ORIGINAL RESEARCH

Pulmonary Rehabilitation Exercise Based on Wearable Device Pedometer Improved Lung Cancer Patients with Impaired Pulmonary Function

Zhi Chen, MM; Yaqin Wang, BM; Pan Qiu, BM; Li Tan, BM; Yi Hu, BM

ABSTRACT

Objective • Lung cancer patients mostly had different degrees of impaired pulmonary function, and these damage also significantly affect quality of life. The concept of pulmonary rehabilitation applicable to patients with chronic respiratory diseases is also applicable to patients with lung cancer. The current application of pulmonary rehabilitation for lung cancer is inconsistent, and reliable guidelines are lacking. The purpose of this study was to investigate the effect of pulmonary rehabilitation exercise based on wearable device pedometer on lung cancer patients with impaired pulmonary function, and to find a suitable pulmonary rehabilitation program for patients with lung cancer.

Methods • In this retrospective study, 100 lung cancer patients with impaired pulmonary function were included. Among them, 51 patients received pulmonary rehabilitation exercise based on a wearable device pedometer (Experiemental group), while 49 received routine nursing mode (Control group). The respiratory function, quality of life, and sports endurance of the two groups were observed.

Results • The incidence of postoperative atelectasis, pulmonary infection, hypoxemia, postoperative oxygen therapy time, chest tube indwelling time, and postoperative hospital stay in the experimental group were significantly lower than those in the control group ($P < .05$); The FEV1, FVC and FVE1% of the experimental group were significantly higher than those of the control group after intervention (all $P < .05$).

Conclusion • Pulmonary rehabilitation exercise based on a wearable device pedometer can effectively improve the respiratory function and exercise endurance of lung cancer patients with impaired pulmonary function and can improve the quality of life and reduce the length of hospital stay. (*Altern Ther Health Med.* 2024;30(1):78-82).

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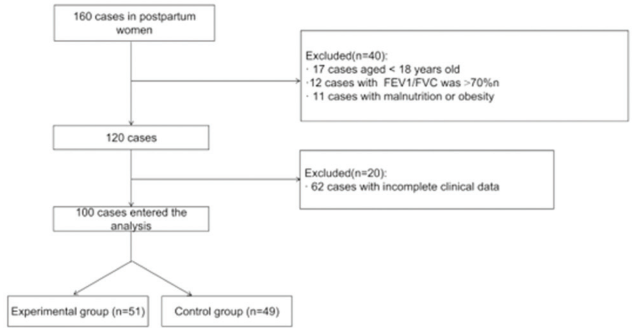
INTRODUCTION

Lung cancer is a common clinical malignant tumor of the respiratory system. Its incidence rate and mortality rate rank first among all malignant tumors in the world, and its high degree of malignancy, rapid progress, and poor prognosis seriously threaten the life safety of patients.[1] Radical resection of lung cancer is a common method to treat lung cancer, which can effectively clear the focus and save the patient's life. However, the operation is traumatic, and patients' respiratory function and exercise endurance after the operation are reduced, which seriously affects their postoperative rehabilitation, and caused complications such as atelectasis, pulmonary infection, hypoxemia. Therefore, strengthening the respiratory function exercise of patients after the operation has important clinical significance for improving lung function and exercise endurance.[2,3] At present, the clinical nursing for respiratory function of patients after radical resection of lung cancer is relatively limited, which is mainly manifested in the absence of systematic respiratory function exercise measures and is mainly conducted in the way of oral teaching by nursing staff. The patients do not master well and have poor compliance, thus affecting the process of lung rehabilitation.[4,5]

In recent years, the rise of the concept of rapid postoperative rehabilitation (ERAS)[6] has made clinicians pay more attention to protecting patients' perioperative pulmonary function. For example, the patient was instructed to perform pulmonary function exercises before surgery (stair climbing exercise, sandbag compression abdominal breathing, cough and expectoration training, etc.), or small tidal volume ventilation combined with appropriate PEEP was used during mechanical

Figure 1. Flow chart showing recruitment.



ventilation during surgery, or manual recruitment was used at intervals during surgery to help the patient reopen collapsed alveoli.[7-9] These methods have certain effects but also have shortcomings. Preoperative pulmonary function exercise requires a certain amount of time and intensity. Although there is no exact standard for pulmonary function exercise at present, studies have shown that patients need to take two or more exercise methods, a certain amount of exercise and a long time of exercise to take effect.[10,11]

