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# Examining The Likelihood Of Readmission To Inpatient Pulmonary Rehabilitation Using A Variety Of Predictors

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# EXAMINING THE LIKELIHOOD OF READMISSION TO INPATIENT PULMONARY REHABILITATION USING A VARIETY OF PREDICTORS

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This thesis, submitted by Allison J. Neil in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

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29 October 2012

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## ABSTRACT

This study involved examining 5 years of existing medical records for patients previously in pulmonary rehabilitation, producing 333 subjects (180 female). The purpose of this study was to determine if any variables could significantly predict readmission, so a better pulmonary rehabilitation programs could be designed. Thus reducing the cost for the health care system as well as the patients themselves, and for in the patients future it would reduced illness, pain, and human suffering. A discriminant analysis was conducted in order to determine the likelihood of readmission into pulmonary rehabilitation using the independent variables of 6MWT difference, PEFR difference, BMI difference, LOS, start 6MWT, and end 6MWT. The discriminant indicated no clear gap discriminating between those readmitted and those never readmitted.

However, out of the variables collected, although non-significant, the three strongest predictors were 6MWT start distance, 6MWT end distance, and BMI difference with statistical coefficients of 0.739, 0.688, and 0.586, respectively. It was also noted that a comparable healthy population was predicted to walk a great deal farther than the COPD patients involved in pulmonary rehabilitation, suggesting that the further the start and end 6MWT was below the normal values, the more likely it was that a patient would be readmitted into the pulmonary rehabilitation program. The findings for the study revealed that out of the variables examined at the start and end of

pulmonary rehabilitation, the 6MWT starting distance was the strongest predictor, and the 6MWT as a whole was a better predictor than PEFR. However, it was clear that the predictors examined were not particularly strong predictors for readmission into a pulmonary rehabilitation program. The results provided showed that there was not one specific predictor that strongly indicated the likelihood for readmission, suggesting there are perhaps a plethora of variables outside of those linked specifically to pulmonary rehabilitation that may be influencing a patient with COPD.

# CHAPTER I

# INTRODUCTION

Most people would like to live a productive and normal life, but for some this can be difficult. For patients with Chronic Obstructive Pulmonary Disease (COPD) it can be a challenge just to walk from the house to the car, as "COPD is characterized by an airflow limitation that is not fully reversible" (Bratas, Espnes, Rannestad, & Walstad 2010, p. 362). The estimated worldwide prevalence of COPD is 834 per 100,000, which constitutes approximately 44 million cases of COPD (Lundback et al., 2003). One common form of treatment for COPD is pulmonary rehabilitation. Both inpatient rehabilitation, where the patient checks "in" to the hospital, and outpatient rehabilitation, where the patient performs activities at home, have been shown to be highly effective in treating COPD (Ferrari et al., 2004; Hui & Hewitt, 2003; Ige, Olarewaju, Lasebikan, & Adeniyi, 2010; Jastrzebski, Gumola, Gawlk, & Kozielski, 2006). Both inpatient and outpatient rehabilitation typically involve some form of supervised exercise training, education, emotional support, breathing exercises, psychosocial and group support, and may also include medical management (Ries, Kaplan, Limberg, & Prewitt, 1995).

When entering and exiting an inpatient pulmonary rehabilitation program, the patient is required to perform initial assessment tests in order to determine their current level of functioning. In many cases, these assessments come in the form of a 6-minute walk test (6MWT) and measurement of one's peak expiratory flow rate (PEFR). The objective of the 6MWT is to walk for as far as possible in six minutes, in order to assess the patient's ability to ambulate. The objective of the PEFR is to measure how fast a person can exhale air, and is one of many tests that measure how well the lungs are working. These tests can also be used to assess the patient's improvements as well as the program's effectiveness for rehabilitating the individual (Balk & Elpern, 2002).

Inpatient pulmonary rehabilitation programs have been shown to improve a patient's 6MWT distance, which is likely associated with an increase in the patient's exercise capacity (Haave, Hyland, & Engvik, 2007). Furthermore, the improvement in exercise capacity may possibly be further affected by changes in the patient's PEFR, which can be used to assess the patient's airflow limitations (Quanje, Lebowitz, Gregg, Miller, & Pedersen, 1997). Exercise capacity as measured by 6MWT and PEFR scores also provide an indication of the likelihood of the patient being readmitted into a hospital setting for the same condition whether it be the emergency room or back into pulmonary rehabilitation. For example, when a patient has a low exercise capacity or PEFR following the completion of a pulmonary rehabilitation program, there is an increased likelihood of readmission following discharge, which is most likely caused by exacerbations (Hurst et al., 2010; Man, Polkey, Donaldson, Gray, & Moxham, 2004; Yohannes & Connolly, 2001).

An exacerbation is characterized by a sudden increase in uncontrolled symptoms and is defined as "sustained worsening of the condition from the stable state and beyond normal day-to-day variations that is acute in onset and may warrant additional treatment in a patient with underlying COPD" (Burge & Wedzicha, 2003, p. 46s). Exacerbations are a key cause for relapse in COPD patients (Gruffydd-Jones, Langley-Johnson, Dyer, Badlan, & Ward, 2007; Man et al., 2004) and it is important to identify factors that can indicate a higher likelihood of exacerbations in order to decrease the likelihood of such readmissions. Medical professionals are thus required to watch for declines in patient's PEFR, which may be an indication of more frequent exacerbations (Donaldson, Seemungal, Bhowmik, & Wezicha, 2002). Such supervision is commonly seen throughout pulmonary rehabilitation and has been shown to prevent the declines in pulmonary function by identifying exacerbations factors, signs, and symptoms prior to the episode, thus reducing the frequency of exacerbations up to 24 months post-discharge (Guell et al., 2000).

