Investigation of the difference between treadmill self-efficacy and actual performance in Taiwanese patients with chronic obstructive pulmonary disease

Chii Jeng, DNSc, RN,[a] Hsiao-Chuan Yang, MSN, RN,[b] Pui Man Wai, PhD,[c] Jen Chen Tsai, DNSc, RN,[a] Ling Ling Wei, MS, RN,[a] and Su-Ru Chen, MSN, RN,[a] Taipei, Taiwan

OBJECTIVE: Because overactivity or underactivity may result in inadequate physical responses among patients with chronic obstructive pulmonary disease (COPD), the purpose of this study was to examine the difference between treadmill self-efficacy and actual treadmill performance. Factors that influence self-efficacy and actual performance were also examined.

DESIGN: The design was a descriptive and correlational study.

SETTING: The study took place at the Research Center of Sports Medicine in University.

PATIENTS: A total of 48 subjects with COPD were recruited from 4 hospitals.

OUTCOME MEASURES: The outcome measures were treadmill self-efficacy and actual treadmill performance.

INTERVENTION: Data were collected by means of treadmill exercise testing and 3 structured questionnaires.

RESULTS: The findings of the study demonstrated that the average maximal functional capacity was 2.94 METs. A positive significant relationship between treadmill self-efficacy and actual performance was observed. However, the majority of subjects (72.9%) underestimated their treadmill performance and only 7 subjects (14.6%) assessed their treadmill performance accurately. Dyspnea was the most common reason for a subject to stop during the exercise testing. The patient's past experience was the most important predictor for both treadmill self-efficacy and actual treadmill performance.

CONCLUSIONS: These results revealed that patients in Taiwan who have COPD have extremely poor functional capacity and most of them underestimated their exercise performance. An assessment of self-efficacy and exercise performance seems imperative in the development of individualized nursing interventions to help COPD patients. (Heart Lung® 2002;31:150-6.)

Chronic obstructive pulmonary disease (COPD) is a worldwide health problem that has an increasing prevalence and mortality rate.[1] In Taiwan, COPD is among the 10 leading causes of death. The mortality rate of COPD was 9.37 per 100,000 persons in 1995, with a 5.06% increase in mortality rate compared with 1994.[2] In Taiwan, because of the fear of activity-induced dyspnea and a long-term sedentary lifestyle, persons who have COPD could develop low self-efficacy with regard to the performance of daily activities. Kaplan et al[3] reported that self-efficacy, rather than maximum oxygen uptake (VO_{2max}), partial pressure of oxygen (PaO_2), and forced expiratory volume in 1 second (FEV_1) was a significant univariate predictor of 5-year survival. Gormley et al[4] demonstrated

From the [a]Taipei Medical University School of Nursing, [b]National Health Insurance Department, and [c]National College of Physical Education and Sports.

Reprint requests: Chii Jeng, DNSc, RN, 250 Wu Hsing St, Taipei, Taiwan 110, ROC.

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that patients who had COPD had self-efficacy perceptions that were significantly lower than actual performance.

The theoretical framework for this study was Bandura's social cognitive theory and his derived self-efficacy theory.[5,6] Bandura considers self-efficacy perceptions to be the most powerful determinants of behavioral change. Efficacy expectation can help one determine whether to engage in a behavior, how much effort to expend, and how long the behavior will last despite possible barriers. Beliefs about personal efficacy develop from cognitive appraisal of information, which arises from 4 major sources: performance accomplishment, vicarious experience, verbal persuasion, and emotional arousal or physiologic feedback. Performance accomplishment is the most powerful source of efficacy information for enhancing self-efficacy and vicarious experience is considered the next most powerful method for changing self-perceptions.[6]

Scherer et al[7] demonstrated that a rehabilitation program that combines education and exercise training is more effective than education alone to improve long-term self-efficacy related to managing or avoiding difficulty in breathing in patients with COPD. Gormley et al[4] found that COPD patients' self-efficacy and actual performance became more congruent throughout 12 walking sessions. Zimmerman, Brown, and Bowman[8] found that the use of a group teaching method improved COPD patients' self-efficacy in self-management.

