm) | 104.1 ± 6.7 |
| Waist to hip ratio | 0.84 ± 0.07 |
| % body fat | 32.4 ± 5.8 |

Data are represented as mean ± SD.

## 3. Results

### 3.1. Characteristics of participants

A total of 12 healthy participants completed the Qigong exercise programme. All of them attended at least 20 of 24 sessions (83.3% of the training programme). Twelve participants completed the first part and 10 participants the second part of this study. Baseline characteristics of subjects are shown in Table 1.

### 3.2. Cognitive function

#### 3.2.1. Memory function

Part 1: no significant differences were noted in DSF and DSB scores between T1 and T2 (DSF: T1 = 9.5 ± 2.5, T2 = 9.4 ± 2.5; DSB: T1 = 8.0 ± 2.8, T2 = 7.8 ± 2.6). Part 2: DSF and DSB scores were also not significantly different between T2 and T3 (DSF: T2 = 10.0 ± 2.3, T3 = 9.3 ± 2.0; DSB: T2 = 8.3 ± 2.6, T3 = 10.0 ± 2.9). Interestingly, a positive correlation between DSF, maximal workload and maximal minute ventilation ($VE_{max}$) during exercise testing was observed (Fig. 1).

#### 3.2.2. Executive function

Time to complete TMT-A was decreased significantly after 8 weeks of Qigong training (part 1: T1 = 50.1 ± 21.7 s; T2 = 32.9 ± 12.8 s; $p = 0.04$) but increased significantly after the detraining phase (part 2: T2 = 30.8 ± 12.9 s; T3 = 42.4 ± 15.7 s; $p = 0.05$) (Fig. 2). At the end of the Qigong training a negative association between TMT-A and maximal heart rate ($p = 0.01$; $r = -0.69$) was found.

Time to complete TMT-B tended to decrease after the exercise training but this did not reach statistical significance (T1 = 83.2 ± 23.1 s; T2 = 77.4 ± 32.0 s). After the detraining phase, there was no significant difference between T2 and T3 (T2 = 70.4 ± 17.6 s; T3 = 71.9 ± 20.7 s) (Fig. 2).

### 3.3. Resting blood pressure and heart rate

At the end of the 8-week intervention period, Qigong participants showed significant pre-to-post-training improvements in SBP (T1 = 133.8 ± 14.9 mmHg; T2 = 115.9 ± 10.7 mmHg; $p < 0.01$), DBP (T1 = 80.0 ± 6.4 mmHg; T2 = 74.9 ± 8.1 mmHg; $p < 0.01$), and MAP (T1 = 97.9 ± 6.2 mmHg; T2 = 88.6 ± 8.4 mmHg; $p < 0.01$) (Fig. 3). After the detraining period, all blood pressure parameters increased again (SBP: T2 = 113.6 ± 8.4 mmHg, T3 = 122.9 ± 10.0 mmHg, $p = 0.01$ DBP: T2 = 73.9 ± 7.2 mmHg, T3 = 84.1 ± 3.2 mmHg, $p < 0.01$; MAP: T2 = 87.1 ± 6.8 mmHg, T3 = 97.0 ± 4.6 mmHg, $p < 0.01$).

Resting heart rate tended to decrease after Qigong training but the difference failed to reach statistical significance (T1 = 77.4 ± 10.1 bpm; T2 = 73.8 ± 2.6 bpm, $p = 0.09$). After the detraining phase, resting heart rate showed a small increase but these