Pulmonary rehabilitation exercise based on a wearable device pedometer is a novel method for lung cancer patients with impaired pulmonary function.[12] Wearable device pedometer can monitor vital sign information in real-time, including changes in blood pressure, heart rate, respiration, blood sugar, sleep quality, etc., and reflect mental health according to physiological changes in combination with environmental and language information, providing scientific basis for patients' treatment.[13,14] Compared with routine physical examinations and seeking help from doctors in case of problems, wearable devices show unique advantages regarding patients' independent participation, real-time feedback of objective data, and telemedicine in the intelligent age. For example, the wearable device developed by Lu Zhiyuan[15] can monitor the physiological signals of the elderly, such as heart rate and blood pressure, as well as skin status, body fat, and other physiological parameters in real-time to achieve daily health monitoring of the elderly. Regarding lung rehabilitation exercise monitoring, head-worn and bracelet wearable devices have been used to monitor pressure, lung function, and other aspects,[16,17] which can reflect the changes of patients' vital signs during lung rehabilitation exercise.

Therefore, our study investigates the effect of pulmonary rehabilitation exercise based on a wearable device pedometer on lung cancer patients with impaired pulmonary function.

MATERIALS AND METHODS

Study design

The study was a retrospective analysis. It was performed from January 2020 to December 2021. We enrolled 100 lung cancer patients with impaired pulmonary function and were divided into the experimental group (n = 51) and the control group (n = 49). This study has been reviewed and approved by the medical ethics committee of our hospital. A flow diagram detailing the selection of patients is shown in Figure 1.

Inclusion criteria

Inclusive criteria: (1) All of them met the diagnostic criteria for lung cancer and were confirmed by pathological examination;[18] (2) Pulmonary function examination showed that FEV1/FVC was ≤70%; (3) Patients were all older than 18 years of age.; (4) Patients had complete epidemiological, clinical, and laboratory data.

Exclusion criteria

(1) The patients had blurred consciousness and mental abnormalities; (2) Patients had cancer metastasis; (3) The patient had severe liver, kidney, and other organ dysfunction; (4) Patients had asthma, chronic obstructive pulmonary disease, and respiratory failure before operation; (5) Patients was malnutrition or obesity.

Interventions

The control group was treated according to the routine nursing mode. It includes doing a good job of observation, anti-infection, fluid infusion, nutritional support, medication guidance, and other nursing, keeping the patient's respiratory tract unobstructed, and guiding the patient to get out of bed.

The experimental group received the pulmonary rehabilitation exercise based on a wearable device pedometer (Shenzhen Jumei Information Technology Co., Ltd). During the period when the patient is in bed, guide him to perform a small range of limb activities, including straight leg lifting, ankle pump movement, and limb flexion and extension. Instruct patients to cough effectively, remove respiratory secretions effectively, and keep the respiratory tract unobstructed; Instruct patients to take abdominal breathing, lip contraction breathing, etc., and exercise their respiratory function. At least 3 groups of patients should be taken every day for at least 5 minutes in each group. When the patient's condition is stable, encourage him to get out of bed early and increase the amount of exercise and the number of training groups on the basis of previous studies. The duration of each exercise is 5 to 15 minutes. At least two walking exercises are carried out every day. At the same time, increase the inspiratory muscle strength training, such as lip contraction breathing, balloon blowing, etc., about 5 minutes each time, 3 to 5 times a day. When the patient recovers well, guide the patient to go up and down stairs, and teach the patient breathing exercises, including abdominal compression breathing, upper limb single lifting breathing, kicking breathing, chest expanding breathing, so that the patient can master the essentials of the movement, wear wearable detection equipment, monitor the patient's vital signs, dyspnea index, psychological state, etc.

Primary outcome

Respiratory function: We collected the data, including forced vital capacity (FVC), forced expiratory volume (FEV) 1 in the first second, the percentage of forced expiratory volume in the first second to the predicted value (FEV1%), and the ratio of forced expiratory volume in the first second to forced vital capacity (FEV1/FVC).

Quality of life: The quality of life scale was investigated by the quality of life scale (QLQ-C30) developed by the European cancer investigation and treatment research group.[19] This scale included six multi-item functional scales: physiological function, psychological function, physical pain, emotional function, social function, and mental health. After the scoring procedures, all scale and single-item scores were linearly transformed to a 0–100 scale. Higher scores for functional scales and the global quality of life scale indicate a 'higher level of functioning or global quality of life', while for symptom scales and single items, a higher score indicates a 'higher level of symptoms.[20]

Cancer-related symptoms change: We also recorded the incidence of cancer-related symptoms such as malnutrition, infection, fatigue, recurrent peptic ulcer, weight loss et al.

