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Effects of Qigong Exercise on Physical Fitness and Patient-reported Health Outcomes in Lung Cancer Survivors

Authors: Ruirui Xing[1], Renwei Wang[2], Eva M. Zopf[3, 4], Jerome N. Rachele[1, 5], Zhen Wang[6], Yuchao Li[7], Weimo Zhu[8]

1 Institute for Health and Sport, Victoria University, Melbourne, Australia

2 School of Exercise and Health, Shanghai University of Sport, Shanghai, China

3 Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia

4 Cabrini Cancer Institute, Department of Medical Oncology, Cabrini Health, Melbourne, Victoria, Australia

5 College of Sport, Health and Engineering, Victoria University, Melbourne, Australia

6 School of Martial Arts, Shanghai University of Sport, Shanghai, China

7 School of Physical Education, Taiyuan Normal University, Jinzhong, China

8 Department of Kinesiology and Community Health, University of Illinois, Urbana, IL 61801, USA

Corresponding authors:

Renwei Wang, School of Exercise and Health, Shanghai University of Sport, Shanghai, China; Email address: renwwang@163.com

Zhen Wang, School of Martial Arts, Shanghai University of Sport, Shanghai, China; Email address: wangzhen@sus.edu.cn

Abstract

Purpose The aim of this study was to investigate the effects of a three-month Guolin Qigong (GQ) intervention on physical fitness and patient-reported health outcomes among patients with lung cancer.

Methods This pilot study was a non-randomised controlled trial. Eligible participants who were over 18 years of age and diagnosed with stage I-IV lung cancer were enrolled in the study and received either the GQ intervention or usual care (UC). Participants in the GQ group performed GQ at least twice a week (one hour per session) for three months. Physical fitness (chair stand, arm curl, sit & reach, back scratch, 8-foot up & go, 6-minute walk test) was assessed at baseline, post-intervention, six months and 12 months. Self-reported quality of life and sleep (European Organization for Research and Treatment of Cancer Quality of Life questionnaire and Pittsburgh Sleep Quality Index) were assessed at baseline, post-intervention and six months.

Results Forty-nine participants (65% females, 59.1±7.0 years old, ranging from 39 to 71 years old) were enrolled in the study, and 25 participants completed all tests at 12-month follow-up (13 in GQ vs. 12 in UC; 68% females, 59.3±5.5 years old). Compared to the UC group, results for the chair stand and arm curl tests improved significantly in the GQ group from baseline to post-intervention ($P = 0.024$ and $P = 0.041$, respectively). Similarly, the 8-foot up & go test improved in the GQ group from baseline to post-intervention and 12 months ($P = 0.004$ and $P = 0.008$, respectively) when compared to the UC group. Between-group analyses also revealed a statistically significant improvement in Global health status/quality of life from baseline to six months ($P = 0.018$) and quality of sleep from baseline to post-intervention ($P = 0.034$) in favor of the GQ group.

Conclusion GQ had a beneficial effect on lower and upper body strength, locomotor performance (speed, agility and balance while moving), quality of sleep and quality of life among lung cancer survivors, but further randomized controlled trials are warranted

to confirm these findings.

Keywords: physical fitness, quality of life, sleep, lung cancer, Qigong

Trial registration: The trial has been registered in the Chinese Clinical Trial Registry (ChiCTR2200059145).

Introduction

Lung cancer is the most common incident cancer and one of the leading causes of cancer death in China [1]. The mortality rate of lung cancer is the highest compared with other types of cancer [2], with this rate expected to increase by approximately 40% between 2015 and 2030 [3]. According to a study by Chen et al., the overall 5-year survival rate in 2015 for cancer patients in China was approximately 36.9% [4]. However, lung cancer had a lower 5-year survival rate of 19.7%, compared to the overall rate for cancer patients [5]. Lung cancer treatment (e.g. chemotherapy) may cause loss of muscle mass and strength and reduce cardiorespiratory fitness [6, 7], and the symptoms such as fatigue, dyspnea and pain, can significantly impact mental well-being and quality of life [8].