Although the effectiveness of selected strategies in improvement of self-efficacy has been supported, it is important to explore the related factors that contribute to determining one's self-efficacy because low self-efficacy may deter patients from engaging in activities of daily living. The purpose of this study was to examine differences between treadmill self-efficacy (confidence in a subject's ability to walk at a maximum level during exercise testing) and actual treadmill performance (actual maximum level achieved during exercise testing) in Taiwanese patients who have COPD. Factors that influence self-efficacy and actual performance also were examined.

METHODS

Research design

This is a descriptive and correlational study. Data were collected by means of graded exercise testing, lung function tests, and 4 questionnaires, which include the Exercise Self-efficacy Scale, Efficacy Sources Inventory, State Trait Anxiety Inventory,[9] and Self-perceived Dyspnea Scale.[10] The study was conducted at the Research Center of Sports Medicine in University. Forty-eight volunteers were recruited who had COPD treated on an outpatient basis and who met the selection criteria, which included a stable disease and a referral from their physician. No subjects participated in any other pulmonary rehabilitation program either before or after discharge.

Exercise testing. A symptom-limited, treadmill-graded exercise test with modified Naughton protocol was used to measure each subject's functional capacity and to determine the difference between his or her perceived efficacy and actual performance in exercise testing. The protocol of exercise testing, which included 10 levels, ranged from 1.0 mph, 0% grade (level 1) to 3.0 mph, 12% grade (level 10), with increasing levels in relatively small increments (≤1 MET per stage) every 3 minutes. The test was terminated on the basis of the following criteria: chest tightness or chest pain, exhaustion, severe dyspnea (Borg Scale >3), SaO_2 less than 90%, reaching 90% maximal heart rate, abnormal electrocardiographic change, or at the request of the subject. The estimated VO_{2max} for each subject was calculated by the formula VO_{2max} = speed × 26.8 × (0.1 + [1.8 × % grade]) + 3.5.[11] This testing was also used to calculate resting heart rate, blood pressure, peak heart rate, and peak blood pressure.

Lung function test. Before exercise testing, a spirometer was used to perform a lung function test that measured FEV_1 and forced vital capacity (FVC). For data analysis, predicted FEV_1 (FEV_1%pred), predicted FVC (FVC%pred), and FEV_1/FVC% were computed. Predicted FEV_1 and FVC were calculated by the equations set up in the spirometer software.

Exercise Self-efficacy Scale. This scale, developed by the investigators, was designed on the basis of the calculated workload (speed and % grade) for each stage of the modified Naughton protocol that was used during the exercise testing. This scale was used to measure a subject's confidence in his treadmill performance ability. For example, the first item is "Please rate your confidence level in walking on the treadmill with a speed of 1.0 mph and a grade of 0% for 3 minutes without stopping." Scores for this scale can vary from a minimum of 0 to a maximum of 100. A high score on the scale indicates a high confidence level in treadmill performance. Internal consistency of this scale was demonstrated by a Cronbach's α coefficient of 0.88. Concurrent validity of the scale was supported by the significant correlation (r = 0.30, P = .042) between this scale and the Duke Activity Status Index.[12]

Efficacy Sources Inventory. Developed by the investigators, this inventory consists of 3 parts. Ten items were designed to measure a subject's past performance accomplishment in daily activities; 4 items measured vicarious experiences of exercise; and 4 items measured a subject's verbal persuasion (ie, verbal exercise encouragement received from others). A standardized score was the obtained score/the maximum score divided by 100. A high score on the scale indicates high self-efficacy. Internal consistency was demonstrated by the Cronbach α coefficient of 0.82 for the entire scale and ranged from 0.60 to 0.88 for the 3 subscales.