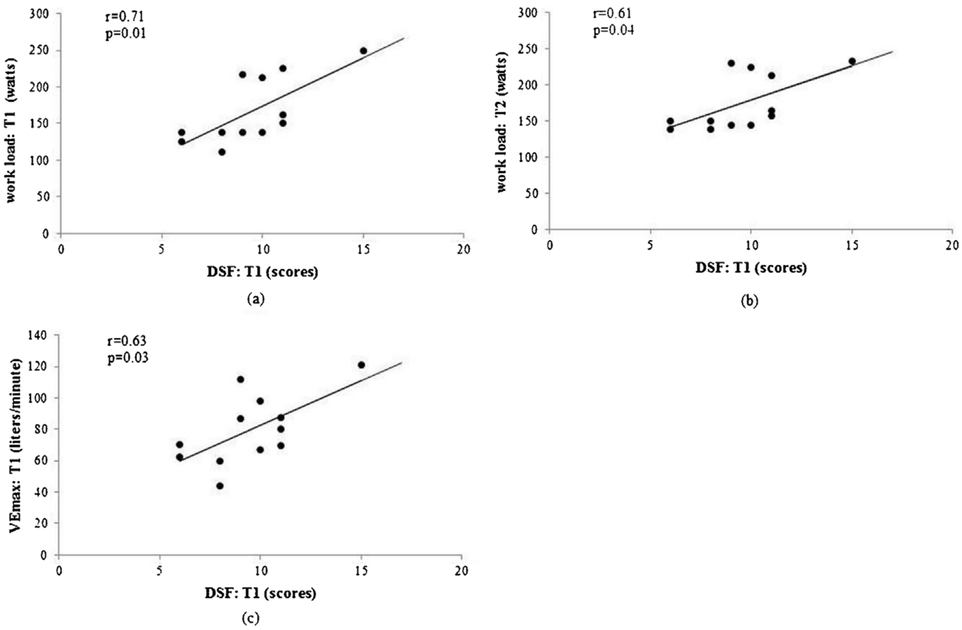


**Fig. 1.** Correlation between digit span forward test at baseline (DSF:T1) and (a) maximal workload at baseline (workload: T1), (b) maximal workload at the first post-test (workload: T2), and (c) maximal minute ventilation at baseline (VEmax:T1).

changes did not reach statistical significance (T2 = 74.7 ± 9.4 bpm, T3 = 78.8 ± 14.4 bpm, $p$ = 0.15).

### 3.4. Exercise performance

Exercise performance parameters are shown in Table 2. After the training period, maximal workload was increased significantly ($p$ = 0.03) while maximal oxygen consumption ($VO_{2max}$), VE, and maximal heart rate ($HR_{max}$) remained unchanged ($p > 0.05$). After detraining, maximal workload and VE decreased significantly ($p < 0.05$) whereas no significant changes in $VO_{2max}$, and $HR_{max}$ ($p > 0.05$) were found.

### 3.5. Gender differences

Focusing on gender difference, males showed significantly higher maximal workloads than females at T1, T2 and T3 (T1: males = 205.8 ± 47.5 W, females = 139.0 ± 15.8 W; T2: males = 208.0 ± 39.5 W, females = 149.8 ± 8.8 W; T3: males = 194.0 ± 52.9 W, females = 136.3 ± 18.6 W, $p < 0.05$) whereas other parameters (memory function, executive function, blood pressure heart rate, and $VO_{2max}$) were not significantly different between gender. In response to Qigong, no differences were found in the percentage change for all parameters between males and females as well.

## 4. Discussion

The main findings of the present study are that 8 weeks of Qigong training resulted in significant improvements in attention and processing speed (TMT-A), systemic SBP, DBP, MAP, and maximal workload. Although no significant changes were noted in the DSF and DSB test, DSF was positively correlated with maximal workload and minute ventilation. Additionally, after 12 weeks of detraining most parameters nearly returned to baseline.

### 4.1. Memory function

The findings that 8 weeks of Qigong training did not significantly improve memory function (DSF and DSB test) is consistent with a previous study demonstrating no significant differences in digital span scores after a 15-week Tai Chi intervention (n = 11).[40] However, it has been shown that older adults who practiced in mind–body (n = 35) or cardiovascular exercises (n = 35) had a similar level of memory function, and their memory was better than those who did not engage in regular exercise (n = 35).[41] The present study did not show a clear

