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# Physical activity in patients with COPD: the role of pulmonary rehabilitation

## Aktywność fizyczna chorych na POChP: znaczenie rehabilitacji oddechowej

**Pneumonol. Alergol. Pol. 2009; 77: 72–76**

### Introduction

Physical activity is defined by the World Health Organization as "any force exerted by the skeletal muscles that results in energy expenditure above resting level" [1]. In this very broad context, physical activity is almost synonymous with life, with death being the ultimate physical inactivity. Much of what we do living involves physical activity, and these can be considered activities of daily living (ADL). Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities [2]. However, it should be noted that not all activities of daily living are physical activities. Physical exercise is obviously a form of physical activity, and the two concepts do overlap considerably. One view is that activity becomes exercise when: 1) it is done on purpose (to get in better shape or win a contest), 2) is structured and repetitive, and 3) it is of higher intensity [2].

Functional status refers to the ability to perform ADLs in the face of disease limitations. According to a model by Leidy [3, 4] functional status has components of functional capacity (what people can do) and functional performance (what they actually do do). This is depicted in figure 1. Activities of daily living and functional performance are therefore virtually synonymous.

The exertional dyspnea and fatigue that accompany COPD often lead to limitation or alteration of some activities. In some cases the activity is eliminated altogether because of these distressing symptoms. COPD is a systemic disease, and its often-present co-morbidities (such as physical deconditioning, loss of muscle mass, anxiety associated with dyspnea-producing activities) may further increase functional performance limitation. Directly-measured physical activity in COPD patients correlates best with their walking ability, and less with their level of airways obstruction [5].

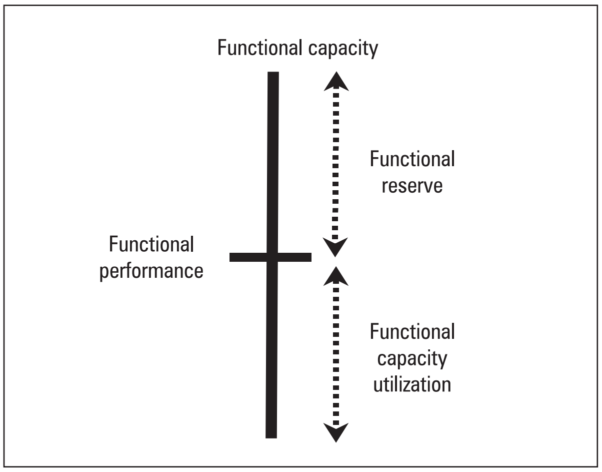


**Figure 1.** A model of functional status proposed by Leidy [4]. Functional status has four components: *functional capacity* (the maximal the individual can do), *functional performance* (what the individual actually does), *functional capacity utilization* (how much of maximal the individual is operating at) and *functional reserve* (how much more he/she can do)

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Praca wpłynęła do Redakcji: 12.12.2008 r.

ISSN 0867–7077

## Physical activity and positive health outcomes in healthy older adults

Older adults with self-reported low levels of physical activity have a greater risk for mortality compared to those with moderate or high levels of physical activity [6–8]. These studies relied on questionnaire-assessments of physical activity — which are often inaccurate, especially since they are subject to recall bias. More recently, the association of directly-measured daily energy expenditure with subsequent mortality has been demonstrated in 302 high-functioning, community-dwelling elderly adults [9]. Total energy expenditure was assessed over two weeks using doubly-labeled water, and resting metabolic rate was determined using indirect calorimetry. Patients were followed for a mean of 6.15 years. Higher free-living energy expenditure was associated with a substantially reduced risk for all-cause mortality: for every 287 kcal/day in free-living energy expenditure, there was an approximately 30% lower risk of mortality. This energy expenditure could be met by about 1 1/4 hours of moderate activity per day. Moderate activity by this categorization includes vacuuming, mopping the floor, child/adult care, lawn work, or walking at 2.5 miles/hour.

These results show an association between physical inactivity and poor outcome in elderly people. Data such as this have le to the promotion of physical activity in older people. Furthermore, this indicate that activity does not have to be of the higher-level physical activity such as working out at high intensity in a gymnasium, which is less likely to be accepted. Rather, moderate physical activity in daily activities, which could be enjoyable, might accomplish this goal.

## Physical activity and positive health outcomes in COPD patients

Decreased questionnaire-rated functional status is a stronger predictor of morality than $FEV_1$ in patients referred to pulmonary rehabilitation [10]. More recently, Garcia-Aymerich and colleagues related functional status to long-range outcomes in a study of individuals who had participated in the Copenhagen City Heart Study from 1981–1983 and 1991–1994 [11]. Of 15 563 subjects, 2386 met the criteria for COPD based on spirometry; patients with asthma were excluded. Follow-up was for a mean of 12 years after the initial assessment. Physical activity had been measured by questionnaire, and was later categorized as very low, low, moderate, or high. This was then related to subsequent hospital admission and mortality data.