State Trait Anxiety Inventory. This inventory consists of 2 subscales (state anxiety and trait anxiety) and includes 20 items per subscale. Anxiety states are characterized by subjective feelings of tension, nervousness, and worry. Trait anxiety refers to relatively stable individual differences in predisposition to anxiety. Because anxiety may result in dyspnea, which may in turn influence a patient's performance during the testing, anxiety level was measured as "emotional arousal" in this study. High scores indicate high anxiety levels. Construct validity of this inventory was supported by its ability to discriminate between psychiatric and nonpsychiatric patients and by a distinct factor structure for items that measure state and trait anxiety. In this study, the Cronbach α coefficient was 0.88 for state anxiety and 0.87 for trait anxiety.

Self-perceived Dyspnea Scale. This scale includes 25 items that measure subjects' degree of dyspnea while they perform daily activities. Subjects rate the level of dyspnea in 5 items that they performed most frequently during the past 2 weeks. The internal reliability and content validity of this scale have been supported by a previous study.[10] Test-retest reliability (r = 0.60, P = .017) for 6 to 8 weeks has been demonstrated in the current study.

Data collection. Subjects were referred by their physicians and were contacted and scheduled for an orientation session and a graded exercise test. A thorough explanation of the study protocol was provided and a consent form was signed on the orientation day. All subjects had to complete the Exercise Self-efficacy Scale, Efficacy Sources Inventory, State Trait Anxiety Inventory, and Self-perceived Dyspnea Scale before the Naughton protocol graded treadmill test and lung function tests were conducted by the investigators. On the basis of the treadmill test results and the exercise self-efficacy scores, subjects were divided into 3 groups: those who underestimated performance, those who accurately estimated performance, and those who overestimated performance. The maximum performance METs were subtracted from the maximum METs of self-efficacy for each subject to obtain an individual difference value. Subjects with negative values underestimated their performance, such that their self-efficacy was lower than actual performance. Subjects with positive values overestimated their performance, and subjects whose difference value equaled zero accurately appraised their walking ability.

Data analysis. The SPSS/PC+ statistical software package was used for data analysis. Descriptive statistics were computed for demographic data. Differences between self-efficacy and actual performance were determined by t test. One-way analysis of variance (ANOVA) was performed to determine differences in all study variables among the underestimated, the accurately estimated, and overestimated groups. A post hoc analysis of the 3 groups was performed using Scheffe's test. Stepwise regression analyses were performed to examine what factors were related to self-efficacy and actual performance. With a .05 significance level, the power of the current study was 0.79 for stepwise regression analyses and 0.89 for the t test.

RESULTS

Forty-eight subjects (43 male and 5 female) with COPD volunteered and provided informed consent for the study. The mean age of the sample was 69.83 years (SD, 7.08). Most subjects (92%) were married and retired. The mean number of years of education was 8.79 (SD, 5.04). Twenty-two subjects (54%) had asthma, 11 subjects (23%) had emphysema, and 11 subjects (23%) had chronic bronchitis. The average duration of smoking of the sample was 36.75 years (SD, 18.38), and 11 subjects still smoked during the study period. The average values of FEV_1%pred, FVC%pred, and FEV_1/FVC% of the sample were 57.57, 69.9, and 60.04, respectively. Fourteen subjects' (29.2%) FEV_1%pred were 70% and 20 subjects' (42%) FEV_1%pred were <50% (severe impairment in lung function) (Table I).

The mean estimated VO_{2max} of this sample was 2.94 METs (SD, 0.89), with an average walking time of 8.88 minutes (SD, 4.42). Most of the subjects terminated the testing at stage III because of dyspnea. Table II displays the mean and standardized scores of 4 sources of efficacy information. Past performance accomplishments were ranked first as the source of efficacy information, whereas vicarious experience and verbal persuasion were ranked sixth and fifth, respectively. To determine which sources of efficacy information might predict treadmill self-efficacy and actual performance, a series of stepwise multiple regression analyses were performed. Table III illustrates that past performance

Table I
Demographic characteristics of the sample (N = 48)