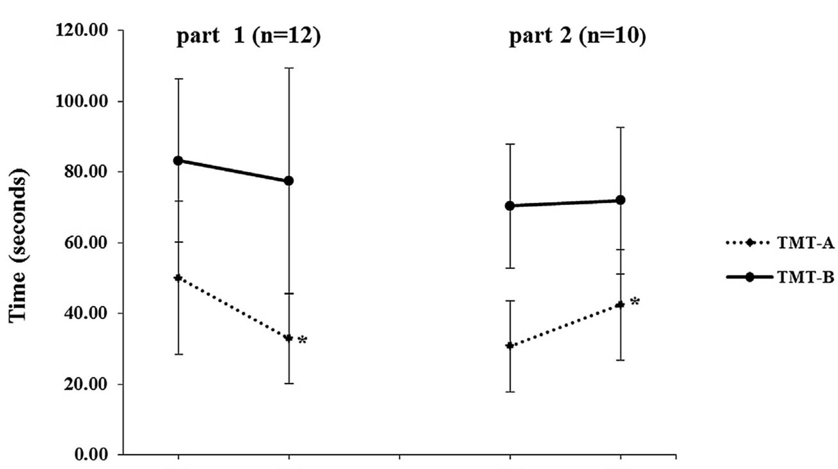


**Fig. 2.** Executive function test at part 1 and 2 of the study. TMT-A = Trail Making Tests A, TMT-B = Trail Making Tests B; T1 = baseline; T2 = immediately after the end of training; T3 = after detraining phase. * Significant difference $p < 0.05$.

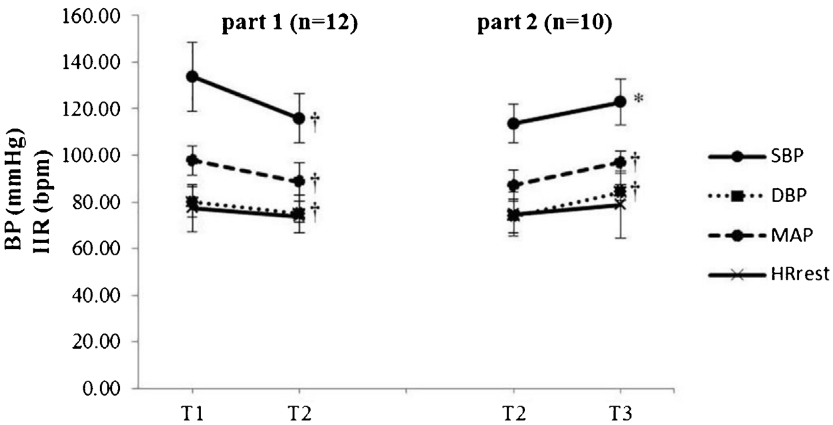


**Fig. 3.** Resting blood pressure and heart rate during part 1 and 2 of the study. SBP = systolic blood pressure,; DBP = diastolic blood pressure; MAP = mean arterial pressure; HRrest = resting heart rate; T1 = baseline; T2 = immediately after the end of training; T3 = after detraining phase; * significant difference $p < 0.05$; † significant difference $p < 0.01$.

association between cognitive function and blood pressure. The observation that DSF was correlated with maximal workload and minute ventilation is consistent with a study of Voelcker-Rehage et al.,[42] who suggested that cognitive function was associated with physical fitness indexed by cardiovascular fitness and muscular strength. Training-dependent performance improvement did not change this relationship as indicated by the positive relationship between baseline DSF and maximal workload after training.

### 4.2. Executive function

Our finding that after 8 weeks of Qigong exercise, the time to complete TMT-A decreased significantly with a subsequent increase after cessation of training is also in line with previous studies demonstrating improvements in TMT-A after exercise training.[8,43,44] The mechanisms underlying the observed improvements are unclear. It is possible that Qigong – consisting of slow body movement, breathing exercise, meditation – done in a concentrated way, facilitates conscious control of each body movement. Previous studies suggested that the combined effects of physical and mental training on cognition are greater than either independently.[45]

The present study showed that mental flexibility (TMT-B) did not change significantly after exercise training. This is inconsistent with a study by Chin et al. who found that TMT-B was significantly improved after 12-weeks of exercise training.[8] Also Overath et al. reported that 10 weeks of an aerobic exercise programme significantly improved TMT-B.[43] There are two possible explanations. First, healthy and unhealthy participants may differ in exercise responses. Participants in the present study were healthy middle-aged subjects, while the study of Chin et al. focused on traumatic brain injury patients,[8] and Overath et al. investigated the effects of exercise in migraineurs.[43] It has been suggested that seniors and clinical populations may benefit more than healthy younger from proper exercise.[46] Second, discrepancies between studies may be explained by a dose-response relationship. Previous studies suggested that higher amount of practice was related to greater improvement after training.[47, 48] The exercise training in the present study was 3 times a week for 8 weeks while Chin et al.[8] and Overath et al.[43] asked participants to performed exercise 3 times a week for 12 and 10 weeks respectively.

