

# Effect of supervised aerobic exercise on the physical and mental health of lung cancer patients

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## Research

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# Abstract

## Background

The present study was designed to evaluate the impact of aerobic exercise and climate on cardiopulmonary fitness, overall physical health, and mental health in non-small cell lung cancer (NSCLC) patients.

## Methods

Between 2014 and 2019, a total of 111 NSCLC patients with stage IIIB and stage IV disease that had undergone standard treatment were separated into two experimental groups: a control group that conducted stretching exercises, and a test group that practiced Guolin qigong (GLQG). Of these patients, 56 remained in Heilongjiang Province and 55 went to Hainan Province during a 4-month period in the winter. Interventions were practiced three times per week. Cardiorespiratory fitness was the primary study outcome, whereas secondary outcomes included changes in anxiety, depression, dyspnea, immune functionality, and quality of life (QOL).

## Results

Patients in the Heilongjiang Province cohort that had practiced GLQG exhibited significant improvements in cardiopulmonary functionality, depression, and QOL (social well-being, functional well-being, and lung cancer subscale scores) relative to the control group ( $P < 0.05$ ). Similarly, in the Hainan Province cohort, the patients that had practiced GLQG exhibited significant improvements in their cardiorespiratory fitness, dyspnea, depression, and QOL relative to controls ( $P < 0.05$ ). Following a 4-month intervention period, we additionally detected significant differences between patient groups in both provinces with respect to both mean albumin-to-globulin ratio (AGR) and neutrophil-to-lymphocyte ratio (NLR) values ( $P < 0.05$ ). The intervention cohort in Hainan Province exhibited significant improvements in cardiorespiratory fitness (VO<sub>2</sub>MAX, FEV<sub>1</sub>/FVC (%), FEV<sub>1</sub>% pred, and FVC % pred), dyspnea, and QOL (Physical and emotional well-being subscales) relative to the intervention cohort in Heilongjiang Province ( $P < 0.05$ ).

## Conclusions

GLQG and a more favorable climate are both associated with significant improvements in the QOL, immune functionality, and cardiorespiratory function of NSCLC patients.

## Background

Non-small cell lung cancer (NSCLC) remains one of the most prevalent and deadly forms of cancer in China, with approximately 35% of patients with locally advanced NSCLC (LA-NSCLC) having unresectable tumors.[1] In these patients, treatment primarily consists of a combination of radiotherapy and/or chemoradiotherapy (CRT). While the development of novel therapeutic regimens has led to a significant reduction in NSCLC-associated mortality, patients may nonetheless suffer from a number of physical and psychological complications following disease treatment.[2] Such complications can include irradiation-induced pulmonary fibrosis, decreased quality of life (QOL), impaired cardiorespiratory fitness, anxiety, and depression.[3, 4] To date, however, limited progress has been made in the alleviation of these complications.

Supervised exercise has been shown to bolster both physical functioning and QOL in cancer patients.[5–7] Qigong is a form of traditional aerobic exercise practiced in China that focuses on promoting harmony between mind, body, energy, and abdominal breathing. This practice combines gentle aerobic exercise with mindfulness activities and has been shown to be beneficial for the functionality of many organ systems.[8, 9] Qigong incorporates focused abdominal breathing that can improve gas exchange and alveolar ventilation, leading patients to feel more invigorated,[10] and it has been shown to improve the emotional resilience and well-being of practitioners.[11, 12] Guo Lin Qigong (GLQG) is a form of this practice that incorporates slow walking-based exercises together with proscribed twisting and arm movements. GLQG can be safely practiced by cancer survivors, and offers clear advantages over of Qigong programs as it promotes greater oxygen inhalation, thereby potentially helping with lung cancer patient rehabilitation.[13] One recent study of breast cancer patients in China found that GLQG was associated with significant improvements in mental health and QOL.[9] Other studies have found that the efficacy of GLQG in cancer patients is linked to

increased arterial blood oxygen contents, potentially further improving microvascular circulation and immune function in these individuals.[14, 15]

Colder climates and higher levels of PM2.5 pollution have been linked to decreased cardiorespiratory fitness in some studies.[16–18] As a large nation, China incorporates a range of climatic environments including tropical, subtropical, and temperate zones. Whereas Heilongjiang Province in northeastern China experiences cold winters and high levels of PM2.5 pollution, Hainan Province in southern China is tropical. Given its favorable climate and cleaner air, many cancer survivors from northern China go to Hainan during the winter.

To date, there have been no prospective trials designed to evaluate the beneficial impacts of GLQG and climate on lung cancer patients. As such, the present study was designed to determine whether GLQG and a more favorable climate would improve cardiorespiratory fitness, immune functionality, and psychological well-being in NSCLC patients.