Exercise is an effective strategy to mitigate treatment-related side effects and improve quality of life and physical fitness in cancer patients [9, 10], which is recommended by the American College of Sports Medicine (ACSM) [11] and the Exercise and Sports Science Australia position statement [12]. There is evidence suggesting that mind-body exercises can exert a positive effect on health-related quality of life [13]. Qigong, a fundamental part of traditional Chinese medicine, possesses a long history extending over thousands of years in China and has been practiced globally for several decades. It encompasses various forms, with Tai Chi being the most popular. Other notable forms include Six Healing Sounds, Eight Strands of the Brocades Qigong, Yijin Jing, and Guolin Qigong [14]. It not only strengthens or balances subtle energy (Qi) circulation throughout a person's entire body, but harmonises the body, mind and spirit [15]. It consists of gentle movements, breathing exercises and meditation, and is considered a low-to-moderate intensity aerobic exercise [16, 17]. Qigong is a meditative-movement therapy in that the movements are simpler, more repetitive, and easier to learn [18, 19]. It has been found to be feasible and safe in cancer patients

[14, 20] and may improve physical and psychological health in cancer patients [21, 22].

Despite some evidence showing the benefits of Qigong among cancer survivors, specific insights into the effects of Guolin Qigong (GQ) in lung cancer patients are largely unknown. Compared with other Qigong forms with over five-thousand-year-old history, GQ was created by Madam Guo more than five decades ago, a long-term cancer survivor who developed a network of self-help groups throughout China. This form of Qigong combines arm movements and slight twisting movements of the waist while slow walking. GQ is designed to promote physical and psychological health and help manage symptoms among patients with cancer [23]. Further, Lam found the GQ might improve survival rate in advanced liver cancer patients [24]. Research presented in conference papers indicates that cancer survivors who have practiced GQ for over ten years demonstrate enhanced levels of relative oxygen intake and physical fitness, as compared to those involved in free-living walking or control groups, among a diverse cohort of cancer patients in China [25, 26]. Although GQ has become popular around the world, with many adopting its techniques, focused research on its impact, especially in lung cancer patients, is scarce. For example, a Canadian study compared medical Qigong, another form of GQ, with endurance and strength training in patients with advanced stage non-small cell lung and gastrointestinal cancers for six weeks [27]. The GQ group showed fewer improvements in exercise capacity compared to the strength training group, which may be due to the limitations of the short intervention period and the small sample size. Notably, the impact on quality of life and psychological wellbeing was equivalent between groups. Further, Oh and colleagues found clinically improved health-related quality of life and symptom management in patients with various cancer types following a 10-week medical Qigong intervention [28]. However, there is a paucity of research focusing specifically on the long-term impacts of GQ in lung cancer survivors, particularly in the domains of physical fitness

and health-related outcomes. Thus, the aim of this prospective non-randomized controlled trial was to assess the impact of GQ on physical fitness and quality of life in lung cancer patients.

Methods

Study design and setting

This was a pilot study of a two-arm non-randomised controlled trial that was conducted from January 2016 to October 2017. This study was carried out in accordance with the Declaration of Helsinki and ethical approval was obtained from the Ethics Committee of the University of Shanghai Sport (Ref: 2018070). Patients with lung cancer were recruited from the 98th Shanghai Cancer Recovery Class, Shanghai, China. It is a self-help support group and non-governmental organization voluntarily united by different cancer patients.

Inclusion criteria consisted of: (1) diagnosed with Stage I-IV non-small cell lung cancer (NSCLC); (2) having completed primary treatment (chemotherapy and/or surgery); (3) >18 years of age; and (4) able to read and answer questionnaires independently. The exclusion criteria were: (1) cardiopulmonary, nerve, muscle, joint disease, or other malignant tumours affecting movement; (2) mental illness or serious cognitive impairment and defects in language; and (3) history of having participated in GQ exercise. Additionally, participants were required to complete the Physical Activity Readiness Questionnaire (PAR-Q) to exclude a potential safety risk with exercise [29]. All participants provided written informed consent prior to enrolment in the study. Following the baseline assessment, participants were given the option to choose between GQ exercise or UC depending on their personal preference.

Exercise intervention

Participants in the GQ group were trained systematically for three weeks on how to

perform GQ by several certified GQ instructors. They learned GQ for two hours per day, five days per week in the Shanghai Cancer Recovery Class. The sessions included the content of GQ: wind breath natural walking, step-in-place gong, up-and-down, open-and-close, one-step toe touch walking, two-step toe touch walking, three-step toe touch walking, strong wind breath fast walking, and 10-min free-living walking [26].