**Table 2**
Comparison of exercise performance between baseline and immediately after the end of training (part 1) and between immediately after the end of the training and after the detraining phase (part 2).

| Test | Part 1 (n = 12) | | Part 2 (n = 10) | |
|---|---|---|---|---|
| | T1 | T2 | T2 | T3 |
| $VO_{2max}$ (ml/kg/min) | 30.2 ± 5.7 | 29.2 ± 3.8 | 30.0 ± 3.5 | 30.0 ± 5.7 |
| $W_{max}$ (watts) | 166.8 ± 46.3 | 174.0 ± 38.9 * | 170.8 ± 37.6 | 159.4 ± 44.9† |
| $VE_{max}$ (L/min) | 79.8 ± 22.4 | 82.8 ± 16.3 | 80.0 ± 11.0 | 73.3 ± 13.8 † |
| $HR_{max}$ (bpm) | 160.7 ± 16.9 | 163.3 ± 18.0 | 164.5 ± 19.6 | 163.7 ± 19.1 |

$VO_{2max}$ = maximal oxygen consumption; $W_{max}$ = maximal workload; $VE_{max}$ = min ventilation; $HR_{max}$ = maximum heart rate; T1 = baseline; T2 = immediately after the end of training; T3 = after detraining phase; * significantly different between T1 and T2 ($p < 0.05$); † significantly different between T2 and T3 ($p < 0.05$).

### 4.3. Blood pressure

Importantly, the present study showed that Qigong exercise improved systemic blood pressure in normotensive people. Referring to the European Society of Hypertension–European Society of Cardiology guidelines,[49] the results of this study showed that blood pressure parameters were improve to the better level after training. At baseline (T1), mean value of SBP was high- normal (133.8 ± 14.9 mmHg) which moved even to optimal (115.9 ± 10.7 mmHg) after Qigong training. A similar situation was found in DBP, which changed from normal (80.6 ± 6.4 mmHg) to optimal level (74.9 ± 8.1 mmHg) after training. These results correspond with previous studies also demonstrating a clear effect of exercise on blood pressure. For example, Qigong training significantly decreased blood pressure in clinical populations.[28–30] Furthermore, Koga et al. reported that mild exercise can reduce systolic, diastolic and mean blood pressure in women with mild essential hypertension.[50] Previous studies suggested that Qigong may reduce blood pressure by the modulation of lipid metabolism.[29] Probably more important, synchronized breathing with movement and control of breathing during Qigong practice may alter ANS activity[24] Literature findings showed that Qigong training enhanced parasympathetic activity.[24,51] and stabilized the sympathetic nervous system[24, 30] Further potential mechanisms may involve diuretic actions through the activation of relevant metabolic pathways.[52] or by enhancing endothelium-dependent vasodilation by increasing the production of nitric oxide.[53]

### 4.4. Cardiorespiratory fitness

The current study found that maximal workload significantly increased after Qigong training whereas $VO_{2max}$ did not. It is possible that Qigong exercise has a preferentially positive effect on muscular strength. This is supported by a previous study, which reported that a Qigong intervention was associated with improvements in leg strength.[54]

### 4.5. Effects of training cessation

The TMT-A, SBP, DBP, MAP and maximal workload returned to baseline 12 weeks after cessation of training, reflecting positive effects of Qigong on these parameters during the training period. To our knowledge, this is the first study to show that the training effects of Qigong on attention and brain processing speed, blood pressure, and maximal workload disappears within 12 weeks of detraining. Various studies suggested that performance declines after training cessation and that the performance loss is related to age,[20] frequency of preceding training,[55] intensity,[56] duration.[20] and type of training.[55] In the present study all of these factors may have contributed to the observed detraining effect. Participants were not regularly active before the training and commenced Qigong with the start of the study. Additionally, the time period of regular training can be considered short as the training period lasted only for 8 weeks.

### 4.6. Differences between sexes

At baseline, immediately after the end of training, and after detraining, males had higher maximal workloads than females, whereas no sex difference in $VO_{2max}$. This finding is partial consistent with a previous study reporting that males had a 32% higher $VO_{2max}$ and 21% higher maximal workload than females.[57] For both part 1 and part 2 of the study, there were no significant differences between males and females in the percentage change for all parameters. However, these findings were based on a small sub-sample (male = 5, female = 7). O'Toole suggested that males and females are similar in the overall response of the cardiovascular system to exercise.[58] Lewis et al. reported that central or peripheral cardiovascular adaptations to aerobic training showed no difference between sexes.[59] Keteyian et al., on the other hand, reported that $VO_{2max}$ responses to aerobic exercise training differ according to sex.[60] Further investigations regarding gender differences in response to Qigong exercise are required.