## Methods

### Study design

A total of 4 groups of NSCLC patients were included in the present study. A control group and a GLQG group were established in both Hainan and Heilongjiang Province, and patients in these groups conducted prescribed interventions for a 4-month period. Outcomes including cardiorespiratory fitness, QOL, anxiety, depression, dyspnea, neutrophil-to-lymphocyte ratio (NLR), and albumin-to-globulin ratio (AGR) were measured for all patients. NLR and AGR were specifically monitored to gauge immune functionality and cancer progression.

### Participants

In total, 131 NSCLC patients (age: 45–75 years) with histologically confirmed stage IIIB or IV disease were recruited using advertisements posted at the Association for Cancer Rehabilitation at Heilongjiang and Harbin Medical University Cancer Hospital between 2014 and 2019. All patients had undergone chemotherapy and/or radiotherapy within the past 12 months, and no patients had practiced any form of Qigong within 6 months. Patients were excluded if they had any history of serious mental illness, psychiatric disease, psychotropic drug exposure, terminal diseases other than NSCLC, or conditions that limited mobility. Interested participants were given the opportunity to attend an informational session regarding the study. Qualified patients were then invited to participate in the study. Three patients did not meet inclusion criteria; Six patients declined to participate. In total, between 2014 and 2019 61 NSCLC patients remained in Heilongjiang Province, while 63 patients went to Hainan Province during the 4 coldest months of the year (November–February). (Fig. 1)

### Interventions

All patients provided informed consent to participate in this study, and were then separated into four groups: control and GLQG groups in Hainan Province, and control and GLQG groups in Heilongjiang Province. Patients in control groups conducted guided stretching exercises (The Ninth Radio Calisthenics), whereas patients in GLQG groups completed three 60-minute GLQG sessions per week for 4 months. A certified GLQG master guided all GLQG training, introducing patients to techniques including meditation, breathing exercises, phonation, massage, and walking). These sessions were also supervised by a research assistant with a background in GLQG and social work. To ensure compliance, all participants were required to self-report the duration and intensity of their prescribed activities each day. Participants were given access to clinical treatment for the duration of the intervention period, and were required not to complete any other exercises such as yoga, tai chi, pilates, other Qigong training, body-mind exercises or if any exercise (endurance exercise, resistance/strength training).

### Outcome assessments

Outcome measures of interest were assessed at baseline, at the end of the first week of intervention, and at the end of the 4-month intervention period. Laboratory data were collected at baseline and following 2 or 4 months of the intervention period.

Questionnaires were administered to patients by trained research assistants, and all blood samples were collected between 7:00 and 10:00 AM. Intervention compliance was ensured via review of attendance records and patient self-reports. Assessors of outcome measured were blinded to patient group assignments. Measured outcomes were as follows:

## 1. Cardiorespiratory fitness

Maximal oxygen uptake was evaluated on a treadmill testing using an adapted version of the Bruce protocol employing a total of two-four 3-minute workload increments of continuous exercise, with the heart rate (HR) being monitored with a fitness watch during testing. The goal of this approach was to raise the HR of participants to between 110 beats per minute (bpm) and either 70% of the HR reserve (HRR) or 85% of the HRmax predicted based on participant age. A minimum of two consecutive measurements was required to ensure data accuracy and to allow for accurate VO2MAX predictions to be made. The results of a pulmonary function test (PFT) were used to measure FEV1 (% of predicted), FVC (% of predicted), and the FEV1/FVC (ratio) for study subjects. These measurements were made using a ZJ81Micro Quark pulmonary function device (Cosmed Company, Italy).

## 2. QOL

NSCLC patient QOL was evaluated using the validated Chinese version of the Functional Assessment of Cancer Therapy–Lung (FACT-L) scale. This instrument is composed of 36 total items grouped into 5 total subscales, including measures of social, physical, functional, and emotional well-being, as well as measures of lung cancer symptoms.

## 3. Anxiety and depression.

The Hospital Anxiety and Depression Scale (HADS) was used to evaluate all study subjects for anxiety and depression. This scale includes two separate subscales to measure these two parameters, and consists of 14 total items.

## 4. Dyspnea

A self-reported Numeric Rating Scale (NRS) was used to evaluate dyspnea symptoms in study subjects. This NRS was modeled after one used to rate pain, and it exhibits well-established validity. The results of this NRS are also closely correlated with those of the validated Visual Analog Dyspnea Scale (VADS). Briefly, this scale consists of a range from 0 (no dyspnea) to 10 (most severe dyspnea). Patients were asked to rate the severity of their respiratory distress using this scale.

## 5. Laboratory data

Collected laboratory data types included neutrophil counts, lymphocyte counts, and serum ALB and GLB values. Absolute neutrophil counts were divided by absolute lymphocyte counts to yield NLR values, whereas serum ALB values were divided by serum GLB values to compute the AGR.