Exacerbations of COPD that lead to readmission into the emergency room or hospital admission are associated with an increased cost to both medical facilities and patients (Gruffydd-Jones et al., 2007). There is no agreed-upon clinical evidence that indicates the main causes for these exacerbations as there have been mixed results when attempting to reduce such readmission rates. Some pulmonary rehabilitation programs have been shown to reduce the risk of exacerbations that require follow-up hospital admittance; however the benefits from such programs tend to decrease with time, suggesting only a short-term reduction in hospital admittance rates. Despite this short-term reduction, eventually the rehabilitation benefits diminish resulting in hospital admittance rates returning to the values commonly seen among those not participating in pulmonary rehabilitation in the first place (Seymour, 2010).

One type of program that has been found to be successful at limiting exacerbations is inpatient pulmonary rehabilitation, which is prescribed once the patient is discharged from the hospital by a physician (Gruffydd-Jones et al., 2007). Conversely, the lack of inpatient pulmonary rehabilitation for COPD patients is a factor associated with more frequent exacerbations (Burge & Wedzicha, 2003), often leading to more frequent relapses requiring a visit to the hospital.

While there is a substantial amount of research that shows the effectiveness of a pulmonary rehabilitation program on certain aspects of a patient's life (Baltzan, Kamel, Alter, & Rotaple, 2004; Clini et al, 2001; Ferrari et al., 2004; Hui & Hewitt, 2003; Ige et al., 2010; Jastrzebski et al., 2006), there is no readily available data that indicates the likelihood of a patient being readmitted into a pulmonary rehabilitation program. It is plausible that health care professionals involved in inpatient pulmonary rehabilitation could compare the pre- and post-rehabilitation assessment tests of a patient in order to determine whether the patient needs longer involvement in the pulmonary rehabilitation program in order to minimize the likelihood of being readmitted post-discharge.

Multiple variables could be used to examine pre- and post-rehabilitation performance: PEFR, 6MWT, BMI, gender, age, and length of stay (LOS), among others. Collection of such performance data could be used to generate corollary data between patients' pre- and post-rehabilitation differences and readmission into a pulmonary rehabilitation program, thus providing an estimate of the strength of the relationship between assessment tests changes and readmission rates. Health professionals could thus refer to such correlations when a patient was considered for discharge from an inpatient pulmonary rehabilitation program. Therefore, the purpose of this study was to determine whether or not there was a difference between patients involved in pulmonary rehabilitation with regard to being readmitted into the program or not. More specifically, we wanted to find the best predictor for readmission into an inpatient pulmonary rehabilitation program. Multiple research questions were asked: which variable was the best predictor for readmission into a pulmonary rehabilitation program, how well did each variable predict readmission, and which assessment test, 6MWT or PEFR, was better than the other at predicting readmission?

# CHAPTER II

# LITERATURE REVIEW

Pulmonary rehabilitation is used for any COPD patient in a stable condition, but is disabled by respiratory symptoms (Ries et al., 2007). Those respiratory symptoms, such as exacerbations, can cause a COPD patient to be admitted to the hospital (Gruffydd-Jones et al., 2007 & Hui & Hewitt, 2003). Those exacerbations and hospital admissions can be reduced with the use of pulmonary rehabilitation (Bourbeau et al., 2003), however, some patients that have participated in pulmonary rehabilitation may still be readmitted to the hospital and there may be a possibility of having to re-enter the pulmonary rehabilitation program (Sin & Tu, 2000). By avoiding an early discharge from the hospital or pulmonary rehabilitation the chance of re-admittance may be reduced. There may be help to determine a way for the health care professionals to see when a patient may be getting discharged to early from a pulmonary rehabilitation program.

This literature review provided an evidence-based review of the literature pertaining to COPD itself, pulmonary rehabilitation programs, performance tests and norm-based tests used during pulmonary rehabilitation, and the readmission rates of pulmonary rehabilitation patients. The literature search was conducted by a omprehensive search that used Pubmed, Medline, and Google Scholar through the year of 1990 to 2012, with the exception of two papers to establish a history for PEFR from the years 1957 and 1959. The key words used were pulmonary rehabilitation and COPD, which were used in combination with the following words and phrases: inpatient, outpatient, 6-minute walk test, shuttle walk test, exercise capacity, peak expiratory flow rate, lung function test, exacerbation, length of stay, and readmission. The literature search was limited to articles published in peer-reviewed journals, in the English language, and the main criterion was the subjects having a pulmonary disease, mainly COPD. The search included randomized controlled trials, systematic reviews, observational studies, and epidemiological studies.

## Chronic Obstructive Pulmonary Disease

COPD does not have a single definition, but the multiple definitions all relate to a group of diseases that case airflow blockages, limitations, and breathing problems (Centers for Disease Control and Prevention, 2012), and the presence of these airflow limitations can increase the likelihood of developing lung cancer (Barnes & Celli, 2009). COPD is a slow progressive disease that may go undetected for many years, and in many cases when the disease is diagnosed the patient could have lost up to 50% of their lung function (Lundback et al., 2003). The prevalence of an airway obstruction could be as high as 50% in those older than 70 years of age (Viegi, Pistelli, Sherrill, Maio, Baldacci, & Carrozzi, 2007). In 2005, COPD caused approximately 126,000 deaths in the United States alone in people older than 25 years of age (Centers for Disease Control and Prevention, 2012), and COPD is projected to cause 4 to 5 million deaths worldwide in 2020 (Lundback et al., 2003). Types of COPD include emphysema, chronic bronchitis, and asthmas (Centers for Disease Control and Prevention, 2012).