## 5. Limitations of this study

One limitation of the current study is the relatively small sample size although it was based on power calculation. However, we did not increase the sample size also due to the relatively time-consuming training and testing. Nevertheless, we found several significant and clinically relevant changes after Qigong training and after training cessation. Another limitation is that there was no matched control group in the study as researchers decided to apply a pre-post design and to evaluate the effect again after a 3 month cessation of exercise training.

## 6. Conclusion

The results of the current study demonstrated that 8 weeks of Qigong training had positive effects on attention, brain processing speed, blood pressure and maximum workload. However, these improvements disappeared 12 weeks after the cessation of Qigong. Consequently, performing Qigong regularly is important to maintain related health effects.

## Competing interests

The authors declare that they have no conflict of interests regarding the publication of this paper.

## References


1 Williams KN, Kemper S. Interventions to reduce cognitive decline in aging. *J Psychosoc Nurs Ment Health Serv.* 2010;48(5):42–51.
2 Fillit HM, Butler RN, O'Connell AW, et al. Achieving and maintaining cognitive vitality with aging. *Mayo Clin Proc.* 2002;77(7):681–696.
3 Launer LJ, Masaki K, Petrovitch H, Foley D, Havlik RJ. The association between midlife blood pressure levels and late-life cognitive function. The Honolulu-Asia Aging Study. *JAMA.* 1995;274(23):1846–1851.
4 Tsivgoulis G, Alexandrov AV, Wadley VG, et al. Association of higher diastolic blood pressure levels with cognitive impairment. *Neurology.* 2009;73(8):589–595.
5 Novak V, Hajjar I. The relationship between blood pressure and cognitive function. *Nat Rev Cardiol.* 2010;7(12):686–698.
6 Hagberg JM, Montain SJ, Martin 3rd WH, Ehsani AA. Effect of exercise training in 60- to 69-year-old persons with essential hypertension. *Am J Cardiol.* 1989;64(5):348–353.
7 Cornelissen VA, Verheyden B, Aubert AE, Fagard RH. Effects of aerobic training intensity on resting, exercise and post-exercise blood pressure, heart rate and heart-rate variability. *J Hum Hypertens.* 2010;24(3):175–182.
8 Chin LM, Keyser RE, Dsurney J, Chan L. Improved cognitive performance following aerobic exercise training in people with traumatic brain injury. *Arch Phys Med Rehabil.* 2015;96(4):754–759.
9 Antunes HK, De Mello MT, Santos-Galduroz RF, et al. Effects of a physical fitness program on memory and blood viscosity in sedentary elderly men. *Braz J Med Biol Res.* 2015;48(9):805–812.
10 Chapman SB, Aslan S, Spence JS, et al. Shorter term aerobic exercise improves brain, cognition, and cardiovascular fitness in aging. *Front Aging Neurosci.* 2013;5:75.
11 Purkayastha S, Raven PB. The functional role of the alpha-1 adrenergic receptors in cerebral blood flow regulation. *Indian J Pharmacol.* 2011;43(5):502–506.
12 Ogoh S, Ainslie PN. Regulatory mechanisms of cerebral blood flow during exercise: new concepts. *Exerc Sport Sci Rev.* 2009;37(3):123–129.
13 Rutland MD, Lee TY, Nimmon CC, Granowska M, Britton KE. Measurement of the effects of a single dose of prazosin on the cerebral blood flow in hypertensive patients. *Postgrad Med J.* 1980;56(662):818–822.
14 Ogoh S, Brothers RM, Eubank WL, Raven PB. Autonomic neural control of the cerebral vasculature: acute hypotension. *Stroke.* 2008;39(7):1979–1987.
15 Mueller PJ. Exercise training and sympathetic nervous system activity: evidence for physical activity dependent neural plasticity. *Clin Exp Pharmacol Physiol.* 2007;34(4):377–384.