## Statistical analysis

SPSS 23.0 was used for all statistical testing. Missing data were addressed using an intention-to-treat (ITT) analysis wherein the most recent available data point was used for subsequent statistical analyses. Data were compared via independent t-tests and  $\chi^2$  tests, as appropriate.  $P < 0.05$  was the significance threshold.

## Results

### 1. Baseline patient characteristics

We observed no significant differences among patient groups at baseline with respect to clinical or demographic variable such as age, sex, disease stage, histological findings, marital status, employment, household income, residence, education, first treatment, target regimen, or ECOG PS score (Table 1). Patients enrolled in the present study were between 40 and 75 years of age (mean:  $58.09 \pm 7.21$  years).

Table 1  
Demographics and medical history of participants at baseline

Variable	HLJ (N = 56)			HN (N = 55)		
	total (n)	Control group (n = 27)	Intervention group (n = 29)	total (n)	Control group (n = 27)	Intervention group (n = 28)
<b>Age (years)</b>						
< 40	11	6	5	12	7	5
40–60	19	11	8	18	10	8
> 60	26	10	16	25	10	15
<b>Gender</b>						
Male	25	11	14	27	13	14
Female	31	16	15	28	14	14
<b>Disease stage</b>						
IIla	26	12	14	26	13	13
IIlb	28	14	14	27	14	13
IV	2	1	1	2	1	1
<b>Histology</b>						
Adenocarcinoma	32	14	18	29	12	17
Squamous cell carcinoma	19	10	9	20	11	9
other	5	3	2	6	4	2
<b>ECOG PS score</b>						
0	35	15	20	34	13	21
1	21	12	9	21	11	9
<b>Education</b>						
Below high school	10	7	3	10	7	3
College and higher	46	20	26	45	20	25
<b>Marital status</b>						
Not married	8	4	4	11	7	4
Married	48	23	25	44	20	24
<b>Employment status</b>						
Retired or unemployed	45	20	25	43	19	24
Employed	11	7	4	12	9	3
<b>Residence</b>						
City	50	23	27	46	20	26
Countryside	6	4	2	9	7	2

	HLJ (N = 56)			HN (N = 55)		
Household income (RMB/month/person)						
< 7000	35	16	19	25	13	12
> 7000	21	11	10	30	14	16

## 2. Baseline patient physical and psychological characteristics

We did not observe any significant differences among patient groups with respect to dyspnea severity or cardiorespiratory fitness at baseline ( $P > 0.05$ ). Similarly, we observed no baseline differences among these groups with respect to anxiety, depression, or QOL ( $P > 0.05$ ) (Table 2), and NLR and AGR were also comparable among groups ( $P > 0.05$ ).

## 3. Intervention-associated changes in patient physical or psychological conditioning

Following the completion of a 4-month intervention period, no significant differences in VO2MAX, FEV1/FVC (%), or dyspnea were observed when comparing patients in the intervention and control groups in Heilongjiang Province ( $P > 0.05$ ), although there was a trend towards improvement in the intervention group (Table 2). In contrast, relative to the control group the intervention group exhibited significant improvements in FEV1% pred, FVC % pred, and depression symptoms at the end of the 4-month intervention period ( $P < 0.05$ ). QOL scores for the subscales corresponding to social well-being, functional well-being, and lung cancer symptoms were also significantly different between these two groups ( $P < 0.05$ ), whereas no significant differences in the physical or emotional well-being QOL dimensions were detected between groups ( $P > 0.05$ ). Anxiety scores also did not differ significantly between groups ( $P > 0.05$ ) (Table 3). At both the 2- and 4-month time points, mean albumin-to-globulin ratio (AGR) and neutrophil-to-lymphocyte ratio (NLR) values differed significantly between intervention and control groups in Heilongjiang Province ( $P < 0.05$ ) (Fig. 2, 3).

