◎原　著

Effects of spa therapy on the six-minute walk test in patients with chronic obstructive pulmonary disease

Shingo Takata[1], Kozo Ashida[1], Yasuhiro Hosaki[1], Masanori Hamada[2], Naofumi Iwagaki[1], Hiroshi Kikuchi[1] and Fumihiro Mitsunobu[1]

[1]Division of Medicine, [2]Division of Rehabilitation, Misasa Medical Center, Okayama University Hospital of Medicine and Dentistry

Abstract：Our previous studies have shown that subjective symptoms and ventilatory function are improved by spa therapy in patients with chronic obstructive pulmonary disease (COPD). In the present study, we investigated the effects of spa therapy on six-minute walk distance in patients with COPD. Subjects were 10 patients with chronic obstructive pulmonary disease (9 males and 1 female) admitted to our hospital to undergo pulmonary rehabilitation. All patients had complex spa therapy (swimming training in a hot spring pool, inhalation of iodine salt solution, and fango therapy) for 4 weeks. Ventilatory function, six-minute walk distance, oxygen saturation and Borg scale were measured. Vital capacity, forced expiratory volume in one second, six-minute walk distance and oxygen saturation increased, but not significantly. Significant decreases were observed for Borg scale. We found that spa therapy improved ventilatory dysfunction and six-minute walk distance in patients with COPD. The results demonstrated that spa therapy may lead to better disease control and exercise tolerance in patients with COPD.

Key words：Chronic obstructive pulmonary disease, Spa therapy, Six-minute walk test, Borg scale, Ventilatory function

Introduction

The usual course of chronic obstructive pulmonary disease (COPD) is a slow worsening of ventilatory function accompanied by gradually increasing symptoms of cough, phlegm and breathlessness and impairment of functional capacity culminating in chronic respiratory failure. The response to treatment is often disappointing with only supplemental oxygen having been shown to alter the natural history. However, pharmacotherapy has an important role in the management of COPD as it is possible to provide symptomatic relief and often some improvement in ventilatory function and exercise capacity. Inhaled corticosteroid, anticholinergic agent, long-acting β_2-agonist, and theophylline are the mainstay of treatment as per the current guideline for the management of COPD[1]. However, for some patients with COPD, tiotropium bromide, fluticasone, procaterol and theophylline may fail to achieve adequate control.

Our previous studies have shown that subjective symptoms and ventilatory function are improved by spa therapy in patients with pulmonary emphysema[2-5].

The assessment of disability in patients with COPD usually requires that the practitioners estimate the patient's capacity for exercise. Methods of assessing the performance of whole body exercise include tests of maximal capacity and endurance capacity. The six-minute walk test is now the most commonly used timed walked test[6,7]. It is simple, and does not require sophisticated equipment or advanced technical training. In addition, walking is a familiar activity typically performed by even the most severely debilitated patients[6,8]. In the six-minute walk test, the patient determines the walking speed, and the distance walked will depend on the patient's capacity to pace himself or herself accordingly. But the effects of spa therapy on six-minute walk test have not been clear.

In the present study, we investigated the effects of spa therapy on walking distance during the six-minute walk test in patients with COPD.

Materials and methods

Subjects were 10 patients with COPD (9 males and 1 female) admitted to our hospital to undergo pulmonary rehabilitation. All patients were ex-smokers. The mean age of the patients was 74.9 years (range, 63 to 81). The mean duration of COPD was 6.6 years. The diagnosis of COPD was performed by clinical symptoms, auscultation findings of the lung, ventilatory function, chest X-ray findings and %LAA<-950 HU of the lung on HRCT, as previously described[9]. All patients showed a difference between prebronchodilator and postbronchodilator values of forced expiratory volume in one second ($FEV_{1.0}$) not exceeding 15%. All patients had complex spa therapy (swimming training in a hot spring pool, inhalation of iodine salt solution, and fango therapy) for 4 weeks[10,11]. The characteristics of the subjects in this study are shown in Table 1.

Table 1 Backgrounds of patients

Patients (male/female)	10 (9/1)
Age (years)	74.9±6.0 (63-81)
Onset (years)	68.3±14.4 (30-79)
Severity of chronic obstructive pulmonary disease	
Stage Ⅰ	1
Stage Ⅱ	5
Stage Ⅲ	4
Stage Ⅳ	0

Ventilatory function tests, vital capacity (VC), forced vital capacity (FVC), $FEV_{1.0}$, forced expiratory flow after 25% of expired FVC (FEF_{25}), forced expiratory flow after 50% of expired FVC (FEF_{50}), forced expiratory flow after 75% of expired FVC (FEF_{75}), mean expiratory flow during the middle half of the FVC (FEF_{25-75}), peak expiratory flow (PEF), residual volume (RV), functional residual capacity (FRC) and diffusing capacity for carbon monoxide (DLco), were performed in all subjects using a CHESTAC 33 (Chest Co) linked to a computer. DLco was measured by the single breath technique using a CHESTAC 33. The values of RV, FRC, PEF and DLco for each patient were expressed as a percent of the predicted values[12]. Bronchodilators were withheld prior to measurements of lung function for more than 12 hours.