16 Colcombe SJ, Kramer AF, Erickson KI, et al. Cardiovascular fitness, cortical plasticity, and aging. *Proc Natl Acad Sci U S A.* 2004;101(9):3316–3321.
17 Kirk-Sanchez NJ, McGough EL. Physical exercise and cognitive performance in the elderly: current perspectives. *Clin Interv Aging.* 2014;9:51–62.
18 Neufer PD. The effect of detraining and reduced training on the physiological adaptations to aerobic exercise training. *Sports Med.* 1989;8(5):302–320.
19. Gamelin FX, Berthoin S, Sayah H, Libersa C, Bosquet L. Effect of training and detraining on heart rate variability in healthy young men. *Int J Sports Med.* 2007;28(7):564–570.
20 Toraman NF, Ayceman N. Effects of six weeks of detraining on retention of functional fitness of old people after nine weeks of multicomponent training. *Br J Sports Med.* 2005;39(8):565–568 [discussion 8].
21 Carvalho MJ, Marques E, Mota J. Training and detraining effects on functional fitness after a multicomponent training in older women. *Gerontology.* 2009;55(1):41–48.
22 Larkey L, Jahnke R, Etnier J, Gonzalez J. Meditative movement as a category of exercise: implications for research. *J Phys Act Health.* 2009;6(2):230–238.
23 Payne P, Crane-Godreau MA. Meditative movement for depression and anxiety. *Front Psychiatry.* 2013;4:71.
24 Chow YW, Tsang HW. Biopsychosocial effects of qigong as a mindful exercise for people with anxiety disorders: a speculative review. *J Altern Complement Med.* 2007;13(8):831–839.
25 Bernardi L, Porta C, Gabutti A, Spicuzza L, Sleight P. Modulatory effects of respiration. *Auton Neurosci.* 2001;90(1–2):47–56.
26 Yang JM. *Qigong Meditation Small Circulation.* xxv. Boston: MA: YMAA Publication Center; 2006:402.
27 Oh B, Butow PN, Mullan BA, et al. Effect of medical Qigong on cognitive function, quality of life, and a biomarker of inflammation in cancer patients: a randomized controlled trial. *Support Care Cancer.* 2012;20(6):1235–1242.
28 Lee MS, Lee MS, Choi ES, Chung HT. Effects of Qigong on blood pressure, blood pressure determinants and ventilatory function in middle-aged patients with essential hypertension. *Am J Chin Med.* 2003;31(3):489–497.
29 Lee MS, Lee MS, Kim HJ, Choi ES. Effects of qigong on blood pressure, high-density lipoprotein cholesterol and other lipid levels in essential hypertension patients. *Int J Neurosci.* 2004;114(7):777–786.
30 Lee MS, Lee MS, Kim HJ, Moon SR. Qigong reduced blood pressure and catecholamine levels of patients with essential hypertension. *Int J Neurosci.* 2003;113(12):1691–1701.
31 Lan C, Chou SW, Chen SY, Lai JS, Wong MK. The aerobic capacity and ventilatory efficiency during exercise in Qigong and Tai Chi Chuan practitioners. *Am J Chin Med.* 2004;32(1):141–150.
32 Griffith JM, Hasley JP, Liu H, Severn DG, Conner LH, Adler LE. Qigong stress reduction in hospital staff. *J Altern Complement Med.* 2008;14(8):939–945.
33 Chan JS, Ho RT, Wang CW, Yuen LP, Sham JS, Chan CL. Effects of qigong exercise on fatigue, anxiety, and depressive symptoms of patients with chronic fatigue syndrome-like illness: a randomized controlled trial. *Evid Based Complement Alternat Med.* 2013;2013:485341.
34 Wang F, Man JK, Lee EK, et al. The effects of qigong on anxiety, depression, and psychological well-being: a systematic review and meta-analysis. *Evid Based Complement Alternat Med.* 2013;2013:152738.
35 Chow Y. *The Effects of Qigong on Reducing Stress and Anxiety and Enhancing Body–Mind Well-Being.* The Hong Kong Polytechnic University; 2011.
36 Robinson R. *Taiji Qigong 18 Movements.* 2017; 2017. [Available from: http://www.