Table 2 Physical and psychological indicators of control group at baseline and at 4 months						
	Hainan			HLJ		
	Baseline	4 months	p	Baseline	4 months	p
<b>Cardiorespiratory fitness</b>						
VO2MAX	53.1 ± 18.3	53.2 ± 13.5	0.079	53.0 ± 16.3	52.2 ± 15.1	0.09
FEV1/FVC (%)	69.5 ± 14.5	71.9 ± 18.5	0.521	70.5 ± 14.5	72.1 ± 13.5	0.15
FEV1, % pred	76 ± 16	76.5 ± 11.6	0.189	76.5 ± 14.5	74.5 ± 10.6	0.19
FVC, % pred	82 ± 14	79.5 ± 11.4	0.067	82.7 ± 11.4	80.5 ± 10.1	0.67
<b>Dyspnea</b>	5.0 ± 1.2	6.0 ± 0.9	0.103	5.0 ± 0.9	6.0 ± 0.6	0.103
<b>HADS</b>						
Depression	10.1 ± 3.4	12.1 ± 4.1	0.131	10.7 ± 2.4	11.1 ± 3.1	0.11
Anxiety	10.6 ± 3.6	13.6 ± 2.5	0.198	11.6 ± 3.6	12.6 ± 3.5	0.39
<b>Quality of life</b>						
Physical well-being	22.8 ± 5.3	24.8 ± 5.3	0.373	21.9 ± 4.3	22.8 ± 4.3	0.73
Social well-being	19.8 ± 5.0	21.8 ± 4.2	0.18	20.8 ± 4.5	20.8 ± 4.2	0.68
Emotional well-being	16.8 ± 5.2	17.6 ± 4.3	0.265	17.8 ± 4.2	17.2 ± 1.3	0.65
Functional well-being	17.9 ± 6.1	16.7 ± 6.2	0.06	18.1 ± 5.5	17.5 ± 3.2	0.56
Lung cancer subscale	19.5 ± 3.6	20.5 ± 2.6	0.679	18.5 ± 3.6	19.5 ± 3.2	0.67

Table 3  
Physical and psychological indicators of intervention groups at baseline and at 4 months

	Hainan				HLJ				
	Baseline	4 months	p	Between-Group Comparison, %Change 1	Baseline	4 months	p	Between-Group Comparison, %Change 2	p Change1 VS%Change 2
<b>Cardiorespiratory fitness</b>									
VO2MAX	51.3 ± 17.1	81.5 ± 13.7	0.02	15.3 ± 6.2	51.3 ± 17.7	61.5 ± 11.7	0.68	11.6 ± 10.2	0.05
FEV1/FVC (%)	70.6 ± 10.9	82.6 ± 10.9	0.01	10.9 ± 1.2	70.6 ± 10.9	74.6 ± 12.0	0.57	9.9 ± 10.5	0.04
FEV1, % pred	74.0 ± 17.2	89.2 ± 16.7	0.04	1.5 ± 7.2	74.1 ± 17.0	80.2 ± 16.7	0.04	0.5 ± 9.2	0.02
FVC, % pred	80.2 ± 21.2	91.2 ± 21.1	0.02	8.9 ± 3.2	80.0 ± 21.1	81.4 ± 21.3	0.04	5.9 ± 10.2	0.04
<b>Dyspnea</b>	5.0 ± 0.98	3.0 ± 0.58	0.04	2.4 ± 3.2	5.0 ± 0.98	4.5 ± 0.8	0.06	2.2 ± 7.2	0.03
<b>HADS</b>									
Depression	10.0 ± 3.4	7.0 ± 3.1	0.03	-1.68 ± 0.3	10.0 ± 3.4	8.0 ± 3.1	0.03	-0.88 ± 0.3	0.02
Anxiety	10.6 ± 3.2	8.6 ± 2.2	0.58	-2.78 ± 1.3	10.6 ± 3.2	8.6 ± 2.2	0.52	-0.78 ± 1.3	0.04
<b>Quality of life</b>									
Physical well-being	21.9 ± 5.0	14.4 ± 4.5	0.04	-2.0 ± 1.5	21.9 ± 5.0	19.4 ± 4.5	0.48	-1.4 ± 1.2	0.03
Social well-being	19.7 ± 3.8	15.1 ± 3.8	0.01	-11.2 ± 0.8	20.1 ± 2.8	17.1 ± 3.2	0.03	-10.2 ± 0.6	0.22
Emotional well-being	18.2 ± 4.2	13.5 ± 4.2	0.03	-2.3 ± 0.3	17.52 ± 4.2	16.8 ± 2.2	0.06	-1.8 ± 0.3	0.03
Functional well-being	15.9 ± 5.1	12.4 ± 1.5	0.04	-3.0 ± 0.2	15.9 ± 3.1	13.9 ± 2.1	0.03	-2.9 ± 0.2	0.66
Lung cancer subscale	20.4 ± 3.6	17.4 ± 3.6	0.01	-1.2 ± 0.2	19.9 ± 1.6	17.5 ± 4.6	0.04	-2.2 ± 0.2	0.09

Within the Hainan patient group, we observed significant mean improvements in cardiorespiratory fitness (VO2MAX, FEV1/FVC (%), FEV1% pred, FVC % pred) and dyspnea symptoms relative to patients in the control group ( $P < 0.05$ ). Intervention group patients also exhibited significant improvements in depression relative to controls ( $P < 0.05$ ), and significant differences were observed between these two groups with respect to both total QOL scores and scores on all five individual QOL subscales ( $P < 0.05$ ). However, despite a positive trend in the intervention group, anxiety scores did not differ significantly between these two groups ( $P > 0.05$ ) (Table 3). In addition, following a 4-month intervention period, AGR and NLR values differed significantly between the intervention and control groups ( $P < 0.05$ ), although these differences were not significant following a 2-month intervention period ( $P > 0.05$ ).