The main cause for COPD is cigarette smoking, however only 10-20% of heavy chronic smokers develop symptomatic COPD suggesting additional risk factors causing COPD (Teramoto, 2007). Some of the additional risk factors include air pollution, occupational exposure, and possibly genetic factors. More polluted areas have shown an increased prevalence of COPD diagnosis, symptoms, and respiratory hospitalization; thus allowing the association of COPD and air pollution to be clear and biologically plausible (Viegi et al., 2007). The risk of occupational exposure is approximately 15%, and can include occupations with exposure to grain, coal, welding fumes, and other mineral dusts (Anto, Vermeire, Vastbo, & Sunyer, 2001). The genetic factors have only recently begun to be studied, there are multiple genotypes being assessed on whether they are associated with COPD (Anto et al., 2001). However, genetic factors are not a singular cause for COPD, but are likely to influence the susceptibility to develop COPD (Viegi, 2007).

### Pulmonary Rehabilitation Program

Pulmonary rehabilitation dates back to the 1960s when Thomas L. Petty, a medical doctor, developed the first outpatient rehabilitation program (Casaburi, 2008). Prior to the outpatient rehabilitation program, patients with COPD were told to avoid activity that may cause dyspnea or the difficulty of breathing. Critics of Petty's rehabilitation program questioned if benefits arose from the rehabilitation, but as the years went by pulmonary rehabilitation produced a substantial amount of physiological evidence which showed a reduction in the prevalence of dyspnea, increased exercise tolerance, and a greater quality of life regardless of the patient's age (Baltzan et al., 2004).

For inpatient and outpatient pulmonary rehabilitation programs there are three phases. Phase I occurs during hospitalization when nurses and dietitians meet with patients and their families to help them understand pulmonary disease and how to make the lifestyle adjustments needed to overcome it. Phase II, known as inpatient care, is done while living at home but periodically returning to a facility with medical professionals to perform the exercise training. Phase III, also known as outpatient care, is a home-based program where the patient lives and rehabilitates at home but goes to the medical facility for regular check-ups and appointments. Ferrari et al. (2004) examined the effectiveness of a minimally supervised outpatient rehabilitation program, which showed improvements in the quality of life and exercise tolerance of the patients involved. In comparison, Haave, Hyland, and Engvik (2007) studied the effectiveness of a 4-week inpatient rehabilitation program, which resulted in improvements in walking tolerance, lung function, perceived health status, and perceived quality of life for the participants, indicating that both types of programs can be effective.

The approach of pulmonary rehabilitation has changed from being a last resort for those with end-stage lung disease, to a near-essential component of COPD management (Balk & Elpern, 2002). The primary goal of medical professionals involved in pulmonary rehabilitation is to help the patient return to the highest level of independence (Ries et al., 1995). Inpatient rehabilitation programs typically run from 3 to 6 months, depending on the patient's specific problems and treatment goals. During phase II of the rehabilitation program, the majority of the time is spent performing an exercise-training program so the patient can be more independent in performing activities of daily living. The education component varies between each individual program but usually lasts from 1 to 3 hours per week (Van Stel, Colland, Heins, Rijssenbeek-Nouwens, & Everaerd, 2002) in order to give the patient more knowledge of the disease, hopefully reducing the need to rely on medical professionals. Some programs also provide behavioral evaluations by examining eating habits and coping mechanisms such as pursed lip breathing, which improves lung oxygenation and reduces dyspnea. These evaluations along with additional therapeutic support are used to promote the patient's relaxation and coping mechanisms (Balk & Elpern, 2002). The combination of the above components creates a multidimensional program that can be more effective in the treatment of the disease than a one-dimensional program utilizing a single approach such as education or exercise alone.

The efficacy of pulmonary rehabilitation programs has been shown in multiple aspects of the patient's physical and psychological wellbeing. Some research indicates patient improvement in dyspnea and functional capacity regardless of patient age, as indicated by enhanced walking and stair climbing (Baltzan et al., 2004). Improvements in walking distance and quality of life have also been seen in patients after 18 months, when rehabilitation programs were maintained (Troosters, Gosselink, & Decramer 2000). Previous work also suggests that rehabilitation patients demonstrate improvements in exercise performance and a reduction in symptoms, such as muscle fatigue, self-efficacy, and shortness of breath, despite little change in measure of pulmonary function, quality of life, depression, or the number of days the patient spends in the hospital (Ries et al., 1995). The differences in results suggest that not all patients respond in the same way, or to the same extent, to pulmonary rehabilitation programs (Haave et al., 2007).

Some problems with pulmonary rehabilitation may arise once the patient has finished the program and entered an outpatient program, which can either be community-based or home-based. Community-based or home-based programs have reported a wide range of adherence from as low as 25% (Cockram, Cecins, & Jenkins, 2006) all the way up to 78% (Steele et al., 2008). For a COPD patient, the disruption of an already established lifestyle routine is a major barrier in attending pulmonary rehabilitation (Keating, Lee, & Holland, 2011). Since most health coverage will pay for a portion of the costs associated with hospital-based pulmonary rehabilitation, the inpatient program might be less expensive overall for the patient when compared to a home-based program where the patient's health care assists very little with the financial burden (Clini et al., 2001). However, when health coverage is not available, the home-based programs may be less expensive for the patient and are more convenient causing them to typically be easier to adhere to (Balk & Elpern, 2002). Therefore, it is prudent to consider that the affordability and availability of a program may affect the patient's long-term adherence to the program. When a patient is able to afford the hospital-based program the patient may attend more days due to the enhanced accountability imposed by group support and medical supervision. Conversely, home-based programs may not have anyone present to motivate and ensure adherence to the program. However, the home-based program might not disrupt their daily routine, which may facilitate a greater adherence for some individuals. It is evident that both programs have their merits, and participation in either or both, must be based upon the individual needs and constraints of the patient.