Once all training courses were completed, participants voluntarily exercised GQ twice a week for at least one hour each session for three-month in one of the parks nearby their homes. The experienced GQ instructors also provided one-on-one supervision (once a week) to participants in parks to ensure good quality exercise performance during the intervention. A brief session was separated into three parts: (1) warm up: gentle breathing and meditation; (2) main exercise: several standing and walking components using a unique "inhale-inhale-exhale" breathing pattern; (3) calm down: breathing exercises and self-massage. In addition, research assistants followed up with participants once per week to check whether they were exercising and to provide emotional support for three months. Participants recorded their GQ exercises in their diaries following each session.

Usual care group Participants in the usual care (UC) group did not receive any formal exercise advice from the research team. Instead, they were instructed to maintain their customary daily routine as recommended by their physicians.

Outcomes

Participants completed a baseline questionnaire which comprised clinical (incl. tumour stage) and sociodemographic data. Physical fitness was measured using the Senior Fitness Test [30], which is a widely used fitness test for elderly with or without chronic diseases. The Senior Fitness Test is tested for reliability, with an intra-class correlation coefficient (ICC) ranging from 0.80 to 0.98 on the different items [31]. The Senior

Fitness Test measures a variety of physiological parameters and functional activities. A more detailed description of the items is provided in the supplementary table 1. Gait speed and balance were assessed with the 8-foot up & go test. Upper body performance was assessed with the arm curl test, and lower body performance was assessed with the chair stand test. Flexibility was measured by means of the chair sit-and-reach and back scratch test. The six minute walk test, which has been used widely with cancer patients, was used to estimate aerobic fitness [32]. Before undertaking the Senior Fitness Test, all participants completed a warm-up for 5-10 minutes. The physical fitness test was assessed at baseline (before three-week training courses), post-intervention (three months), six months, and 12 months follow up and was conducted by trained research assistants.

Health-related quality of life was measured using the European Organization for Research and Treatment of Cancer Quality of Life questionnaire (EORTC QLQ-C30) [33]. The EORTC QLQ-30 includes five functional scales, three symptom scales, a global health status/quality of life (QoL) scale, and six single items. This questionnaire is among the most widely used among patients with cancer and shows high validity and reliability (Cronbach's alpha coefficient ≥ 0.7) [34]. To measure the quality of sleep, the Pittsburgh Sleep Quality Index (PSQI) was used, which internal consistency Cronbach's alpha for the Global Sleep Quality scale was 0.81 and test-retest reliability was ranging from 0.770 to 0.808 [35].These patient-reported outcomes were assessed at baseline (before three-week training courses), post-intervention (three months), and six months.

Statistical analysis

Regarding the nature of a pilot study, the aim was to recruit 50 patients, with 25 in each group. The sample size was determined based on the number of patients in the Shanghai Cancer Recovery Class and the interest expressed by patients in a prior

evaluation.

The study followed the intention-to-treat approach: data from all participants that completed the baseline assessment were included in the following analyses. Normal distribution was tested by the Shapiro-Wilk test due to small sample size ($n < 50$). The baseline characteristics between the GQ and UC groups were assessed by a chi-square test and *t* test for categorical and continuous data, respectively. Between-group and within-group changes were examined using mixed model repeated measure analysis, as they can accommodate missing data without the need for imputation, thereby providing a natural way to deal with missing values or dropouts [36]. Time was treated as a categorical variable. The covariates included in the mixed models included group, time, group × time and the baseline value for the outcome variable. Participants were treated as random effects (random intercept) and the first-order autoregressive (AR(1)) covariance structure was used. *P* values < 0.05 were considered significant for all analysis. Hedge's *g* effect size was calculated to help interpretate the changes between groups at post-intervention (all data), 6 months (all data), and 12 months (physical fitness data). Effect sizes were defined as small effect size ($0.2 < g < 0.49$), moderate effect size ($0.5 < g < 0.79$) and strong effect size ($g > 0.8$) according to Cohen's rule. All analyses were performed using IBM SPSS Version 26.0.

Results

Characteristics of the patients

Forty-nine participants expressed interest, met all the eligibility criteria and were enrolled into the study. Eighteen participants chose to take part in the GQ group and thirty-one participants preferred to receive UC. The post-intervention completion rate for assessments was 93.9%, with 69.4% of participants completing the third assessment at six months and 51.0% completing the final assessment (physical fitness test only) at 12 months. Of participants that dropped out of the study, 27.8% were from

the GQ group, and 61.3% were from the UC group at the 12 months follow-up time point. The flow of participants through the study and reasons for dropout are detailed in Figure 1.