Sports endurance: The patients in the two groups were evaluated by the degree of 6MWT and CAT scale, and 0 was no dyspnea; 1. There is shortness of breath when going up a gentle slope or walking fast; 2 points: walking speed is slower than that of peers; 3 points: stop to breathe after walking 100 m; 4 points: dyspnea, severely restricting the patient's life.[21]

Statistical analysis

More than two medical staff confirmed all the data in this study and entered into the computer. Statistical Product and Service Solutions (SPSS) 19.0 (SPSS Inc., Chicago, IL, USA) statistical analysis software processed all the data in this study. Prism 8 software (graphic software) was used for charts. The independent variable screening method in multiple linear regression is step-by-step method. The independent variable screening methods in univariate and multivariate logistic regression are input and forward stepwise, respectively. The measurement data were expressed by ($\bar{x} \pm s$), and the count data were expressed by percentage (%). The general demographic data of the two groups were statistically described by descriptive analysis, and the constituent ratio of the two groups was compared by χ^2 test; the comparison between the two groups before intervention and after the intervention was compared with the test, $P < .05$, indicating that the difference was statistically significant.

RESULTS

Clinical data

In this study, there were 65 males and 35 females, and 74 (74%) of them had an adenocarcinoma (LUAD) histology, and 26 (26%) of them had a squamous cell carcinoma histology. Furthermore, there was no significant difference in gender, age, marital status, stage, pathological type, and smoking status between the two groups ($P > .05$) (Table 1).

Comparison of lung function indexes

The level of FEV1, FVC, and FEV1 / FVC before intervention had no significant difference between the two groups ($P > .05$), while after intervention, the lung function had improved in the experimental group, and the difference had statistical significance compared with control group ($P < .05$) (Table 2).

Table 1. Comparison of clinical data between the two groups

	Experimental group (n = 51)	Control group (n = 49)	t/χ^2	P value
Age(years)	51.05±7.91	50.35±7.19	3.25	.34
Sex			3.28	.42
Male (n%)	38(74.5%)	27(55.1%)		
Female (n%)	13(25.5%)	22(44.9%)		
BMI	20.7±2.28	20.4±2.76	2.209	.53
Smoking	39(76.5%)	37(75.5%)	1.96	.55
Marital status			17.83	.34
Married	13(25.5%)	15(30.6%)		
Single	16(31.4%)	10(20.4%)		
Divorced or separated	12(23.5%)	11(22.4%)		
Widowed	8(15.7%)	12(24.5%)		
Unknown/missing	2(3.9%)	2(4.1%)		
Pathological type			3.21	.11
Adenocarcinoma	39(76.5%)	35(71.4%)		
Squamous cell carcinoma	12 (23.5%)	14 (28.6%)		
Location (case)			2.34	.08
Right upper lung	13 (25.5%)	14(28.6%)		
Right middle lung	9 (17.6%)	7 (14.3%)		
Right lower lung	9 (17.6%)	6 (12.2%)		
Left upper lung	9 (17.6%)	7 (14.3%)		
Left lower lung	11 (21.7%)	15 (30.6%)		
Stage			0.28	.41
Phase Ia	2 (3.9%)	2(4.1%)		
Phase Ib	24 (47.1%)	7 (14.3%)		
Phase IIa	7(13.7%)	15 (30.6%)		
Phase IIb	8 (15.7%)	14(28.6%)		
Phase IIIa	10 (19.6%)	11(22.4%)		

Table 2. Comparison of lung function indexes between two groups.

Index	time	Experimental group (n = 51)	Control group (n = 49)	t	P value
FEV1(L)	Before treatment	1.11±0.38	1.17±0.42	1.028	.320
	After treatment	3.26±0.38	2.91±0.51	3.113	.001
	t	4.218	3.216	-	-
	P value	.000	.000	-	-
FVC(L)	Before treatment	1.47±0.59	1.45±0.57	1.201	.861
	After treatment	3.91±0.53	2.75±0.48	1.939	.000
	t	3.128	2.416	-	-
	P value	.000	.000	-	-
FEV1/FVC(%)	Before treatment	52.94±5.51	53.08±5.72	2.113	.908
	After treatment	63.43±4.32	58.57±5.41	6.138	.000
	t	8.618	7.216	-	-
	P value	.000	.000	-	-

Note: Significant difference as $P < .05$.