Pulmonary rehabilitation is an effective treatment and can be made affordable for all patients with COPD, either through a hospital-based program or a home-based program (Balk & Elpern, 2002; Trooster et al., 2000; Griffiths, Phillips, Davies, Burr, & Campbell, 2001). Ideally, pulmonary rehabilitation should be multidimensional: involving both physiological and psychological therapy in order to achieve improvement in daily living functions, breathing comfort, and disease education for the patient. With the current information available indicating the effectiveness of pulmonary rehabilitation, it should be encouraged for all patients, with the understanding that each program should be tailored to the individual in order to reach their personal goals and regain their independence.

## Performance Tests

The shuttle walking test (SWT) and the 6MWT are commonly used to measure exercise capacity for those individuals participating in pulmonary rehabilitation (Balk & Elpern, 2002). The SWT is performed by walking up and down a 10-meter path at a predetermined speed, which is dictated by an audio-signal from a tape, similar to that of a metronome, with the cadence of the audio-signal increasing every minute (Vagaggini et al., 2003). The test is terminated if the patient is too fatigued to continue or is unable to finish the shuttle in the allotted time given by the audio-signal. The 6MWT is performed by having the patient walk as far as they can in the allotted 6 minutes (Spencer et al., 2008). The patient is able to stop to rest and continue again when ready, and the test is stopped either when the patient experiences severe dyspnea, the 6 minutes have elapsed, or self-termination which is when the patient requests to stop.

The SWT has been directly compared to the 6MWT through the examination of cardiorespiratory responses of 18 COPD patients after performing a walking test (Vagaggini et al., 2003). During a one-day session, patients performed two SWT and two 6MWT in a randomized order with a 30-minute break between each test. The patients' heart rates, blood pressures, respiratory rates, oxygen saturations and dyspnea were measured before the test and within 60 seconds of test completion. A greater distance was covered in the second test when compared to the first, for both the 6MWT and the SWT. However, there were statistically significant differences only between the first and second tests distances for the SWT. Vagaggini et al. (2003) suggested that the significant change between the first and second test distances for the SWT might have been due to the fact that the SWT is more difficult to perform the first time due to a lack of familiarization, suggesting that the learning effect for the SWT may have been more pronounced than it was with the 6MWT. However, Vagaggini et al. (2003) did not consider the momentum needed to stop and accelerate for the SWT, which may have affected the patient's distance achieved during each of the SWT. Despite these differences, the blood pressure, heart rate, respiratory rate, and oxygen saturation showed no difference between the pre- and post-walk test values, suggesting that both the 6MWT and SWT were equally effective measures of exercise capacity for COPD patients. However, other research has indicated higher maximum heart rates and the dyspnea reportings at the end of the SWT than at the end of the 6MWT (Singh, Morgan, Scott, Walters, & Hardman, 1992), suggesting that the 6MWT might be preferred for the medical safety of the patients with COPD.

Amongst the types of walk tests that measure exercise capacity in COPD patients, the 6MWT is the most commonly used, has a better tolerance level, is easier to administer, imitates activities of daily living more accurately, and has the greatest repeatability (Enright, 2003). The 6MWT is a self-paced test whereas other tests, such as the SWT, require patients to maintain a given pace. The primary component measured during a 6MWT is the total distance covered. Additional secondary measurements of fatigue, dyspnea, heart rate, and possibly oxygen saturation, are often also considered. Furthermore, the distance covered in a 6MWT has been shown to have a moderate relationship ($r \geq .5$) with one's peak oxygen consumption, indicating that the 6MWT may be a valid measure of exercise capacity (Jenkins, 2007), refer to Table 1 for more information on the reviewed literature.

Despite the research advocating the use of the 6MWT, the findings of Spencer, Alison, and McKeough (2008) contradict the previous conclusions mentioned above. Spencer et al. (2008) conducted a study with 44 subjects performing multiple 6MWTs: two 6MWT prior to pulmonary rehabilitation, two immediately after 8-weeks of pulmonary rehabilitation, and two 3 months after the completion of an 8-week pulmonary rehabilitation program (Spencer et al., 2008). Similar to Vagaggini et al.

(2003), Spencer et al. (2008) found that the second test of the day always resulted in a greater distance being covered; the patients' heart rate, oxygen saturation, and dyspnea responses also significantly improved the second time around. Such results indicate that familiarization and adequate warm-up can greatly influence the results of the 6MWT. Therefore, before performing a 6MWT there is a need for patients to be familiarized with the test, otherwise the results may be misrepresenting the improvements, as results tend to improve more after rehabilitation by those patients with a familiarization test than by those who were not familiar with the 6MWT (Jenkins & Cecins, 2010).

Both the SWT and 6MWT are widely used tests to measure the exercise capacity of patients involved in pulmonary rehabilitation (Vagaggini et al., 2003; Rasekaba, Lee, Naughton, Williams, & Holland, 2009). However, the 6MWT appears to better reflect activities of daily living than do other walk tests, as it is self-paced. In addition, the 6MWT is a reliable, safe, and inexpensive test with good reproducibility for testing exercise capacity of the patients in pulmonary rehabilitation, specifically when the patients have been previously familiarized with the test.