The six-minute walk test was carried out in a hospital corridor, which is 100 m. Subjects were instructed to walk as fast as possible for 6 minutes and to cover as much ground as possible in that time. They were allowed to slow down or stop if necessary, but were required to resume walking as soon as they felt able. Each minute subjects were given feedback on the elapsed time, and were encouraged to continue walking. All subjects were familiar with the six-minute walk test prior to the study.

Data shown in this paper are presented as mean±SEM. Statistically significant differences of the mean were estimated using the unpaired Student's t-test. A p value of <0.05 was regarded as significant. Analyses were performed using StatView 5.0 (Abacus Concepts, Inc., Berkeley, CA).

Results

VC, FVC, $FEV_{1.0}$, FEV_{75}, FEV_{50}, FEV_{25}, FEV_{25-75}, %FRC, %PEF, %DLco values slightly increased, the increase in the 10 parameters was not significant. %RV value slightly decreased, the decrease was not significant (Table 2).

Table 2 Changes of ventilatory parameters by spa therapy

	Spa therapy	
	Before	4weeks
VC(ℓ)	2.42±0.64	2.79±0.70
FVC(ℓ)	2.15±0.84	2.65±0.74
FEV_1(ℓ)	1.17±0.57	1.44±0.70
FEF_{75}(ℓ/sec)	1.77±1.37	2.29±1.86
FEF_{50}(ℓ/sec)	0.70±0.58	0.78±0.61
FEF_{25}(ℓ/sec)	0.22±0.08	0.25±0.12
FEF_{25-75}(ℓ/sec)	0.75±0.57	0.91±0.73
%RV(%)	152.2±37.5	149.4±35.4
%FRC(%)	102.4±28.1	109.3±18.9
%PEF(%)	40.7±15.8	50.6±28.0
%DLco(%)	51.5±25.7	57.1±31.1

VC:vital capacity, FVC:forced vital capacity
FEV_1: forced expiratory volume in one second
FEF_{75}: forced expiratory flow after 75% of expired FVC
FEF_{50}: forced expiratory flow after 50% of expired FVC
FEF_{25}: forced expiratory flow after 25% of expired FVC
FEF_{25-75}: mean expiratory flow during the middle half of FVC
RV: residual volume, FRC: functional residual capacity
PEF: peak expiratory flow, DLco: diffusing capacity for carbon monoxide

Six-minute walk distance values before and after spa therapy were 288±104 m and 327±109 m, respectively ($p>0.05$). Significant decrease was observed in maximum Borg Scale values following spa therapy for 4 weeks (2.0±1.3 and 1.6±1.3) ($p<0.05$). Minimum oxygen saturation values and oxygen saturation values at rest slightly increased, but not significantly. Heart rate at rest and maximum heart rate slightly decreased, but not significantly (Table 3).

Table 3 Changes of six-minute walk test by spa therapy

	Spa therapy	
	Before	4weeks
Walk distasnce (m)	288±104	327±109
Maximum Borg scale	2.0±1.3	1.6±1.3 [a]
Minimum SpO_2 (%)	87.1±5.9	88.5±8.0
SpO_2 at rest (%)	95.8±1.9	96.6±1.0
Heart rate at rest (/min)	72.7±8.5	72.8±4.3
Maximum Heart rate (/min)	103.9±17.7	115.6±17.4

a:$p<0.05$
SpO_2: oxygen saturation

Discussion

COPD is considered one of the major public health problems in the world[13]. It was recently defined as a disease characterized by airflow limitation, not fully reversible[14,15], usually progressive, and accompanied by an abnormal pulmonary inflammatory response to noxious gases or particles[16].

Our previous studies have shown that spa therapy improves ventilatory parameters in patients with COPD[2-4]. However, it is still unclear whether spa therapy improves six-minute walk distance.

The six-minute walk test is simple to perform, has been standardized[17] and predicts the risk of death in COPD patients[18,19]. Its use as a clinical tool has gained acceptance, since it is a good predictor of the risk of death among patients with other chronic diseases, including congestive heart failure[20] and pulmonary hypertension[21], and COPD[18]. Indeed, the distance walked in six minutes has been accepted as a good outcome measure after interventions such as pulmonary rehabilitation[22].