Comparison of exercise endurance

There was no significant difference in 6MWT and CAT scores between the two groups before intervention ($P > .05$). After the intervention, the 6MWT and CAT scores of the two groups were both increased, and the difference was statistically significant ($P < .05$). The change range of 6MWT and CAT scores in the experimental group was greater than that in the control group ($P < .05$). The number of acute attacks in the study group during the observation period was significantly lower than that in the control group ($P < .05$) (Figure 2).

Comparison of perioperative indexes

The time of oxygen therapy, chest tube indwelling, and postoperative hospital stay in the experimental group were shorter than the control group, and the difference had statistical significance compared with the control group ($P < .05$) (Table 3).

Figure 2. Comparison of exercise endurance between two groups.

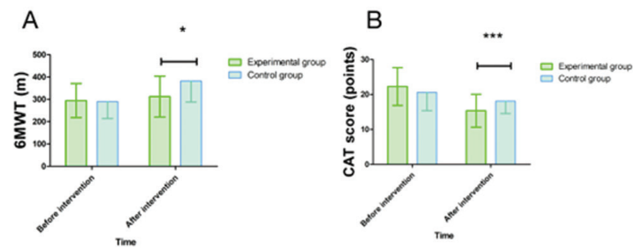


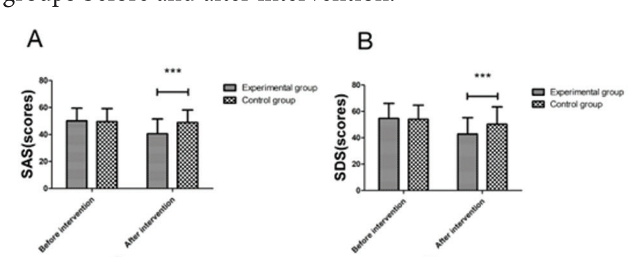
Table 3. Comparison of perioperative indexes between two groups

	Experimental group (n = 51)	Control group (n = 49)	*t*	*P* value
Postoperative oxygen therapy	82.14 ± 24.29	66.20 ± 21.11	3.286	.002
Chest tube indwelling	4.78 ± 2.15	8.66 ± 2.96	4.587	.000
Postoperative hospitalization	3.52 ± 1.44	6.73 ± 2.14	3.505	.001

Table 4. QLQ-C30

	time	Experimental group (n = 51)	Control group (n = 49)	*t*	*P* value
Physiological function (points)	Before intervention	70.51± 75.92	68.51± 72.16	5.992	.189
	After intervention	93.22+95.37	81.06±85.33	8.235	.000
	t	4.218	3.216	-	-
	P value	.000	.000	-	-
Psychological function (points)	Before intervention	70.12± 78.95	73.53± 76.22	7.639	.427
	After intervention	110.12 ± 115.24	78.54 ± 80.05	9.424	.000
	t	3.128	2.416	-	-
	P value	.000	.000	-	-
Physical pain (points)	Before intervention	66.23±81.22	68.45±75.24	8.940	.616
	After intervention	95.47±97.21	81.45±83.24	7.349	.000
	t	8.618	7.216	-	-
	P value	.000	.000	-	-
Emotional function (points)	Before intervention	61.01±64.32	61.54±63.27	6.538	.180
	After intervention	94.08±98.27	75.28±80.69	10.444	.000
	t	6.91	7.15	-	-
	P value	.000	.000	-	-
Social function (points)	Before intervention	65.87±70.89	62.18±65.21	4.636	.220
	After intervention	95.21±99.30	84.21±87.64	9.567	.000
	t	9.9	5.78	-	-
	P value	.000	.02	-	-
Mental health (points)	Before intervention	68.58±74.55	65.36±70.52	6.377	.750
	After intervention	86.28±90.57	77.22±80.06	9.458	.000
	t	5.892	8.135	-	-
	P value	.029	.04	-	-

Figure 3. Comparison of SAS and SDS between the two groups before and after intervention.



Comparison of quality of life (QLQ-C30)

The QLQ-C30 of patients (physiological function, psychological function, physical pain, emotional function, social function, and mental health) in the experimental group improved more significantly compared with the control group; the difference was statistically significant ($P < .05$) (Table 4).

SDS and SAS in two group

As shown in Figure 3, the difference between SDS and SAS were statistically significant between the two groups ($P < .05$). The scores of SDS and SAS were significantly improved in the experimental group compared with the control group ($P < .05$).