### Norm-Based Tests

In order to estimate exercise capacity and lung function, the patient's peak expiratory flow rate (PEFR) is often collected along with the 6MWT, and may be used to gauge patient improvements while participating in pulmonary rehabilitation (Balk & Elpern, 2002). PEFR is a measure of the fastest flow rate of exhaled air after maximal inspiration (Chaitra & Maitri, 2011). By collecting 6MWT and PEFR data, pre- and post-rehabilitation, medical professionals are able to objectively quantify patient improvements following treatment. However, the 6MWT and PEFR do not necessarily reflect the same information, as the PEFR may not be an accurate measure of exercise capacity for those patients in pulmonary rehabilitation. For example, one recent study found that pulmonary rehabilitation resulted in improved exercise capacity; however, these changes in exercise capacity were shown to be independent of the pulmonary norm-based tests (PEFR), which did not improve following pulmonary rehabilitation (Ige et al., 2010). Similar results were reported by Ries et al. (1995) who found no increase in lung function tests; these results suggest that although norm-based tests are beneficial, the data obtained from them may not be a valid estimate of functional exercise capacity. Nevertheless, pulmonary function tests are used as an outcome measure to assess disease severity, prognosis of the patient, and as a measure of mortality (Wilson, MacDonald, Watter, & O'Rourke, 2006).

To compare the different means of measuring ventilatory capacity, Wright and McKerrow (1959) compared the PEFR and the forced expiratory volume in 1 second ($FEV_1$) against each other. PEFR came into consideration as an alternative to forced expiratory volume (FEV) because $FEV_1$ previously required a connection to an electric supply, whereas PEFR did not. The adoption of the PEFR made performing ventilatory tests simpler by introducing an instrument called a flowmeter. Higgins' (1957) studied men aged 55 to 64 and found a high correlation ($r = .86$) between PEFR and FEV in 0.75 seconds. The difference being that FEV is a measure of the total volume forcefully expired after one breath, whereas $FEV_1$ or $FEV_{.75}$ are measures of forcefully expired air for a given period of time (1 and 0.75 seconds, respectively).

Table 1

Literature Reviewed for Walking Tests and Pulmonary Function Tests

| Author | Type of Study | Particpants | Assessment | Duration | Results (significant) |
|---|---|---|---|---|---|
| Troosters, 2000 | Randomized Controlled Trial | 50 COPD Patients | $FEV_1$ & 6MWT | 6 months | 6MWT inc. 52m, $FEV_1$ inc. .19L/min |
| Haave, 2007 | Interventional Clinical Study | 92 COPD Patients | 6MWT & $FEV_1$ | 4 weeks | 6MWD inc. an average of 25m and were significantly correlated with $FEV_1$, |
| Baltzman, 2004 | Epidemiological Study | 230 COPD Patients | 6MWT | April 1999 – March 2000 | 6MWT inc.significantly for 40% of the patients |
| Spencer, 2008 | Prospective, Longitudinal Study | 40 COPD Patients | 6MWT & Lung Function | 3 months/PR 8 weeks | Inc. of 27m for 6MWT from walk 1 to walk 2 |
| Man, 2004 | Randomized Controlled Trial | 42 COPD Patients | SWT | 8 weeks | SWT distance inc. 60m |
| Donaldson, 2002 | Observational Study | 109 COPD Patients | $FEV_1$ & PEFR | November 1995-November 1998 | The more frequent the exacerbations the greater the decline in $FEV_1$ and PEFR |
| Guell, 2011 | Randomized Controlled Trial | 60 COPD Patients | 6MWT & $FEV_1$ | 2 years/ 3 month PR | Inc. in 6MWT ($p=0.0001$), reduced exacerbations ($p<0.0001$) |
| Ige, 2010 | Randomized Controlled Trial | 44 COPD Patients | SWT, PEFR, & $FEV_1$ | 6 weeks | SWT inc. 25m |

*Note*: Inc.= Increased

The high correlation between PEFR and FEV suggests that the two can be used in a similar manner to assess pulmonary function (Higgins, 1957; Wright & Mckerrow, 1959). More recent research has compared the frequencies of exacerbations over the course of a year in patients with COPD regarding their decline in lung function, as measured by both PEFR and $FEV_1$ (Donaldson et al., 2002). The patients were measured every 3 months over the course of a year, and those patients experiencing more frequent exacerbations showed a significantly greater decline in PEFR and $FEV_1$, throughout the year, than those with infrequent exacerbations. Similarly, Troosters et al. (2000) found that patients who died during their study, which assessed the short- and long-term effects of outpatient rehabilitation in COPD patients, had a significantly lower $FEV_1$ than those who survived. With declines in both PEFR and $FEV_1$ coinciding with an increased frequency of exacerbations, previous research confirms Wright and Mckerrow's analysis that PEFR and $FEV_1$ can be viewed as ventilatory tests that provide similar information (Donaldson et al., 2002; Troosters et al., 2000), as indicated by the high correlation between the two ($r = .84$) (Emerman & Cydulka, 1996; Gautrin, D'Aquino, Gagnon, Malo, & Cartier, 1994).

When comparing baseline values taken prior to pulmonary rehabilitation with post-rehabilitation values over 72 months, Ries et al. (1995) found that pulmonary rehabilitation produced significant changes in endurance exercise testing using an incremental, symptom-limited $VO_2$ test on a treadmill, but no change in pulmonary function ($FEV_1$). Ige, Olarewaju, Lasebikan, and Adeniyi (2010) reported similar findings and concluded that the improvements made during the SWT were independent of the changes in the $FEV_1$ ventilatory function test. Ige et al. (2010) enrolled patients with COPD in a 6-week outpatient program, in which they attended twice a week. Exercise capacity and pulmonary function of the patients were assessed prior to and at the completion of the program. The initial measurements included questionnaires, ventilatory tests, and oxygen saturation tests before and after a SWT, as well as a resting ECG. The results at the end of the 6-week program showed no significant change in $FEV_1$, vital capacity, PEFR, baseline oxygen saturation, or in breathlessness measured on the Borg scale (Appendix A). However, the SWT distances were increased by a mean of 25 meters, indicating that performance in functional exercise tests such as the SWT may be independent of pulmonary function tests.