Compared to those with very low levels of physical activity at baseline, COPD patients with low, moderate, or high physical activity at the initial evaluation had a lower subsequent risk of hospital admission, with a relative incidence rate of 0.72. These individuals also had lower risks for all-cause mortality (hazard ratio 0.76), and respiratory mortality (hazard ratio 0.70). These effects were independent of age, gender, COPD severity factors, or background of cardiac disease. In later analyses these investigators also demonstrated that active cigarette smokers with higher levels of physical activity had a slower rate of decline in FEV1 and were less likely to develop COPD than those with low physical activity [12]. Strikingly, these effects were present even after removing potential confounders and risk factors for $FEV_1$ decline.

These studies provide strong evidence that physical inactivity in COPD patients is associated with faster disease progression, increased health care utilization, and increased risk for all-cause and respiratory mortality.

## COPD: life in slow motion [13]

Clinicians have long realized that their patients with COPD are physically inactive [14, 15]. As COPD progresses, dyspnea and fatigue become more severe and patients decrease their physical activities to reduce these symptoms. Exertional dyspnea cannot occur without exertion [16]. Patients (and physicians) are usually not aware of the extent of this activity limitation. Therefore, when assessing the impact of COPD on the individual, the clinician must not only assess the severity of exertional dyspnea but also the extent of activity limitation resulting from it.

Assessment of activity in COPD patients has traditionally been performed using self-report questionnaires. However, physical inactivity in COPD patients has recently been objectively documented with direct recordings of physical activity. In 2000 Steele and colleagues reported activity assessments in COPD patients using a tri-axial accelerometer worn at the waist [17]. This device detects movements in three planes, and movements can be summed for each minute to give vector magnitude units, or VMU. VMU during the day correlated highly with walk distance ($r = 0.74$), $FEV_1$ ($r = 0.62$), and, to a lesser degree, with self-reported activity from the Pulmonary Functional Status and Dyspnea Questionnaire ($r = -0.29$). This study set the stage for subsequent direct measurements of activity in COPD patients.

Pitta and colleagues [18] assessed daily physical activities using a Dynaport activity monitor,

**Table 1. Studies evaluating the effect of pulmonary rehabilitation on directly-measured physical activity in patients with COPD**

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|---|---|
| Sewell et al. 2005 | Both individually-targeted and general-exercise pulmonary rehabilitation led to significant increases in physical activity. Activity counts increased by 29% and 41%, respectively |
| Steele et al. 2008 | Main focus of study was exercise adherence at 20 weeks following an adherence intervention. All patients had activity monitored using RT-3 accelerometers before and after outpatient pulmonary rehabilitation. Rehabilitation had no significant effect on activity counts |
| Walker et al. 2008 | Patients completing pulmonary rehabilitation had significant increases in leg activity counts compared to controls. These changes were unrelated to changes in muscle strength or walking distance, but were significantly positively correlated with baseline $FEV_1$ |

which consisted of a tri-axial accelerometer worn at the waist and a sensor on the thigh. Data from 50 patients with COPD were compared with 25 health elderly individuals. COPD patients spent significantly less time walking and standing and more time sitting and lying than the healthy control subjects. Walking time correlated significantly with the six minute walk distance (r = 0.76). A subsequent study by this group [19] demonstrated that physical activity was substantially decreased in a group of COPD patients following an exacerbation, and even at one month later was still considerably lower than clinically-stable, COPD patients.

These results indicate that patients with COPD are, on average, very sedentary. Furthermore, physical inactivity appears to be reduced even further following exacerbations. Since physical inactivity in COPD patients is detrimental, as discussed earlier, it makes sense to incorporate strategies to promote physical activity in these patients. One such strategy is pulmonary rehabilitation.

## The effect of pulmonary rehabilitation on physical activity in COPD patients

Pulmonary rehabilitation results in significant and clinically-meaningful improvements across several outcome areas of importance to COPD patients. Of all treatments, this intervention results in the greatest improvements in dyspnea, exercise tolerance, quality of life, and health care utilization. These positive outcomes occur despite the fact that pulmonary rehabilitation has no significant effect on lung function. This apparent paradox is explained by the fact that COPD is a systemic disease and also has frequent co-morbidities. Pulmonary rehabilitation has effectiveness in some of these areas. For example, patients with COPD are frequently physically deconditioned after gradually assuming a sedentary lifestyle because of exertional dyspnea; this deconditioning adds to exercise intolerance. This, in turn, further increases dyspnea. Exercise training can interrupt this vicious circle.

It seems intuitive that if an individual increases his or her exercise capacity from exercise training then this will be carried over into increased physical activities in daily living. That is, if people ‘can do’ more they will eventually ‘do do’ more [20]. Actually the medical literature is not univocal in this area, as outlined in table 1. Sewell and colleagues [21] compared to approaches to exercise training in COPD: an individually-targeted or a general exercise approach. Daily activity measured using a uni-axial accelerometer worn on a belt at the waist was one of the primary outcome variables they analyzed. Both approaches to exercise training led to significant improvements in outcomes. Relevant to this discussion, activity counts increased by 41% and 29% in the individually-targeted and general exercise groups, respectively. While both groups improved significantly from their baseline, the inter-group difference was not statistically significant. This study provided the first data that directly-measured physical activity improves following pulmonary rehabilitation.

