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Original Article

Changes in heart-rate variability of survivors of nasopharyngeal cancer during Tai Chi Qigong practice

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Abstract. [Purpose] To explore the changes in heart-rate variability (HRV) of survivors of nasopharyngeal cancer (NPC) before, during, and after a Tai Chi (TC) Qigong exercise. [Subjects and Methods] Eleven survivors of NPC participated voluntarily in the study. The heart rate of each participant was measured continuously for 1 minute before the TC Qigong intervention, during the 5-minute TC Qigong intervention, and for 1 minute after the intervention, using a Polar heart-rate monitor. Spectral HRV was expressed in terms of normalised low frequency (LF) power, normalised high frequency (HF) power, and the low frequency/high frequency (LF/HF) power ratio. [Results] Both the LF-power and the HF-power components had significant time effects. However, the time effect of the LF/HF power ratio was not significant. Post hoc contrast analysis revealed a significant decrease in LF power and a concomitant increase in HF power during the 4th minute and 5th minute of the TC Qigong exercise. [Conclusion] Five minutes of TC Qigong exercise was found to improve HRV by increasing HF power and decreasing LF power, but these effects were transient. TC Qigong might be an appropriate exercise for improving the ANS function and psychological and cardiac health of survivors of NPC.
Key words: Autonomic nervous system, Mind-body exercise, Head-and-neck cancer

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INTRODUCTION

Autonomic nervous system (ANS) dysfunction is common in cancer patients[1)]. Cancer treatments such as chemotherapy and radiotherapy may also cause a variety of cardiac complications[2)]. Moreover, cancer-related dysfunction and the side-effects of cancer treatment can increase stress and adversely affect the psychological health of cancer patients and survivors[3)]. In recent years, heart-rate variability (HRV) has commonly been used as an indicator of the regulation of the heart by the ANS[4, 5)]. Changes in HRV are also associated with psychological symptoms and stress-induced sympathetic activation[4–7)]. Therefore, cancer may adversely affect patients' HRV[8)].

Compared with other cancer types, the incidence rate of nasopharyngeal cancer (NPC) is high, ranging from 25 to 50 per 100,000 in Southeast Asia and North Africa[9)]. Some of the survivors are young, which makes their ANS function and cardiac and psychological health especially clinically important. However, no researchers to date have measured HRV with specific attention to NPC survivors.

It is known that exercise training can improve cardiac ANS activity[10)]. Tai Chi (TC) Qigong, which is a kind of Chinese mind-and-body exercise, can be used to bring the body and mind into balance, reduce the side-effects of cancer treatments (e.g. cardiotoxicity)[2)] and relieve stress[3, 11)]. Details of the TC Qigong form have been described by Mak[11)]. It primarily involves meditation, coordinated breathing (Qigong), and slow and smooth TC movements[11)]. Therefore, we hypothesised that TC Qigong practice may improve HRV in survivors of NPC. The aim of this study was to explore the changes in HRV in survivors of NPC before, during, and after TC Qigong practice. The results may have clinical implications for the use of TC Qigong in the improvement of ANS function and the psychological and cardiac health of cancer survivors.

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SUBJECTS AND METHODS

Eleven survivors of NPC were recruited from the Nature Health Qigong Association by convenience sampling. All of the participants were ethnic Chinese who fulfilled the following inclusion criteria: a history of NPC diagnosis (i.e. positive Epstein-Barr virus DNA and biopsy-test results) and the completion of conventional medical care; medical stability; aged between 40 and 85 years; normal cognitive and sensorimotor functions; and at least three months' training in 18-Forms Tai Chi Internal Qigong[11] (3 sessions per week and 1 hour per session). The criteria for exclusion were as follows: significant respiratory, cardiovascular, neurological or musculoskeletal disorders that might have affected test performance; the use of medication of any form; and habitual smoking or drinking. Ethical approvals were obtained from the Ethics Committees of the University of Hong Kong and the Hong Kong Institute of Education. Written informed consent was also obtained from the participants. All of the procedures were conducted in accordance with the Declaration of Helsinki.

All of the physical measurements were taken by a physiotherapist and a trained research assistant at the Nature Health Qigong Association during a supervised TC Qigong training session. The room temperature was maintained at 22 °C. Before the HRV measurements, which were performed in a group setting, the participants were each asked to provide information on their demographic characteristics and medical histories (Table 1).

Polar heart-rate monitors (Polar Vantage NV, Polar Electro Oy, Finland) were used to continuously collect heart-rate data (in the form of R to R peak intervals) from all of the participants for 1 minute before the TC Qigong intervention (while standing still), during the 5-minute TC Qigong intervention, and for 1 minute after the TC Qigong intervention (while again standing still). The participants were asked to breathe naturally during the pre- and post-intervention periods, and to coordinate their breathing with their bodily movements during the TC Qigong exercise[11].

After the data collection (which took 7 minutes), frequency spectral analysis of the participants' HRV was conducted at 1-minute intervals using the Kubios HRV Version 2.1 software package (Biosignal Analysis and Medical Imaging Group, University of Eastern Finland, Finland). The participants' spectral HRV was expressed in terms of three components: normalised low frequency (LF) power (0.04–0.15 Hz), normalised high frequency (HF) power (0.15–0.4 Hz), and the low frequency/high frequency (LF/HF) power ratio. Normalised LF power represents a predominantly sympathetic modulation of the sinus node, while normalised HF power can be regarded as an index of vagal (parasympathetic) modulation. The LF/HF power ratio reflects sympathovagal balance, and may provide a better estimation of sympathetic influence on the heart rate. A ratio of less than 1 suggests a greater parasympathetic outflow, and a ratio greater than 1 indicates a shift toward increased sympathetic modulation[4, 5].

The statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) Version 20.0. Statistics such as the mean and standard deviation values were used to describe the demographic and outcome variables. Normality of the data was checked using the Shapiro-Wilk test. Mauchly's Test of Sphericity was also used to check the sphericity assumption. The Greenhouse-Geisser epsilon adjustment was used to correct violations of sphericity. All of the heart-rate data recorded before, during, and after the TC Qigong exercise were analysed using one way repeated measures analysis of variance (ANOVA). Post hoc contrast analysis of the time effect was performed when appropriate. The significance level was chosen as 0.05.

Table 1. Demographic characteristics of the participants

Total number of participants	11
Age (years)	54.7±7.4
Gender (number of males/females)	6/5
Height (cm)	164.9±9.5
Weight (kg)	61.9±12.3
Body-mass index (kgm^{-2})	22.7±3.6
Post-NPC duration (years)	11.7±7.0

Values are given as the mean ± SD unless otherwise specified.
NPC: nasopharyngeal cancer

RESULTS

The demographic data are presented in Table 1. Repeated-measures ANOVA revealed that the time effects of the normalised LF-power outcome ($F[6,60]=8.630$, $p<0.001$) and the normalised HF-power outcome ($F[6,60]=8.629$, $p<0.001$) were significant. However, the time effect of the LF/HF power ratio was not significant ($F[1.850,18.502]=2.859$, $p=0.086$). Post hoc contrast analysis of the outcomes with significant time effects revealed a significant decrease in normalised LF power and a concomitant increase in normalised HF power during the 4th minute ($p<0.001$) and 5th minute ($p<0.001$) of the TC Qigong exercise, compared with the baseline (pre-intervention) values. No significant differences were found between the pre- and post-intervention normalised LF power values or the pre- and post-intervention normalised HF power values ($p>0.05$) (Table 2).

DISCUSSION

This is the first study to show that as few as 4 or 5 minutes of TC Qigong practice may increase the normalised HF-power component and decrease the normalised LF-power component of HRV of survivors of NPC. Moreover, although the LF/HF power ratio was not found to have an overall statistical significance for the current sample size, it exhibited a trend of decrease towards the end of the TC Qigong exercise. Our results suggest that TC Qigong increases cardiac vagal tone, and simultaneously reduces sympathetic activity in cancer survivors[5]. However, these favourable outcomes were transient, disappearing within 1 minute of the cessation of the exercise.

Our findings are in agreement with those of a previous study in which Qigong training was shown to increase nor-

Table 2. Measurements of HRV of NPC survivors before, during and after TC Qigong practice

	Pre-intervention	1st minute TC Qigong	2nd minute TC Qigong	3rd minute TC Qigong	4th minute TC Qigong	5th minute TC Qigong	Post-intervention
Normalised LF power (nu)	75.1± 16.4	74.8± 17.6	66.1± 21.0	72.9± 14.7	40.6± 9.7**	44.0± 17.0**	62.9± 19.3*
Normalised HF power (nu)	24.9± 16.4	25.2± 17.6	33.7± 20.8	27.0± 14.5	59.0± 9.5**	55.8± 16.9**	37.0± 19.2*
LF-/HF-power ratio	5.76± 6.34	6.46± 8.36	4.12± 4.17	3.94± 3.30	0.74± 0.33	1.26± 1.88	2.66± 2.24

Values are given as the mean ± SD.
TC: Tai Chi; HRV: heart rate variability; NPC: nasopharyngeal cancer.
*$p<0.05$ for the results of the repeated-measures ANOVA.
**$p<0.05$ compared with the pre-intervention values.

malised HF power and decrease the LF/HF power ratio in healthy young adults[12]. We hypothesise that this phenomenon is due to meditation during TC Qigong training eliciting increases in parasympathetic tone[13] and/ or slow abdominal breathing during TC Qigong training eliciting reductions in sympathetic activity and enhancing vagal activity[14]. Further studies should be carried out examining both healthy individuals and survivors of NPC to test this hypothesis.

The major clinical implication of our findings is that TC Qigong has the potential to enhance the balance of the ANS in survivors of NPC by adjusting sympathetic and parasympathetic activity[15]. As a result, it may reduce stress[7], improve psychological health[4], and reduce cardiac disorders[15] among this particular group of individuals.

Although the results of this pilot study are promising, this study had several limitations. The respiratory rate, which may affect HRV[16], was not monitored concurrently; and other confounding factors that may influence HRV, such as age, gender[17] and body-mass index[18], were not controlled for in the analysis. Also, the sample size was small and no control group was used; therefore, the statistical power and internal validity of this study may have been compromised. Due to these potential limitations, the results of this study should be interpreted with caution.

In summary, a 5-minute TC Qigong exercise was found to improve HRV by increasing normalised HF power and decreasing normalised LF power (from the 4th minute of the exercise onward), but its effects were transient. This suggests that TC Qigong may be an appropriate exercise for improving ANS function and the psychological and cardiac health of survivors of NPC. However, regular practice may be necessary to maintain these beneficial effects.

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