A study by Ferrari et al. (2004) produced inconsistent results when examining the effects of outpatient rehabilitation (education, upper and lower limb exercise, and stretching for 12 weeks) on pulmonary function, exercise tolerance, and quality of life in patients with COPD. In order to monitor these variables, patients were assessed before and after rehabilitation using a variety of pulmonary functions tests (FVC, $FEV_1$, $FEV_1$/FVC ratio, functional residual capacity, total lung capacity, and residual volume/total lung capacity ratio), graded exercise test, and a Health Status Index (SF-36), which yields 8 separate subscales: physical function, physical role, bodily pain, general health, vitality, social function, emotional role, and mental health. The rehabilitation program did not produce any significant variations or improvements in the pulmonary tests including the $FEV_1$, even though the exercise tolerance was significantly increased. With the Health Status Index (SF-36), the patients began with low scores when compared to those of healthy adults, but after rehabilitation, the patients showed significant improvement on six of the 8 subscales (Appendix B). Considering the fact that the $FEV_1$ showed little variation between pre- and post-rehabilitation testing, one might assume that PEFR would also remain unchanged as PEFR and FEV have such a high correlation ($r = .83$), as shown by Gautrin et al. (1994); these findings provide further support for the proposed independence of pulmonary testing and exercise capacity.

The PEFR has been shown to be reliable measurement of lung function (Douma et al., 1997). However, the PEFR did not always show the same improvements as exercise capacity tests did, suggesting that the results of the PEFR and the 6MWT may be independent of one other. Considering this independence, and the fact that PEFR did not increase as a patient progresses, suggests that PEFR may not be the most reliable predictor of readmission rates for those participating in pulmonary rehabilitation. Conversely, the 6MWT appeared to be more sensitive to changes in patient's functional capabilities and therefore may more accurately foreshadow future readmission rates.

### Readmission Rates

COPD patients account for 1.4 million days spent in the hospital per year; this time is primarily attributed to elderly patients, as they have a higher frequency of disease and relapse compared to their younger counterparts (Sin, & Tu, 2004). Of the emergency room visits from COPD patients between December 2005 and March 2006, 28% were caused by exacerbations from the disease; however some other psychological, social, and medical factors such as poor quality of life, environmental pollutants, and bacterial respiratory infections were also responsible for readmission (Gruffydd-Jones et al., 2007). With the high frequency of readmissions in COPD patients, researchers have begun to study the effectiveness of pulmonary rehabilitation on the patients' readmission rates (Man et al., 2004). However, many studies examining readmission have only looked at patients with COPD after they have been readmitted to the emergency room, rather than examining the re-enrollment into a pulmonary rehabilitation program. Another inconsistency throughout the re-admittance research is the length of time that data are being collected, which ranges anywhere from 15 days (Sin & Tu, 2004) to 1 year (Troosters, Casaburi, Gosselink, & Decramer, 2005). The above discrepancies suggested that the data may not be consistent across studies due to such a wide range in period assessment, which was known to affect the long-term effects of a pulmonary rehabilitation program, and the effects were often still seen after 12 months completion (Guell et al., 2000), refer to Table 2 for more literature reviewed for hospitalizations and pulmonary rehabilitation assessment tests.

Patients are usually able to safely participate in pulmonary rehabilitation shortly after experiencing an exacerbation, and when doing so, patients participating in such programs have been shown to have an expedited recovery (Man et al., 2004). Some studies have looked at the effectiveness of pulmonary rehabilitation on patient relapse rate; those studies that have focused on post-pulmonary rehabilitation and hospital admissions have shown fewer hospitalizations and shorter stays when compared to a control group not participating in a pulmonary rehabilitation program (Troosters, 2005; Hermiz et al., 2002; Hui & Hewitt, 2003). Man (2004) found that a treated group was readmitted 30% less frequently and had fewer inpatient days, when compared to a control group not participating in pulmonary rehabilitation. Along with fewer hospitalizations, intervention groups have also been shown to have shorter stays. Hui and Hewitt (2003) showed a reduction in the length of stay from a mean of 7.4 days to 3.3 days following the completion of a pulmonary rehabilitation program; this shorter stay was concomitant to a reduction in hospital admission from 1.2 admissions per patient per year to 0.6 admissions. Even without a reduction in hospital readmissions, the practice of pulmonary rehabilitation appears to be a more effective use of the money and time of the health care system as it facilitates more consultations on the general practitioners' premises rather than alternative costly at-home visits (Griffiths et al., 2000).

Hui and Hewitt (2003) collected data from patients involved in 18 months of pulmonary rehabilitation. The authors found that up to 12 months after the completion of the program both the number of patient hospitalizations and the length of the stay were reduced; they also noted significant increases in the 6MWT with a mean increase of 90.5 meters. Despite these gains, there were no significant changes in the $FEV_1$ lung functions. Griffith et al. (2000) indicated similar findings, reporting no significant differences in the lung function tests but significant changes in the exercise capacity tests, and a reduced number of hospital days for those individuals participating in rehabilitation for a duration of 6-weeks. Such lung function tests, along with measurements of walking capacity were collected before, immediately following the 6-weeks, and 1 year after either usual treatment (primary-care follow-ups with no pulmonary rehabilitation) or rehabilitation. Griffiths et al. (2000) found that there were no significant differences between the control and the rehabilitation group for the lung function values, but there were significant improvements in the rehabilitation group for the SWT at 6-weeks, the benefits of which appeared to still be present even after a year.

These findings coincide with the substantially lower number of days spent in the hospital by the rehabilitation group when compared to the control group, likely due to the increased functional capacity of those individuals participating in pulmonary rehabilitation. The improvements in exercise capacity tests and hospital days suggest that the exercise capacity test may have a stronger relationship with relapse rates than do lung function test.