Baseline characteristics of the study participants are presented in Table 1. Thirty-one females and twelve males were included in the study. The majority of patients were diagnosed with a stage I tumour. All patients received lung resection surgery prior to participating in this study. Sixty-one percent of participants had completed chemotherapy treatment prior to attending the study. All physical fitness variables were normal distribution, while patient-reported health outcomes were non-normal distribution. No statistically significant differences were found between the two groups at baseline.

Physical fitness

The effect of GQ exercise on physical fitness is summarized in Table 2. When compared to the UC group, the GQ group improved significantly in the chair stand test and arm curl test following the intervention (mean difference 2.21; 95% CI, 0.30, 4.12; $P = 0.024$; hedge's $g = 0.10$ and mean difference 2.07; 95% CI, 0.09, 4.06; $P = 0.041$; hedge's $g = 0.23$ respectively). Significant between-group changes were also observed for the 8-foot up & go test from baseline to post-intervention and 12 months in favour of the GQ group (mean difference -0.71; 95% CI, -1.19, -0.23; $P = 0.004$; hedge's $g = 0.12$ and mean difference -0.85; 95% CI, -1.47, -0.22; $P = 0.008$, hedge's $g = 0.16$ respectively). In terms of within-group differences, the GQ group experienced significant improvements from baseline to post-intervention and 12 months in the chair stand from the baseline to post-intervention and at 12 months in the chair stand test, with scores evolving from 13.95±0.64 to 17.12±0.64, and to 21.85±0.74 ($P < 0.05$). Similarly, in the arm curl test, this group showed improvements, with scores increasing from 16.25±0.71 to 19.14±0.71, and then to 22.15±0.82 ($P < 0.05$). The UC group

improved in both tests from baseline to 12 months (from 14.39±0.50 to 20.61±0.77, 16.69±0.55 to 20.53±0.84, $P < 0.05$). Within the GQ group, a significant improvement from baseline (6.63±0.15) to six months (5.78±0.17) and 12 months (5.43±0.18) was also observed in the 8-foot up & go test ($P < 0.05$). The 6-minute walk test improved significantly within both groups from baseline (439.47 in GQ vs. 438.12 in UC) to six months (484.05 in GQ vs. 484.63) and 12 months follow-up (510.28 in GQ vs. 513.95 in UC).

Patient-reported health outcomes

Quality of life and quality of sleep outcomes are summarized in Table 3. Significant between-group differences in favour of the GQ group were observed in Global health status/QoL at six months (mean difference 13.09; 95% CI, 2.32, 23.85; $P = 0.018$, hedge's $g = 0.63$), constipation at post-intervention (mean difference 12.73, 95% CI, 2.05, 23.41; $P = 0.020$; hedge's $g = 0.78$) and PSQI score at post-intervention (mean difference -2.04; 95% CI, -3.92, -0.16; $P = 0.034$; hedge's $g = 0.14$). Regarding within-group changes in patient-reported health outcomes, the GQ group experienced a significant increase in Global health status/QoL from baseline to post-intervention and 6-month, a significant reduction in pain from baseline to six months, and improvements in PSQI post-intervention, while the UC group experienced significant improvements in social function from baseline to six months and a reduction in constipation post-intervention.

Table 1. Baseline demographic characteristics of study participants.

	GQ (*n* =18)	UC (*n* = 31)	*P* value
Age, years, mean (SD)	59.2 (7.3)	59.8 (6.7)	0.643
Gender, *n* (%)			
Female	12 (66.7%)	23 (74.2%)	0.299
Male	6 (33.3%)	8 (25.8%)	
Years since diagnosis	2.8 (0.7)	2.6 (0.8)	0.921
Cancer stage, *n* (%)			0.107
I	9 (50.0%)	17 (54.8%)	
II	3 (16.7%)	1 (3.2%)	
III	4 (22.2%)	8 (25.8%)	
IV	2 (11.1%)	5 (16.1%)	
Primary treatment, *n* (%)			
Radiotherapy	3 (16.7%)	1 (3.2%)	0.147
Chemotherapy	15 (83.3%)	15 (48.4%)	0.694
n.a		8 (25.8%)	

GQ: Guolin Qigong; SD: standard deviation; UG: usual care.