Characteristics	Mean	SD	Range
Age (y)	69.83	7.08	49–89
Education (y)	8.79	5.04	0–20
Years of disease	5.21	4.82	0.5–20
Smoking history (y)	36.75	18.38	0–60
FEV_1%pred	57.57	21.97	15–107
FVC%pred	69.90	25.28	30–141
FEV_1/FVC%	60.04	15.08	32.9–98.2
Sex (No.)			
Male	43	90%	
Female	5	10%	
Marital status (No.)			
Currently married	44	92%	
Widowed	4	8%	
Diagnosis (No.)			
Asthma	26	54%	
Emphysema	11	23%	
Chronic bronchitis	11	23%	
Employment (No.)			
Retired	44	92%	
Work full-time	4	8%	

accomplishment explained 35% of the variance of treadmill self-efficacy ($F = 24.82$, $P < .0001$, df = 47) and was the strongest predictor of actual treadmill performance. Together, the past performance accomplishment, resting heart rate, and FEV_1/FVC% explained 50% of the variance of actual treadmill performance ($F = 14.35$, $P < .0001$).

The difference between actual performance (the maximum performance METs) and treadmill self-efficacy (the maximum METs that the subject had 100% confidence in completing during testing) was computed after exercise testing. A significant difference was observed between treadmill self-efficacy (2.20 ± 1.15 METs) and actual performance (2.940.89 METs) ($t = –4.28$, $P < .0001$).

Six subjects (12.5%) overestimated, 7 subjects (14.6%) correctly estimated, and 35 subjects (72.9%) underestimated their actual performance. Table IV presents the comparisons of all study variables among the 3 groups. It was found that treadmill self-efficacy, actual treadmill performance, dyspnea level, past performance accomplishments, FEV_1%pred, FEV_1/FVC%, and peak heart rate during testing were significantly different among the 3 groups. Post hoc tests using Scheffes procedure showed that the overestimated group had higher treadmill self-efficacy, actual treadmill performance, FEV_1%pred, FEV_1/FVC%, and peak heart rate during testing, and lower dyspnea level than did the accurate-estimate group. It was also found that the accurate-estimate group had the longest history of disease, and the lowest treadmill self-efficacy, actual treadmill performance, and lung function (FEV_1%pred, FVC%pred, FEV_1/FVC%).

DISCUSSION

The purpose of this study was to examine differences between treadmill self-efficacy and actual treadmill performance in Taiwanese subjects with COPD. The results reveal that subjects' self-efficacy was significantly lower than actual performance. Most subjects (72.9%) underestimated their ability in performing treadmill tests, congruent with Gormley's results[4] that most COPD patients have low self-confidence in exercise. Gormley's study also revealed that self-efficacy and actual performance became more congruent over time, though 44% of the sample continued to underestimate ability to walk relative to actual performance during 12 sessions of walking. The most common patterns of changes in self-efficacy and actual performance for subjects across the 12 sessions were increased con-

Table II
Mean and standard deviation of source of efficacy information

Efficacy information source	Mean (SD)	Standardized score* (%)	Rank
Past performance			
Accomplishments (40)	26.79 (5.17)	67	1
Physiologic arousal			
Level of dyspnea(25)	11.46 (3.32)	45.8	2
Emotional arousal			
Trait anxiety (80)	35.50 (5.72)	44.4	3
State anxiety (80)	34.08 (5.07)	42.6	4
Verbal persuasion (12)	4.50 (0.83)	37.5	5
Vicarious experience (12)	4.19 (0.53)	35	6

*Standardized score = Obtained score/the maximum score divided by 100.

Table III
Stepwise regression analysis of treadmill exercise efficacy and actual performance model indicators

Dependent variables	Independent variables	B		R^2	Cumulative R^2	F	*P*
Exercise self-efficacy	Past performance accomplishment	1.94	0.59	0.35	0.35	24.82	.0001
Actual performance	Dyspnea	–0.10	–0.368	0.336	0.336	13.50	.0001
	Resting heart rate	–0.02	–0.32	0.068	0.404		
	FEV_1/FVC%	0.02	0.309	0.075	0.479		

gruency and consistent underestimation. Ewart et al[13] demonstrated that even a single session of exercise tests could improve a subject's self-efficacy. Therefore, to decrease the differences between self-efficacy in exercise and actual performance, an exercise test or a period of exercise training should be arranged for COPD patients.