There was contradictory research regarding the relationship between lung function tests, exercise capacity tests, and corresponding relapse rates. Bourbeau et al. (2003) found no differences between the usual care group, regular check-ups only, and the pulmonary education group in either the lung function tests or the 6MWT, but the acute exacerbations were less frequent in the intervention group, resulting in reduced hospital admission. The similarities in the lung function and 6MWT could have been due to the intervention group only receiving education rather than a multidimensional program including exercise. Even when receiving pulmonary rehabilitation, there are still other related risk factors which often result in hospital admission, such as bacterial respiratory infections, age, and co-morbid diseases, such as streptococcus pneumonia, which is a type of bacterial infection, or pulmonary hypertension, which is common in COPD patients (Yohannes & Connolly, 2001).

Table 2

Literature Reviewed for Hospitalizations and Pulmonary Assessment Tests

| Author | Type of Study | Particpants | Assessment | Duration | Results (significant) |
|---|---|---|---|---|---|
| Cockram, 2006 | Randomized Controlled Trial | 21 COPD Patients | Functional Capacity, & Hospital Utilization | 8 weeks | 6MWT mean inc. 19.1m & reduced hospital usage |
| Ries, 1995 | Randomized Clinical Trial | 119 COPD Patients | $FEV_1$, Walking Test, & Hospital Utilization | 8 weeks | Inc. in walking tests, slight not significant decease in duration of stay |
| Seymour, 2012 | Randomized Controlled Trial | 60 COPD Patients | Hospital Utilization | June 2005- April 2008 | The hospital admission for COPD exacerbation was lowered |
| Bourbeau, 2003 | Multicenter, Randomized Clinical Trial | 469 COPD Patients | Acute Exacerbations, Hospital Admissions, & ER Visits | February 1998- July 1999 | Hospital usage for exacerbation reduced 39.8%, other health problems reduced 57.1%, & ER reduced 58.9% |
| Griffiths, 2000 | Randomized Controlled Trial | 200 COPD Patients | Hospital Utilization | 1 year study/6 week PR | PR group had less days spent in the hospital than control group (mean 10.4 vs. 21.0) |
| Hui,2003 | Prospective Longitudinal Study | 36 COPD Patients | 6MWT, FEV1, & Hospital Utilization | 18 months | 6MWT inc. 90.5m, hospital admission for exacerbations went from 1.2 to .6 per year, & LOS went from 7.4 days to 3.3 days per year |
| Man, 2004 | Randomized Controlled Trial | 42 COPD Patients | Hospital Utilization | 8 weeks | PR group was readmitted 30% less frequently and had fewer inpatient days |

There is no way to fully prevent relapses and readmissions in patients with COPD. However, there may be a way to promote adherence to the pulmonary rehabilitation program, thereby reducing the number of readmissions suffered by patients. The 6MWT seemed to be a more accurate measure of readmission probability when compared to the PEFR. Nevertheless, using both the 6MWT and PEFR together may provide a more accurate assessment of pulmonary and functional capabilities, and therefore provide a more precise estimate of the likelihood of hospital readmission. These comparisons may in turn be an effective tool used by health care professionals in order to determine the appropriateness of patient discharge and the corresponding risk for readmission.

## Summary

Pulmonary rehabilitation is intended to restore the patient to the highest level of independent functioning (Ries et al., 2007). Inpatient and outpatient pulmonary rehabilitation have been shown to be effective tools in the treatment of COPD, especially if they are multidimensional programs (Balk & Elpern, 2002; Trooster et al., 2000; Griffiths, Phillips, Davies, Burr, & Campbell, 2001); and has been shown to reduce the number of hospitalizations along with reducing the length of the stay (Man, 2004). Pulmonary rehabilitation uses assessment tests to determine the effectiveness of the program; among these tests are 6MWT and PEFR. The 6MWT is the most commonly used because it is easy to administer and imitates activities of daily living more accurately (Enright, 2003). While the PEFR has been shown to be a reliable measurement of lung function (Douma et al., 1997), unlike the 6MWT, the PEFR does not always increase with the patient's progress (Gautrin et al, 2004). This finding suggested that the 6MWT may be more accurate at predicting readmission rates over the PEFR. The readmission rates of COPD patients has been researched and analyzed for hospital admissions, but there was a lack of research for the re-entry into a pulmonary rehabilitation program. The need for further research on the premature discharge of patients from pulmonary rehabilitation and identifying the predictors of the readmission of patients re-entering pulmonary rehabilitation, which may be essential in the prevention of avoiding readmission all together following a pulmonary rehabilitation program.

# CHAPTER III

# METHOD

## Study Design

The design of this study was a case-control study. This study involved searching through 5 years of existing medical records for patients who had previously participated in Altru Health System's pulmonary rehabilitation programs (Grand Forks, ND). The intent of this study was to examine the difference between a group of readmitted (R) patients (cases) and a group of never readmitted (NR) patients (controls) from a pulmonary rehabilitation program, along with the relationship between the dependent variable of pulmonary rehabilitation readmission and multiple independent variables including 6MWT and PEFR differences, BMI difference, LOS, and start and end 6MWT. These comparisons were used to find the best predictor of readmission into a pulmonary rehabilitation program.

## Participants

The participants included in this study were both male and female patients of the pulmonary rehabilitation unit during the 5-year period of 2007 – 2011. Patients that did not complete the pulmonary rehabilitation sessions were not included in the analysis. Thirty-one patients were excluded from this study due to incompletion of the pulmonary rehabilitation program. The consent of the participants was not needed as the records were pre-existing and the data to be collected contain no identifiable markers. However, a waiver of authorization was granted through both the Altru Health System and University of North Dakota (UND) Institutional Review Board (IRB). The waiver of authorization was obtained to forgo the authorization requirement from the participant as disclosure of protected health information (PHI) involved provides minimal risk to the participant's privacy; the research could not be practically done without this waiver due to restricted access and use of the PHI. Altru IRB approval was granted on May 24, 2012 with an IRB number of ST-107, and UND IRB approval was granted on May 21, 2012 with an IRB number of 201205-401.