In this study, effects of spa therapy on pulmonary emphysema were examined in relation to six-minute walk distance and we found that six-minute walk distance was improved by spa therapy.

Mucociliary clearance is an effective and essential biological barrier against microorganisms and particulate matter. This specialized apparatus consists of secretory cells and ciliated cells that beat in a coordinated and metachronal fashion. Their propulsive force mobilizes the mucus blanket toward the larynx for elimination. Dysfunction of the mucociliary clearance is a common respiratory disturbance in patients with obstructive lung disease such as chronic bronchitis, asthma, bronchiectasis, and cystic fibrosis. This dysfunction is an important marker of accelerated loss of ventilatory function in COPD[23].

Our previous studies have demonstrated that spa therapy improved mucociliary clearance and ventilatory dysfunction[24-27]. Suzuki reported that there was significant correlation between six-minute walk distance values and ventilatory function[28].

In the present study, we examined the effects of spa therapy in six-minute walk test in patients with COPD and we found that spa therapy improved ventilatory dysfunction and six-minute walk distance in patients with COPD.

In conclusion, to our knowledge, this is the first study to look at the effects of spa therapy on the six-minute walk test in patients with COPD. The results demonstrated that spa therapy may influence on six-minute walk test and lead to better disease control and exercise tolerance in patients with COPD.

ACKNOWLEDGEMENTS

This work was supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture of Japan (№ 17500474).

References

1. Global Initiative for Chronic Obstructive Lung Disease. Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease, NHLBI/WHO Workshop Report. Bethesda, National Heart, Lung and Blood Institute. April, 2001 (Update 2006), GOLD website (www.goldcopd.com), 2006.
2. Mitsunobu F, Mifune T, Hosaki Y, et al.: Effects of spa therapy on patients with pulmonary emphysema. Relationship to disease

severity evaluated by low attenuation area of the lung on high resolution computed tomography. J Jpn Assoc Phys Med Balneol Climatol 61 : 79－86, 1998.
3. Mitsunobu F, Mifune T, Hosaki Y, et al. : Improvement of pulmonary emphysema of pulmonary function by spa therapy in patients with emphysema, evaluated by residual volume (RV) and low attenuation area (LAA) of high-resolution computed tomography (HRCT). J Jpn Assoc Phys Med Balneol Climatol 62 : 121－128, 1999.
4. Mitsunobu F, Mifune T, Hosaki Y, et al. : Effects of spa therapy on pulmonary emphysema in relation to IgE-mediated allergy. J Jpn Assoc Phys Med Balneol Climatol 63 : 120－126, 2000.
5. Mitsunobu F, Hosaki Y, Ashida K, et al. : Five-year observation of the effects of spa therapy for patients with pulmonary emphysema, evaluated by %low attenuation area (%LAA) of the lungs on high-resolution CT, %DLco and %residual volume (RV). J Jpn Assoc Phys Med Balneol Climatol 67 : 148－154, 2004.
6. Sciurba FC, Slivka WA : Six-minute walk testing. Seminars in respiratory and critical care medicine 19 : 383－392, 1998.
7. Elpern EH, Stevens D, Kesten S, et al. : Variability in performance of timed walk tests in pulmonary rehabilitation programs. Chest 118 : 98－105, 2000.
8. Solway S, Brooks D, Lacasse Y, et al. : A qualitative systematic overview of the measurement properties of functional walk test used in the cardiorespiratory domain. Chest 119 : 256－270, 2001.
9. Mitsunobu F, Hosaki Y, Ashida K, et al. : Long-term spa therapy prevents the progressive pathological changes of the lung in patients with pulmonary emphysema. J Jpn Assoc Phys Med Balneol Climatol 66 : 91－98, 2003.
10. Mitsunobu F, Kitani H, Okazaki M, et al. : Clinical effects of spa therapy on bronchial asthma. 6. Comparison among three kinds of spa therapies. J Jpn Assoc Phys Med Balneol Climatol 55 : 185－190, 1992.
11. Tanizaki Y, Kitani H, Okazaki M, et al. : Clinical effects of complex spa therapy on patients with steroid-dependent intractable asthma (SDIA). Jpn J Allergol 42 : 219－227, 1993.
12. Cotes JE : Lung function. In Assessment and Application in Medicine, 4th Eds, Blackwell Scientific Publications, Oxford, England, 1979, 329－387.
13. Hurd S : The impact of COPD on lung health worldwide : epidemiology and incidence. Chest 117 (Supl 2) : S1-S4, 2000.
14. American Thoracic Society : Standards for the diagnosis and care of patients with COPD. Am J Respir Crit Care Med 152 (5 Pt 2) : 77－121, 1995.
15. British Thoracic Society : Goals of the COPD guidelines. Thorax 52 (Supl 5) : 1－26, 1997.
16. Pauwels RA, Buist AS, Calverley PM, Jenkins CR, Hurd SS ; GOLD Scientific Committee : Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. NHLBI／WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) Workshop summary. Am J Respir Crit Care Med 163 : 1256－1276, 2001.
17. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories : ATS statement : guidelines for the six-minute walk test. Am J Respir Crit Care Med 166 : 111－117, 2002.
18. Gerardi DA, Lovett L, Benoit-Connors MI, et al. : Variables related to increased mortality following outpatient in pulmonary rehabilitation.