Compared with the Heilongjiang Province intervention group, patients in the Hainan Province intervention group exhibited significant improvements in cardiorespiratory fitness (VO2MAX, FEV1/FVC (%), FEV1% pred, and FVC % pred), dyspnea, and both the physical and emotional well-being subscales ( $P < 0.05$ ). No significant differences were observed between these two



intervention groups with respect to other QOL subscale scores (social well-being, functional well-being, or lung cancer symptoms), anxiety scores, or depression scores ( $P > 0.05$ ). In addition, AGR and NLR values were comparable between these two intervention groups at both the 2- and 4-month time points ( $P > 0.05$ ) (Table 3, Fig. 2, 3).

## Discussion

A number of systematic reviews conducted in recent years have concluded that exercise represents a safe and effective intervention that can help to control symptoms and enhance cardiorespiratory fitness in cancer patients that are either undergoing or have recently completed adjuvant therapy.[19–26] Qigong is a traditional form of exercise that has been practiced in China for over 3,000 years, and that has been shown to offer a number of benefits to the health of its practitioners. To date, however, there has been relatively limited research aimed at exploring the value of GLQG training in NSCLC patients.

Survivors of NSCLC often experience poorer impaired cardiorespiratory function, decreased QOL, and greater anxiety and depression relative to the general population. This study was therefore designed to evaluate the impact of GLQG training and climate on the cardiorespiratory fitness, dyspnea symptoms, QOL, anxiety/depression, and AGR and NLR variables in patients with histologically confirmed inoperable NSCLC. These patients were separated into four groups and underwent either GLQG training or basic stretching exercises in either Hainan or Heilongjiang Province. The results of this study suggested that both GLQG and a favorable climate were associated with beneficial physical and psychological outcomes among NSCLC patients.

Previous studies have demonstrated a direct correlation between increased cardiorespiratory endurance and decreased mortality among cancer patients. In the present study, we found that while there were no significant differences between the control and intervention groups in Heilongjiang Province with respect to patient VO2MAX, FEV1/FVC (%), or dyspnea, there were intervention-related upward trends for all of these variables. These patients may have experienced more robust improvements had they been subjected to a longer intervention period or to more robust medical supervision during cardiorespiratory endurance training. In the Hainan cohort, we found that patients in the intervention group exhibited marked improvements in FEV1% pred, FVC % pred, and depression scores relative to controls ( $P < 0.05$ ). In the Hainan cohort, patients in the intervention group exhibited significantly improved cardiorespiratory fitness (VO2MAX, FEV1/FVC (%), FEV1% pred, FVC % pred), dyspnea, and depression relative to controls ( $P < 0.05$ ). In addition, the intervention group in Hainan Province exhibited significant improvements in cardiorespiratory fitness (VO2MAX, FEV1/FVC (%), FEV1% pred, FVC % pred), dyspnea, and physical and emotional well-being relative to intervention group patients in Heilongjiang Province ( $P < 0.05$ ). Together, these results thus suggest that GLQG and/or a more favorable climate are associated with improvements in cardiorespiratory capacity and dyspnea symptoms in NSCLC patients, with the combination of these two interventions being most efficacious.

Previous work by Milne et al.[27, 28] revealed that a combination of aerobic exercise and resistance training for 8 weeks was associated with improved cardiovascular fitness, while Sprod et al.[29] found that only cancer patients that had exercised for a minimum of 6 months exhibited significant improvements in pulmonary functionality (FVC, FEV1). We found that a 4-month period of GLQG exercise was associated with significantly improved cardiovascular endurance.[30] This may be attributable to the fact that Qigong is gentler than are resistance training/aerobic exercise, incorporating mindfulness activities and gentle aerobic exercise to achieve positive outcomes over the long-term. Previous research, however, has not evaluated the impact of GLQG on the cardiopulmonary fitness of NSCLC patients. Given the fact that it is a form of gentle exercise, it may offer some of the same beneficial effects as other exercise training through comparable mechanisms associated with increased endothelial nitric oxide synthase and myocardial heat shock protein levels that can reduce chemotherapy-driven myocardial lipid peroxidation. GLQG is primarily focused on breathing exercises, however, emphasizing the importance of breathing fresh air in an oxygen-rich environment. Air pollution is known to adversely impact human health, and as such a more favorable climate will inevitably benefit GLQG practitioners. In addition, work by Qin et al. found that aerobic exercise was associated with a reduction in the adverse pulmonary effects of PM2.5 in Wistar rats, underscoring the beneficial cardiorespiratory effects of such exercise.[31] Qigong practices are also thought to alter blood viscosity and vascular elasticity, thus improving microvascular circulation in practitioners. [32]