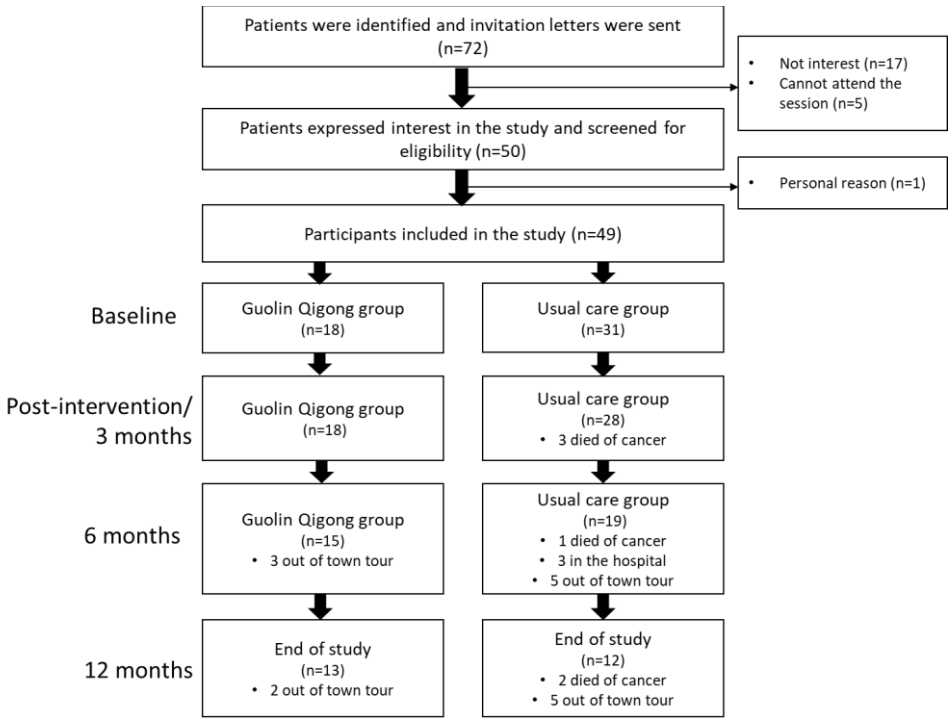

Figure 1. Recruitment flow diagram.

Table 2. Physical fitness outcomes by group over time.

		Baseline	Post-intervention	6 months	12 months	Between-group difference from baseline to post- intervention			Between-group difference from baseline to 6 months			Between-group difference from baseline to 12 months		
		Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean difference	*P* value	ES	Mean difference	*P* value	ES	Mean difference	*P* value	ES
Chair stand test, rep	GQ	13.95 (0.64)	17.12 (0.64)[a]	16.32 (0.74)	21.85 (0.74) [c]	2.21 (0.30; 4.12)	0.024	0.10	1.25 (-1.27; 3.77)	0.329	0.75	1.69 (-0.91; 4.30)	0.202	0.01
	UC	14.39 (0.50)	15.35 (0.51)	15.51 (0.75)	20.61 (0.77) [c]									
Arm curl test, rep	GQ	16.25 (0.71)	19.14 (0.71)[a]	18.09 (0.81)	22.15 (0.82) [c]	2.07 (0.09; 4.06)	0.041	0.23	2.48 (-0.23; 5.18)	0.072	0.01	2.07 (-0.79; 4.92)	0.155	0.25
	UC	16.69 (0.55)	17.51 (0.56)	16.06 (0.82)	20.53 (0.84) [c]									
Chair sit & reach test, cm	GQ	-3.14 (1.41)	-0.45 (1.41)	0.96 (1.62)	2.18 (1.64)	4.11 (-0.18; 8.41)	0.060	0.09	3.16 (-2.47; 8.78)	0.269	0.04	1.85 (-3.98; 7.59)	0.539	0.05
	UC	-2.66 (1.07)	-4.09 (1.12)	-1.71 (1.67)	0.86 (1.70)									
Back scratch test, cm	GQ	-2.50 (1.07)	-1.93 (1.07)	-0.06 (1.25)	-2.87 (1.25)	3.02 (-0.49; 6.53)	0.089	0.15	0.26 (-4.11; 4.64)	0.906	0.06	-0.71 (-5.15; 3.74)	0.754	0.72
	UC	-2.10 (0.81)	-4.55 (0.85)	0.08 (1.29)	-1.76 (1.31)									
8-foot up & go test, sec	GQ	6.63 (0.15)	6.16 (0.15)	5.78 (0.17)[b]	5.43 (0.18) [c]	-0.71 (-1.19; -0.23)	0.004	0.12	-0.34 (-0.95; 0.26)	0.265	0.83	-0.85 (-1.47; -0.22)	0.008	0.16
	UC	6.49 (0.11)	6.74 (0.12)	5.98 (0.18)	6.15 (0.19)									
6-minute walk test, meter	GQ	439.47 (8.26)	462.60 (8.26)	484.05(9.70) [b]	510.28(9.71) [c]	18.43 (-9.86; 46.73)	0.199	0.35	-1.92 (-36.41; 32.57)	0.912	0.36	-5.02 (-40.05; 30.01)	0.777	0.17
	UC	438.12 (6.31)	442.82 (6.74)	484.63(10.14)[b]	513.95(10.56)[c]									