A study by Steele and colleagues [22] was designed primarily to evaluate an exercise adherence intervention following pulmonary rehabilitation. Patients with chronic respiratory disease (most had COPD) all received outpatient pulmonary rehabilitation, twice a week for eight weeks. Following this, they were randomized to an exercise adherence intervention or standard follow-up. Activity was measured for six consecutive days using an RT-3 tri-axial accelerometer worn at the waist. Surprisingly, there was no significant increase in activity counts from baseline to immediately post-rehabilitation despite an n of 106 subjects. The authors attributed this lack of response to the ‘disappointing measurement characteristics of the accelerometer’ rather than to a lack of effectiveness of pulmonary rehabilitation in this outcome area.

More recently, Walker and colleagues [23] performed a series of studies evaluating directly-measured physical activity in COPD. Physical activity was measured using a uni-axial accelerometer worn just above the dominant ankle. Activity

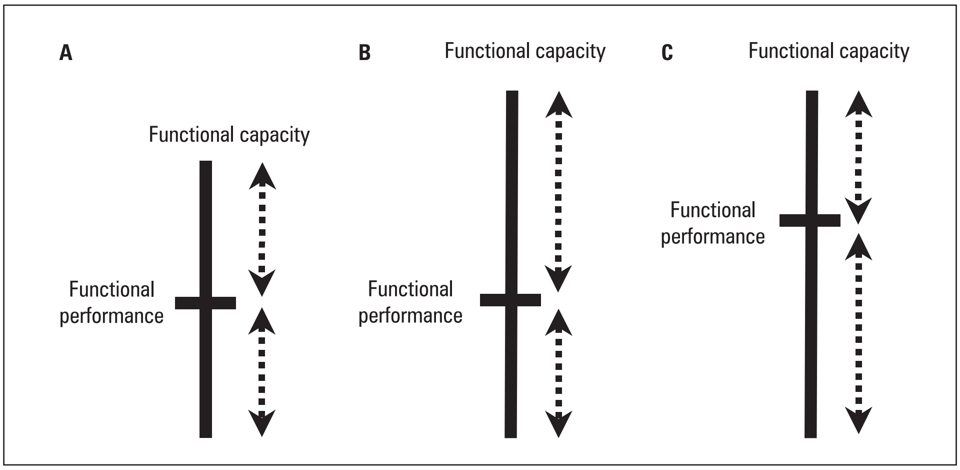


**Figure 2.** Pulmonary rehabilitation exercise training increases exercise capacity, but this is not necessarily translated into increased performance (daily physical activities). Figure 2A shows the relationship between functional performance and functional capacity. Figure 2B shows an increase in functional capacity brought about by an increase in exercise performance, but there is no corresponding increase in functional performance (daily activities). Figure 2C shows an increase in physical activities. The educational component of pulmonary rehabilitation, through promoting activity in the home setting, may help in this regard

measured this way correlated with whole body activity measured with a Dynaport Activity Monitor, a device which has been successfully utilized in COPD studies [18]. As might be expected, leg activity was reduced compared to control subjects. Activity was significantly increased after pulmonary rehabilitation. Interestingly, increased activity was unrelated to improvement in muscle strength or walking distance, even both improved with pulmonary rehabilitation. Improvement in activity was positively correlated with baseline lung function: those with better lung function increased their activity more following rehabilitation.

## Summary

As is the case for healthy adults, regular physical activity is important for patients with COPD. Individuals with COPD are often very sedentary, and those who are more physically inactive have a greater risk for hospitalization and mortality, even after controlling for cigarette consumption and severity of airflow limitation. Therefore, it makes sense to promote physical activity in these patients. There is a strong evidence base that pulmonary rehabilitation increases exercise tolerance in COPD. Although the number of studies is limited and results not uniform, it appears that pulmonary rehabilitation also increase physical activity levels in COPD. The improvement in activity in this setting, however, probably does not simply reflect the increased capacity to exercise. Pulmonary rehabilitation is more than just exercise training, and the educational component which stresses increased activity is probably equally important in this regard. The interplay between exercise capacity and performance can perhaps be conceptualized using the Leidy model of functional status, as depicted in figure 2. Pulmonary rehabilitation exercise training undoubtedly increases exercise capacity, as evidenced by increased walk test distances or increased time on treadmill endurance tests. However, this will not necessarily increase exercise performance in daily activities, as given by the horizontal bar. Patients who have assumed a sedentary lifestyle over years or decades might not readily change their behaviors. However, if patients can be instructed to get up and do things, this newly-achieved increased exercise capacity might be translated into more daily activities.

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