Although a relationship between FEV_1 and peak VO_{2max} has been demonstrated, pulmonary function does not accurately predict exercise performance in patients with COPD.[14] In the current study, subjects with poor lung function (FEV_1%pred and FEV_1/FVC%), negative exercise experience, and higher level of dyspnea tended to more accurately estimate their ability. On the contrary, subjects with higher lung function tended to underestimate or overestimate their exercise ability. Because underestimation may result in decreased daily activities and overestimation may result in severe physical symptoms during exercise, interventions should be directed at helping individuals with COPD to judge their exercise ability accurately, even when their lung function is good.

The average estimated VO_{2max} of this study sample during exercise testing was 2.94 METs and 71% of the sample had <3 METs, which is much lower than the report (4.6-6.2 METs) of a previous study.[15] This suggests that functional capacity in Taiwanese subjects who have COPD is extremely poor and may limit their daily activity performance because 5 METs is considered to be the minimal fitness level needed to independently perform daily activities.

Dyspnea was also found to be the most common reason (27 subjects) that participants stopped during the exercise testing, but the SaO_2 values of all 27 subjects were >90%. Nevertheless, 27% of the sample (13 subjects) terminated the testing because their SaO_2 was <90%, but this dyspnea level was mild (<3). During exercise testing, SaO_2 decreased from 95.0% to 91.67%. The decrease in

Table IV
Differences in study variables among 3 groups

Variables	Underestimate (n = 35) mean (SD)	Accurate estimate (n = 7) mean (SD)	Overestimate (n = 6) mean (SD)	F
Age (y)	69.7 (5.3)	68.0 (8.6)	72.7 (13.2)	0.71
Disease time (y)	4.6 (3.9)	7.6 (6.5)	5.8 (7.3)	1.13
Exercise self-efficacy	17.8 (9.9)	13.3 (5.7)	56.2 (18.9)[a,b]	34.44†
Exercise test	3.1 (0.9)[c]	2.0 (0.4)	3.1 (0.8)	5.65*
Dyspnea	11.5 (3.3)	13.7 (1.3)[d]	8.8 (3.9)	3.81*
Past performance accomplishments	26.8 (5.0)	23.4 (4.5)	30.5 (5.1)[a]	3.32*
Vicarious experience	4.2 (0.6)	4.1 (0.4)	4.2 (0.4)	0.04
Verbal persuasion	4.5 (0.9)	4.6 (0.8)	4.3 (0.5)	0.15
Trait anxiety	36.1 (5.9)	33.0 (4.4)	35.2 (5.8)	0.84
State anxiety	34.7 (5.2)	33.3 (5.1)	31.5 (3.9)	1.12
FEV_1(%pred)	57.7 (20.9)	40.9 (19.1)	77.3 (16.5)[a]	5.26*
FVC(%pred)	69.4 (26.5)	62.4 (24.5)	81.5 (16.6)	0.94
FEV/FVC(%)	61.0 (15.6)	48.9 (10.6)	68.6 (9.2)[a]	3.25*
Rest SaO_2	95.9 (1.6)	95.4 (2.2)	96.3 (1.2)	0.51
Peak SaO_2	91.8 (2.8)	90.4 (3.8)	92.5 (1.4)	0.95
Resting heart rate	92.8 (14.8)	92.4 (16.7)	96.8 (15.0)	0.20
Peak heart rate	125.0 (15.5)	118.6 (8.6)	141.8 (21.9)[a]	3.93*

[a]Overestimate group > accurate-estimate group.
[b]Overestimate group > underestimate group.
[c]Underestimate group > accurate-estimate group.
[d]Accurate-estimate group > overestimate group.
*$P < .05$.
†$P < .0001$.