chirontaichi.co.uk/downloads/taiji_qigong_18_movements.pdf].
37 Nouchi R, Taki Y, Takeuchi H, et al. Beneficial effects of short-term combination exercise training on diverse cognitive functions in healthy older people: study protocol for a randomized controlled trial. *Trials.* 2012;13:200.
38 Miller SM, Taylor-Piliae RE. Effects of Tai Chi on cognitive function in community-dwelling older adults: a review. *Geriatr Nurs.* 2014;35(1):9–19.
39 Tombaugh TN. Trail Making Test A and B: normative data stratified by age and education. *Arch Clin Neuropsychol.* 2004;19(2):203–214.
40 Chang JY, Tsai PF, Beck C, et al. The effect of tai chi on cognition in elders with cognitive impairment. *Medsurg Nurs.* 2011;20(2):63–69 [quiz 70].
41 Chan AS, Ho Y, Cheung M, Albert MS, Chiu HFK, Lam LCW. Association between mind-body and cardiovascular exercises and memory in older adults. *J Am Geriatr Soc.* 2005;53(10):1754–1760.
42 Voelcker-Rehage C, Godde B, Staudinger UM. Physical and motor fitness are both related to cognition in old age. *Eur J Neurosci.* 2010;31(1):167–176.
43 Overath CH, Darabaneanu S, Evers MC, et al. Does an aerobic endurance programme have an influence on information processing in migraineurs? *J Headache Pain.* 2014;15:11.
44 Mortimer JA, Ding D, Borenstein AR, et al. Changes in brain volume and cognition in a randomized trial of exercise and social interaction in a community-based sample of non-demented Chinese elders. *J Alzheimers Dis.* 2012;30(4):757–766.
45 Curlik DM. 2nd, Shors TJ. Training your brain: do mental and physical (MAP) training enhance cognition through the process of neurogenesis in the hippocampus. *Neuropharmacology.* 2013;64:506–514.
46 Wick J. *Pharmacy Practice in an Aging Society.* USA: The Haworth press Inc.; 2006:41.
47 Lynch M, Sawynok J, Hiew C, Marcon D. A randomized controlled trial of qigong for fibromyalgia. *Arthritis Res Ther.* 2012;14(4):R178.
48 Chan JS, Ho RT, Chung KF, et al. Qigong exercise alleviates fatigue, anxiety, and depressive symptoms, improves sleep quality, and shortens sleep latency in persons with chronic fatigue syndrome-like illness. *Evid Based Complement Alternat Med.* 2014;2014:106048.
49 European Society of Hypertension-European Society of Cardiology Guidelines C . 2003 European Society of Hypertension-European Society of Cardiology guidelines for the management of arterial hypertension. *J Hypertens.* 2003;21(6):1011–1053.
50 Koga M, Ideishi M, Matsusaki M, et al. Mild exercise decreases plasma endogenous digitalislike substance in hypertensive individuals. *Hypertension.* 1992;19(Suppl. 2):II231–6.
51 YUPSZ , Chai JY. Heart rate variation in heart regulation of Qigong. *Acta Univ Tradit Medical Sinensis Pharmacol Ahanghai.* 2000;14:40–41.
52 Arakawa K. Exercise, a measure to lower blood pressure and reduce other risk. *Clin Exp Hypertens.* 1999;21(5–6):797–803.
53 Goto C, Higashi Y, Kimura M, et al. Effect of different intensities of exercise on endothelium-dependent vasodilation in humans: role of endothelium-dependent nitric oxide and oxidative stress. *Circulation.* 2003;108(5):530–535.
54 Liu X, Miller YD, Burton NW, Chang JH, Brown WJ. Qi-gong mind-body therapy and diabetes control: a randomized controlled trial. *Am J Prev Med.* 2011;41(2):152–158.
55 Hakkinen K, Alen M, Kallinen M, Newton RU, Kraemer WJ. Neuromuscular adaptation during prolonged strength training, detraining and re-strength-training in middle-aged and elderly people. *Eur J Appl Physiol.* 2000;83(1):51–62.
56 Fatouros IG, Kambas A, Katrabasas I, et al. Strength training and detraining effects on muscular strength, anaerobic power, and mobility of inactive older men are intensity dependent. *Br J Sports Med.* 2005;39(10):776–780.
57 Woo JS, Derleth C, Stratton JR, Levy WC. The influence of age, gender, and training on exercise efficiency. *J Am Coll Cardiol.* 2006;47(5):1049–1057.
58 O'Toole ML. Gender differences in the cardiovascular response to exercise. *Cardiovasc Clin.* 1989;19(3):17–33.
59 Lewis DA, Kamon E, Hodgson JL. Physiological differences between genders: implications for sports conditioning. *Sports Med.* 1986;3(5):357–369.
60 Keteyian SJ, Duscha BD, Brawner CA, et al. Differential effects of exercise training in men and women with chronic heart failure. *Am Heart J.* 2003;145(5):912–918.