Previous research has shown that lung cancer patients practicing GLQG exhibit improvements in microcirculation. In the present study, we also observed significant trends towards improvements in the QOL of intervention group patients. Qigong intervention

activities help to promote relaxation and improved regulation of emotions and other central nervous system functions. GLQG, in particular, enables its practitioners to better achieve inner peace through regulated breathing activities, potentially relieving emotional burdens and improving mental and immunological functionality. In traditional Chinese practice, Qigong is considered to be an optimal approach to achieving a healthy body and mind through the cultivation of qi (vital energy) and yi (consciousness or intention). Through the strengthening and balancing of these factors, Qigong practitioners can potentially slow disease progression or mitigate its adverse effects. In line with our results, Chen et al. also determined that GLQG was able to improve QOL among cancer patients.[13]

ALB and GLB are two key indicators of systemic inflammation and anti-tumor responses.[33] These indicators are commonly evaluated based on the combined AGR value, which has been studied in a range of cancer types including hepatocellular carcinoma, lung cancers, and nasopharyngeal carcinoma.[34, 35] Neutrophils and lymphocytes are key regulators of systemic immunity, and a higher NLR value is associated with a poorer prognosis among cancer patients.[29, 36, 37] Herein, we found that there were significant differences between groups with respect to mean AGR and NLR values when comparing intervention and control groups ( $P < 0.05$ ). As systemic inflammation is a key driver of cancer progression, we hypothesize that GLQG and a more favorable climate may improve cancer patient prognosis via suppressing systemic inflammation.

There are a number of limitations to the present pilot study. For one, we had a limited sample size. In addition, participants were neither randomized nor blinded to their interventions. Future large-scale randomized studies with a longer intervention period will therefore be needed to better validate the findings of the present study. Despite these limitations, the positive results of our study suggest that GLQG and a favorable climate may facilitate significant improvements in physical and psychological well-being among NSCLC patients. As this non-pharmacological intervention strategy is relatively inexpensive and is not associated with significant side effects, it may represent an ideal intervention strategy for cancer patients.

## Conclusion

We examined the health-promoting effects of GLQG and climate in lung cancer survivors. Results show GLQG and a favorable climate could significantly improve participants' cardiorespiratory fitness as well as their QOL, emotional condition, and immune function. This method offers an effective nonpharmacological therapy for cancer with reduced cost and no side effects.

## Abbreviations

AGR albumin-to-globulin ratio

CRT chemoradiotherapy

FACT-L Functional Assessment of Cancer Therapy–Lung

GLQG Guolin qigong

HADS Hospital Anxiety and Depression Scale

HR heart rate

HRR HR reserve

ITT intention-to-treat

LA-NSCLC Locally advanced NSCLC

NSCLC non-small cell lung cancer

NLR neutrophil-to-lymphocyte ratio

NRS Numeric Rating Scale

PFT pulmonary function test

QOL quality of life

VADS Visual Analog Dyspnea Scale

## Declarations

**Ethics approval and consent to participate** The Institutional Review Board (IRB) of Harbin Medical University Cancer Hospital approved the present study, and all participants provided informed consent following a review of both verbal and written information pertaining to the present study. All participation was fully voluntary, with patients having the result to freely withdraw from the study. All data was anonymized.

**Consent for publication** Not applicable.

**Availability of data and materials** The dataset analyzed during the study is not publicly available due to required data protection, but available upon reasonable request with approval by the corresponding author.

**Competing interests** None of the authors had any potential conflict of interests in this study.

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## Authors' contributions

Tang Dabei offered advice for the article framework and conceived the conception and design of the trial. Jianli Ma drafted the first manuscript and participated in trial communication and monitoring. Zhong Chu and Xiaowei Wang modified the manuscript the carried out statistical calculations. All authors participated in revision of the manuscript and approved the final version.