Eur Respir J 9 : 431－435, 1996.
19. Celli BR, Cote CG, Marin JM, et al. : The body-mass index, airflow obstruction, dyspnea, and exercise capacity index in chronic obstructive pulmonary disease. N Engl J Med 350 : 1005－1012, 2004.
20. Shah M, Hasselblad V, Gheorgiadis M, et al. : Prognostic usefulness of the six-minute walk in patients with advanced congestive heart failure secondary to ischemic and nonischemic cardiomyopathy. Am J Cardiol 88 : 987－993, 2001.
21. Miyamoto S, Nagaya N, Satoh T, et al. : Clinical correlates and prognostic significance of six-minute walk test in patients with primary pulmonary hypertension : comparison with cardiopulmonary exercise testing. Am J Respir Crit Care Med 161 : 487－492, 2000.
22. Pulmonary hehabilitation-1999. Am J Respir Crit Care Med 159 : 1666－1682, 1999.
23. Restrepo RD : Inhaled adrenergics and anticholinergics in obstructive lung disease : Do they enhance mucociliary clearance? Respiratory Care 52 : 1159－1175, 2007.
24. Tanizaki Y, Komagoe H, Sudo M, et al. : Changes of ventilatory function in patients with bronchial asthma during swimming training in a hot spring pool. J Jpn Assoc Phys Med Balneol Climatol 47 : 99－104, 1984.
25. Tanizaki Y : Improvement of ventilatory function by spa therapy in patients with intractable asthma. Acta Med Okayama 40 : 55－59, 1986.
26. Tanizaki Y, Kitani H, Okazaki M, et al. : Clinical effects of spa therapy on bronichial asthma 5. Efficacy of inhalation with iodine salt solution. J Jpn Assoc Phys Med Balneol Climatol 55 : 179－184, 1992.
27. Tanizaki Y,Mitsunobu F : Respiratory disease, Balneology, climatology and physical medicine, Tanizaki Y, 1st edition, Japanese Association of Physical Medicine, Balneology and Climatology, Tokyo, 2004, 258－270 (in Japanese).

慢性閉塞性肺疾患患者における温泉療法の６分間歩行に対する効果

高田真吾[1)]，芦田耕三[1)]，保﨑泰弘[1)]，
濱田全紀[2)]，岩垣尚史[1)]，菊池　宏[1)]，
光延文裕[1)]

岡山大学病院三朝医療センター内科[1)]
同　三朝医療センターリハビリテーション科[2)]

我々は温泉療法が慢性閉塞性肺疾患患者に対して，呼吸機能改善効果を有することを報告してきた。今回我々は慢性閉塞性肺疾患患者を対象に温泉療法の６分間歩行試験に及ぼす影響について検討した。当院入院中の慢性閉塞性肺疾患患者10例（男性９例，女性１例）を対象として，温泉プール水中運動，鉱泥湿布療法，ヨードゾル吸入療法等による複合温泉療法を4週間施行し，その間の呼吸機能，６分間歩行試験における歩行距離，動脈血酸素飽和度，修正Borgスケールの変化を比較検討した。呼吸機能検査では，肺活量，１秒量等の改善傾向が認められた。６分間歩行距離，動脈血酸素飽和度は上昇傾向にあった。修正Borgスケールは有意に低下傾向した。温泉療法により呼吸機能の改善が得られ，これにより動脈血酸素飽和度及び６分間歩行距離が上昇したと考えられた。温泉療法が慢性閉塞性肺疾患の治療に有用であることが示唆された。

検索用語：慢性閉塞性肺疾患，温泉療法，６分間歩行試験，ボルグスケール，呼吸機能