ES: effect size; GQ: Guolin Qigong; SE: standard error; UG: usual care.

[a] *P* value<0.05 for changes within groups from baseline to post intervention/3 months

[b] *P* value<0.05 for changes within groups from baseline to 6 months

[c] *P* value<0.05 for changes within groups from baseline to 12 months

Table 3. Patient-reported health outcomes by group over time.

		Baseline	Post-intervention	6 months	Between-group difference from baseline to post intervention			Between-group difference from baseline to 6 months		
		Mean (SE)	Mean (SE)	Mean (SE)	Mean difference	*P* value	ES	Mean difference	*P* value	ES
Global health status/QoL	GQ	65.45 (2.88)	79.27 (3.20) [a]	82.19 (3.19) [b]	9.42 (-1.51; 20.34)	0.090	0.14	13.09 (2.32; 23.85)	0.018	0.63
	UC	66.67 (2.07)	71.07 (3.08)	70.32 (2.64)						
Physical function	GQ	75.76 (1.40)	75.18 (1.55)	75.99 (1.55)	-1.07 (-6.38; 4.24)	0.689	0.10	0.34 (-4.90; 5.57)	0.899	0.10
	UC	76.54 (1.01)	77.04 (1.49)	76.44 (1.28)						
Role function	GQ	91.17 (2.55)	90.35 (2.81)	91.32 (2.83)	0.80 (-8.44; 10.03)	0.864	0.11	0.90 (-8.56; 10.37)	0.850	0.38
	UC	91.73 (1.83)	90.12 (2.69)	90.98 (2.35)						
Emotional function	GQ	78.11 (2.60)	84.82 (2.89)	86.23 (2.88)	1.54 (-8.78; 11.86)	0.766	0.03	3.19 (-6.58; 12.95)	0.519	0.10
	UC	79.18 (1.87)	84.35 (2.78)	84.12 (2.39)						
Cognitive function	GQ	76.50 (2.27)	82.25 (2.49)	83.47 (2.49)	2.28 (-5.64; 10.20)	0.567	0.22	3.63 (-4.63; 11.89)	0.385	0.00
	UC	77.78 (1.62)	81.24 (2.36)	81.12 (2.07)						
Social function	GQ	67.58 (3.07)	75.38 (3.43)	77.87 (3.39)	-1.23 (-13.32; 10.85)	0.839	0.81	-2.59 (-14.06; 8.88)	0.655	0.60
	UC	69.61 (2.19)	78.65 (3.27)	82.49 (2.83) [b]						
Fatigue	GQ	33.99 (2.88)	30.59 (3.16)	29.76 (3.17)	0.97 (-8.95; 10.89)	0.845	0.33	-7.03 (-17.48; 3.41)	0.184	0.31
	UC	33.93 (2.07)	29.56 (2.98)	36.74 (2.64)						
Nausea/vomiting	GQ	4.40 (2.38)	6.12 (2.64)	5.78 (2.64)	4.96 (-4.68; 14.60)	0.308	0.03	5.03 (-3.89; 13.95)	0.266	0.23
	UC	6.59 (1.71)	3.36 (2.54)	2.94 (2.18)						
Pain	GQ	18.25 (2.26)	12.36 (2.48)	8.76 (2.49) [b]	3.68 (-4.21; 11.58)	0.355	0.34	-3.72 (-11.98, 4.53)	0.373	0.03
	UC	18.98 (1.62)	9.41 (2.35) [a]	13.22 (2.07)						
Dyspnea	GQ	28.61 (4.06)	16.07 (4.49)	20.47 (4.51)	-10.49 (-25.38; 4.40)	0.164	0.20	-3.30 (-18.38; 11.79)	0.666	0.36
	UC	29.32 (2.93)	27.27 (4.30)	24.48 (3.73)						
Insomnia	GQ	29.48 (4.03)	17.13 (4.43)	23.87 (4.45)	-4.35 (-18.50; 9.80)	0.541	0.09	-1.18 (-15.93; 13.56)	0.874	0.03
	UC	29.89 (2.90)	21.89 (4.21)	25.47 (3.69)						
Appetite loss	GQ	16.61 (3.42)	13.78 (3.79)	8.87 (3.79)	-6.41 (-19.50; 6.67)	0.332	0.18	-9.78 (-22.57; 3.00)	0.132	0.09
	UC	14.80 (2.45)	18.39 (3.65)	16.85 (3.14)						
Constipation	GQ	18.31 (2.92)	16.68 (3.23)	12.24 (3.22)	12.73 (2.05; 23.41)	0.020	0.78	-3.14 (-13.96; 7.68)	0.566	0.06
	UC	17.52 (2.09)	3.17 (3.08) [a]	14.59 (2.68)						
Diarrhea	GQ	10.25 (4.02)	21.79 (4.45)	16.69 (4.44)	10.97 (-3.67; 25.61)	0.139	0.31	8.26 (-6.66; 23.18)	0.275	0.33
	UC	12.46 (2.92)	13.03 (4.23)	10.65 (3.68)						
Financial difficulties	GQ	32.70 (5.87)	32.18 (6.53)	23.05 (6.49)	5.14 (-16.85; 27.12)	0.642	0.69	-4.38 (-26.25; 17.50)	0.692	0.01
	UC	29.12 (4.21)	23.46 (6.23)	23.84 (5.39)						
PSQI	GQ	7.24 (0.60)	5.01 (0.63) [a]	5.77 (0.63)	-2.04 (-3.92; -0.16)	0.034	0.14	-2.00 (-4.08; 0.07)	0.058	0.16
	UC	7.15 (0.44)	6.95 (0.60)	7.68 (0.56)						