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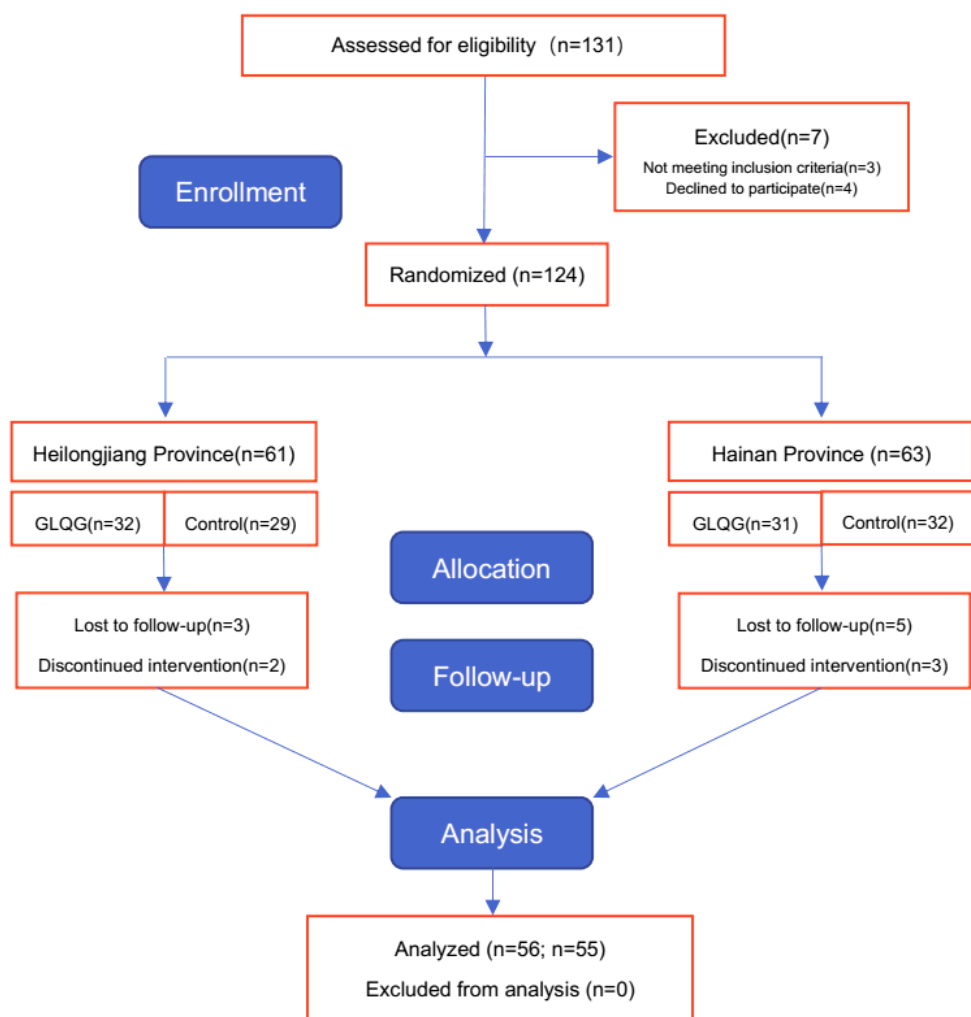
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## Figures



**Fig. 1 Flow chart of participants recruitment and study design**

**Figure 1**

Study Flowchart.