DISCUSSION

This study found that the incidence of postoperative atelectasis, pulmonary infection, hypoxemia, postoperative oxygen therapy time, chest tube indwelling time, and postoperative hospital stay in the experimental group were significantly lower than those in the control group ($P < .05$); The FEV1, FVC and FVE1% of the experimental group were significantly higher than those of the control group after intervention (all $P < .05$).

The thoracic integrity of patients undergoing thoracic surgery is damaged, and intercostals, chest muscles, diaphragms, etc., are damaged. Patients are prone to a decline in pulmonary function after surgery.[22] Invasive operations such as endotracheal intubation during operation will damage respiratory mucosa, increase of airway secretions, severe surgical trauma, and lobectomy, which often lead to postoperative cough and even limited respiratory movement. Pulmonary rehabilitation exercise based on a wearable device pedometer can promote the recovery of alveolar ventilation and ventilation function, increase the strength and endurance of respiratory muscles, increase the body's activity, effectively prevent respiratory muscle fatigue, and improve the pulmonary function of patients after surgery. It is an effective measure to prevent pulmonary complications.[23,24] It includes upper and lower limb sports and respiratory muscle training, which can slow down the respiratory rate and improve the endurance and intensity of respiratory muscle. Upper limb exercise training can improve the adaptability of the body to upper limb exercise, reduce oxygen consumption, and enhance ventilation efficiency; The activity of the lower limb muscle group can improve the physiological muscle function and personal exercise ability, thus enhancing the patient's cardiorespiratory function. At the same time, monitoring the patient's vital signs and other changes can effectively reduce the occurrence of adverse events.[25] In this study, we developed a personalized perioperative pulmonary rehabilitation exercise program for patients undergoing radical lung cancer resection, equipped with a wearable device pedometer. All exercise indicators were quantified and detectable. The specially trained nurses led patients to get out of bed and exercise in groups. For patients lying in bed, the bed nurses provided targeted personalized exercise guidance, improving patients' exercise accuracy and effectiveness.[26] Through repeated training during perioperative period, the patients can master the methods of pulmonary rehabilitation exercise, better cooperate with postoperative nursing work, and promote the patients' reexpansion of the surgical side lung and the elimination of sputum.

Research showed that pulmonary rehabilitation exercise based on wearable device pedometer enables patients to recognize their own state, face up to diseases, and face death with a more calm attitude. The significance of supporting exercise lies in that through mutual encouragement between patients and warm guidance from medical staff, patients' loneliness and psychological pressure can be reduced, and the faith and courage to overcome diseases can be established. The results showed that the scores of patients' depression and depression scale were significantly decreased ($P < .05$). In addition, cancerous fatigue in the two groups was also significantly improved. Cancer fatigue, like other negative emotions, is due to the adverse effects of long-term radiotherapy, chemotherapy and surgical treatment. Patients with low physical function and poor sleep quality and quality of life will increase their sense of fatigue. Pulmonary rehabilitation exercise based on wearable device pedometer uses an objective way to let patients feel breath, feel their body, feel emotions and pain, cultivate patients concentration, avoid excessive negative thoughts, and reduce their fatigue experience. In recent years, pulmonary rehabilitation exercise based on wearable device pedometer has been widely used in disease control, chronic disease care, and other fields.[27-30] It can be used as a non-drug therapy for cancer patients for in-depth research, aiming to bring gospel to the treatment of cancer patients.

However, this study also has shortcomings. First, this study is a single-center retrospective case-control study with a small sample size. There may be errors caused by selection bias and recall bias, which need to be verified by a large sample of multiple centers. Second, this study does not analyze all the collected indicators, thus affecting the model's prediction accuracy. A larger, multi-center study is required to verify its applicability.

Therefore, pulmonary rehabilitation exercise based on a wearable device pedometer can effectively improve the respiratory function and exercise endurance of lung cancer patients with impaired pulmonary function and can improve the quality of life and reduce the length of hospital stay. This Pulmonary rehabilitation exercise based on wearable device pedometer is worthy to be popularized in clinical practice.

CONFLICT OF INTEREST

The authors have no potential conflicts of interest to report relevant to this article.

AUTHOR CONTRIBUTIONS

ZC, YW and YH designed the study and performed the experiments, PQ collected the data, LT analyzed the data, ZC, YW and YH prepared the manuscript. All authors read and approved the final manuscript. ZC and YW contributed equally to this work

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ETHICAL COMPLIANCE

This study was approved by the ethics committee of Wuhan Central Hospital.

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