ES: effect size; GQ: Guolin Qigong; PSQI: Pittsburgh Sleep Quality Index; SE: standard error; UC: usual care.

[a] *P* value<0.05 for changes within groups from baseline to post-intervention/3 months

[b] *P* value<0.05 for changes within groups from baseline to 6 months

Discussion

Findings from this non-randomised controlled pilot study suggest that GQ can improve physical fitness, QoL and sleep quality in lung cancer survivors. Specifically, when compared to the UC group, the GQ group experienced significant improvements in lower and upper body strength, locomotor performance (speed, agility and balance while moving) and quality of sleep after completing the three-month GQ training. Further, QoL was significantly higher in the GQ group when compared to the UC group at the six-month follow-up.

It is widely acknowledged that aerobic and/or resistance exercise can improve physical fitness in lung cancer patients, however the effects of mind-body exercises, and in particular GQ, on physical health outcomes are underexplored [37, 38]. This study demonstrates that GQ can also have a beneficial effect on physical fitness in lung cancer patients, with improvements in lower and upper body strength and locomotor performance observed in the QG group when compared to UC. However, our study found no improvement in aerobic capacity. It is possible that longer intervention periods of mind-body exercises are necessary to elicit greater improvements in aerobic capacity. For example, Wang et al. reported the higher level of aerobic capacity in 6 minute walk test after long-term GQ practice in patients with various types of cancer compared to the control group [25]. Similarly, Fong et al. reported significant improvements in aerobic capacity among nasopharyngeal cancer survivors following six months of Tai Chi [39]. Further, previous studies have reported that exercise modalities involving higher intensities might have more beneficial effects on physical fitness. For example, Cheung et al. found greater improvements in the up & go and sit & stand test in advanced lung cancer patients receiving an aerobic exercise intervention compared to a Taichi intervention [40]. Similarly, Vanderbyl et al. reported that six-week cardiovascular and resistance exercises increase physical fitness in

advanced cancer patients when compared to Qigong, though the sample size was lower than 10 per group [27]. Further, in a three-arm study involving around four hundred female cancer survivors, researchers found leg strength significantly improved in the strength training group compared with controls, while balance improved in the Tai Chi group compared with controls [41]. While further studies are required to better understand the effect of GQ on physical health outcomes, the findings of this study are promising, especially in conjunction with the beneficial effects on patient-reported health outcomes.