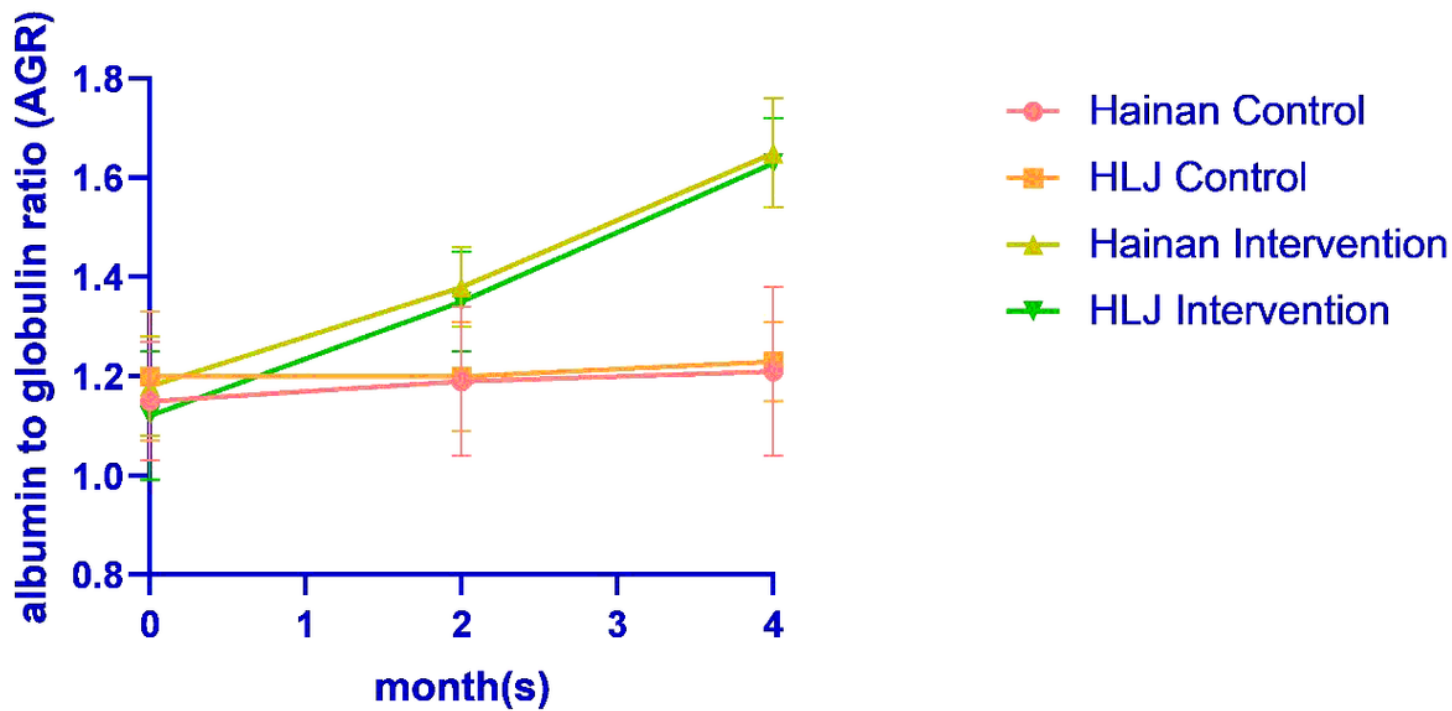
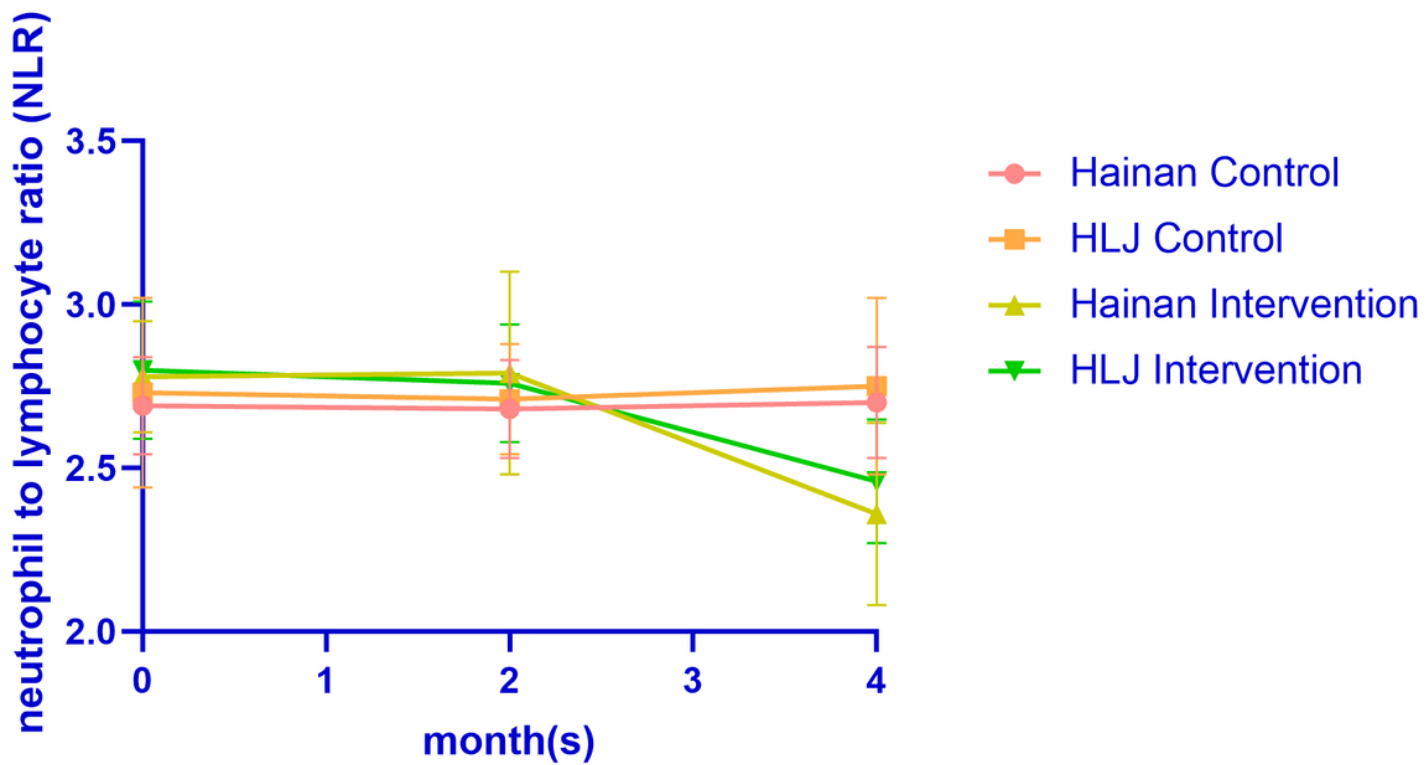


Fig.2 The change of albumin-to-globulin ratio in different months.

Figure 2

Intervention-associated changes in patient physical or psychological conditioning



**Figure 3**

Intervention-associated changes in patient physical or psychological conditioning