SaO_2 significantly correlated with dyspnea at rest ($r = -0.385$, $P = .007$). However, in contrast to the findings of Chodosowska and Zielinski,[16] a weak correlation ($r = -0.252$, $P = .084$) between degree of dyspnea and SaO_2 during exercise was observed in this study. Differences in modes of exercise tests (6-minute walking test or treadmill exercise test) and severity of disease (resting SaO_2, 92% or 95%) between these 2 studies may be possible reasons for the discrepancy. In the future, more research is needed to support the relationship between degree of dyspnea and SaO_2.

Negative relationships between dyspnea level and actual performance ($r = -0.58$, $P < .0001$) as well as between dyspnea level and exercise self-efficacy ($r = -0.496$, $P < .0001$) were observed in the current study. These results suggest that dyspnea rather than SaO_2 was a significant factor in determining exercise performance among patients who have COPD. Similar to previous findings,[17] dyspnea was the most important predictor in exercise performance. However, a low test-retest correlation coefficient ($r = 0.6$, $P = .017$) for the Self-perceived Dyspnea Scale might influence the stability of the data.

With respect to 4 sources of efficacy information, the results of this study reveal that subjects' past performance accomplishment was the most important predictor of treadmill self-efficacy and actual performance. This result supports Bandura's social cognitive theory that past performance is the most powerful source of efficacy information for enhancing self-efficacy. However, vicarious experience and verbal persuasion were not correlated with treadmill self-efficacy in this study. A low score in vicarious experience and verbal persuasion was observed, which indicates that exercise-related encouragement and instructions from others might be insufficient or have limited impact.

Physiologic indicators of level of dyspnea, FEV_1%pred, and FEV_1/FVC% were significantly correlated with treadmill self-efficacy supporting the findings of Graydon and Ross.[17] However, a significant relationship between anxiety (emotional arousal) and exercise self-efficacy was not supported even though this relationship also had been demonstrated in the study of Graydon and Ross.[17] In the current study, it was observed that subjects had the highest anxiety level as soon as testing began, perhaps because most subjects were unfamiliar with the machine and because measures were completed before testing began rather than during testing.

CLINICAL IMPLICATIONS

In summary, this study demonstrates that the majority of subjects who have COPD in this study in Taiwan have extremely poor functional capacity and underestimated their treadmill exercise performance. The overestimated group and the underestimated group tended to have higher treadmill self-efficacy, actual treadmill performance, lung function, peak heart rate during testing, and lower dyspnea level. However, the accurate-estimate group tended to have the longest history of disease, and the lowest treadmill self-efficacy, actual treadmill performance, and lung function. The subject's past exercise experience was the most important predictor for treadmill self-efficacy, whereas dyspnea was the most important predictor in actual treadmill performance.

Because of lack of regular exercise and overprotection by family compared with Westerners, most patients with COPD in Taiwan lead a sedentary lifestyle that would avoid activity-induced dyspnea or other symptoms and they have a poor quality of life. There are few trained professionals in pulmonary rehabilitation and very few hospitals that provide pulmonary rehabilitation programs. To improve the quality of care for COPD patients in Taiwan, a pulmonary rehabilitation center should be established as soon as possible. The findings of this study have implications for improving physical performance and self-confidence of COPD patients. An assessment of treadmill self-efficacy and maximal functional capacity seems imperative in the development of individualized nursing interventions to help COPD patients attain optimal health status. A routine treadmill exercise test should be arranged before COPD patients' hospital discharge in order to improve confidence in their ability to exercise. In addition, teaching COPD patients how to monitor the level of dyspnea during exercise may help subjects become more aware of their ability to exercise without dyspnea.

According to Bandura's theory, performance accomplishment, vicarious experience, verbal persuasion, and emotional arousal or physiologic feedback are 4 major sources of efficacy information to enhance self-efficacy. Because most of the subjects underestimated their self-efficacy, use of appropriate strategies such as encouraging exercise at an adequate intensity level during daily activities (performance accomplishment), introducing model cases to patients (vicarious experience), and providing verbal persuasion may improve the patient's self-efficacy. For further research, a random control study will be needed to determine the effectiveness in improving self-efficacy of the above strategies.

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