Exercise has been shown to improve patient-reported health outcomes, such as quality of life, psychological wellbeing and sleep, in lung cancer patients [38]. The significant improvements that we observed in global health and quality of sleep in the GQ group compared to the UC group, are also in line with a recent systematic review and meta-analysis of randomized and non-randomized clinical trials, which summarized the beneficial effects of Tai Chi and Qigong interventions on sleep and quality of life in cancer patients [13]. Our observations indicate that the quality of life in GQ group exhibited a steady increase, rising from 65.45 at baseline to 82.19 at 6 months. In contrast, the UC group demonstrated a minor increase from 66.67 at baseline to 71.07 after intervention, before slightly declining to 70.32 at 6 months. This trend is consistent with findings from other studies, such as Oh et al when compared to UC [28]. Moreover, Molassiotis et al. reported an improvement in Global health status in patients with lung cancer after 12-week “Qigong Standard” exercise compared with a waitlist group that received UC [42]. Five-to-six weeks of GQ was found to elicit beneficial effects on QoL among women with breast cancer undergoing radiotherapy when compared to a wait list control group, particularly in those with elevated levels of depressive symptoms [43]. Our findings, particularly the significant improvements noted at the 6-month follow-up, suggest that some lung cancer patients continued to exercise following the

intervention, as indicated during our infrequent contact. Regarding the effects of mind-body exercises on sleep, Lu et al. found improvements in quality of sleep compared to a control group among patients with colorectal cancer participating in a 24-week Baduanjin Qigong while undergoing chemotherapy [44]. Similarly, MaQuade and colleagues reported significant improvements in sleep duration among prostate cancer patients undergoing radiotherapy who received Qigong/Tai Chi interventions compared to those receiving light exercise and wait list controls [45]. While a latest review on mind-body therapies in cancer care supports the strong effects of Tai Chi and Qigong interventions on fatigue and sleep in patients with cancer [46], we found no intervention effect on fatigue. However, we did not include a dedicated fatigue questionnaire in our study, which may have provided better insights. Further, our study revealed an unexpected improvement in constipation in the UC group compared to the GQ group at three-months. At the six-month follow-up, no significant difference was observed between the GQ and UC groups in terms of constipation (12.24 vs. 15.59). Further investigation is required to understand the reasons behind these unexpected findings. Regarding the other subscales measured by the EORTC-QLQ C30, our study found no significant differences between the groups.

This study has several strengths and limitations. The long follow-up period enabled us to observe changes in physical fitness, quality of life and sleep following the intervention and should be considered a strength. Additionally, this study is unique as it only included lung cancer survivors. Limitations include the dropout rate among the UC group (> 50%), which is much higher than in the GQ group (27.8%). This is understandable given the enthusiasm among cancer patients around GQ [47]. Patients in the UC group mainly dropped out because they chose to travel rather than stay in Shanghai to attend the assessments. While it is not uncommon that exercise trials involving usual care groups have unequal dropout rates, this may lead to bias [48].

Another limitation is that we did not assess the physical activity levels and comorbidity between groups. Moreover, the mean age of our study participants, 59.3 years old, is below the average age for lung cancer patients (65.97 years old in 2014) [49]. Expanding our study to include a more diverse age range is recognized. Future studies may address the age-related limitation. Lastly, the study was not a randomized controlled trial as the group allocation was based on patient preference. However, previous research indicates that this preference-based approach produces similar observed effects on clinical outcomes and adherence, while also resulting in lower attrition rates compared to randomized controlled trials of the same exercise interventions [50]. Future randomized controlled studies with large sample sizes and active engagement are warranted to investigate the effects of GQ on physical fitness and patient-reported health outcomes in lung cancer survivors.

Conclusions

The findings from this study suggest that GQ is both feasible and beneficial for patients with lung cancer, with improvements observed in lower and upper body strength, locomotor performance (speed, agility and balance while moving), quality of sleep and life. Yet, further randomized controlled trials are warranted to assess the effects of GQ exercise on, for example, physical capacity.

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the University of Shanghai Sport (Ref: 2018070).

Conflict of interest The authors declare that they have no conflict of interest.

Consent to participate Informed consent was obtained from all individual participants

included in the study.

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Data availability The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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