### Procedures

The data was collected in the fall of 2012 using computer access to medical records of patients that were previously involved in pulmonary rehabilitation at Altru Health System from a previous 5 year period, 2007-2011. Altru had a full list of all patients with COPD from 2007-2011 using code GO424. Each individual patient number (MRN) was entered in the EDM database for years 2007-2010, and into the Epic database for the year 2011. The patients that were involved in pulmonary rehabilitation were included in the study. The inclusion criteria was that the patient had to start pulmonary rehabilitation at Altru Health System between 2007-2011 and complete the same program also at Altru prior to 2011, a patient was omitted if they did not complete the program at Altru or if the patient had died prior to completion. The information obtained from the medical records was the patient's age, pre- and post-pulmonary rehabilitation PEFR and 6MWT, gender, smoking history, BMI, if the patient was readmitted into the pulmonary rehabilitation program at a later date once or multiple times, and LOS during pulmonary rehabilitation. When necessary, the difference was found between the pre- and post- rehabilitation measurements. Table 3 is an example of the spreadsheet on which the data was recorded.

### Statistics

A discriminant analysis was conducted in an attempt to discriminate between groups (R vs. NR) based upon if group membership (R VS. NR) be significantly determined by the predictor variables examined by the prediction strength of each of the independent variables. Within the discriminant analysis, the statistical procedures used were the Eigenvalues, Wilks' lambda, canonical discriminant functions, structure matrix, and classification results. These functions were conducted in order to find grouping percentages of the patients. The 6MWTdifference, PEFR difference, 6MWT start distance, 6MWT end distance, LOS and BMI difference were used as predicting variables for patient readmission into pulmonary rehabilitation. Statistical Package for the Social Sciences, IBM Statistics Version 19 was used to perform the analysis and interpretation of the data collected. Alpha levels were set at $P < 0.05$.

Table 3

Recording Data Spreadsheet

| ID | Age | Sex | LOS | Height | Weight | Pre-PEFR | Post-PEFR | Pre-6MWT | Post-6MWT | Re-admit |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 72 Y | M | 239 D | 1.80 m | 95.30 kg | 5.84 L/s | 7.14 L/s | 1100 ft. | 2006 ft. | No |
| 2 | 64 Y | M | 98 D | 1.74 m | 122.52 kg | 3.73 L/s | 4.44 L/s | 686 ft. | 1056 ft. | Yes |
| 3 | 88 Y | M | 153 D | 1.66 m | 68.90 kg | 8.05 L/s | 8.01 L/s | 571 ft. | 1636 ft. | Yes |
| 4 | 72 Y | F | 212 D | 1.60 m | 91.58 kg | 3.15 L/s | 3.69 L/s | 650 ft. | 360 ft. | Yes |

*Note*: Y= years, M= male, F= female, LOS = Length of Stay, D= days, m = meters, kg = kilograms, L/s= liters per second, ft.= feet

# CHAPTER IV

# RESULTS

A discriminant analysis was conducted to predict whether a patient would be readmitted into a pulmonary rehabilitation program or not. Subject demographics indicated a sample consisting of 98% Caucasians, with a mean height of 1.67 m, a mean weight of 84.79 kg, and a mean age of 69 years. The height, weight, and age was collected for a total of 333 subjects (180 female); BMI was calculated using the height and weight, and can be found in Table 4.

Table 4

Participants Base Data

| | Males | | Females | |
|---|---|---|---|---|
| Variable | Mean | Std. Deviation | Mean | Std. Deviation |
| Age (years) | 70.71 | 8.93 | 67.01 | 10.74 |
| Height (m) | 1.74 | 0.07 | 1.60 | 0.06 |
| Weight (kg) | 90.80 | 21.22 | 78.78 | 20.18 |
| BMI ($kg/m^2$) | 29.79 | 8.93 | 30.74 | 10.74 |

The independent variables used as predictors were as follows: LOS, PEFR difference, BMI difference, 6MWT start distance, 6MWT end distance, and 6MWT difference. There were important, yet non-significant, mean differences between the NR group and the R group in the predictors of the start 6MWT and the end 6MWT, as seen in Table 5.

Table 5

Group Statistics

| | Never Readmitted | | Readmitted | |
|---|---|---|---|---|
| Variable | Mean | Std. Deviation | Mean | Std. Deviation |
| LOS (days) | 154.76 | 67.91 | 155.64 | 76.88 |
| 6MWT Start (ft.) | 769.77 | 355.42 | 672.47 | 326.16 |
| 6MWT End (ft.) | 995.53 | 397.54 | 898.32 | 292.92 |
| 6MWT Diff. (ft.) | 225.75 | 376.10 | 225.85 | 318.37 |
| PEFR Diff. (L/s) | 0.18 | 1.01 | 0.11 | 0.76 |
| BMI Diff. ($kg/m^2$) | 0.16 | 1.91 | -0.26 | 1.70 |

The discriminant function also showed a non-significant association between the predictors and the groups as the predictors accounted for only 3% of group variability, and 97% unexplained variability (p> 0.05), as seen in Table 6 and Table 7.

Table 6

Eigenvalues

Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | .027 | 100.0 | 100.0 | .163 |

Table 7

Wilks' Lambda Table

**Wilks' Lambda**

| Test of Function(s) | Wilks' Lambda | Chi-square | df | Sig. |
|---|---|---|---|---|
| 1 | .973 | 8.864 | 5 | .115 |

However, despite the lack of significant differences between groups, the structure matrix indicated that 6MWT start distance was the strongest predictor (.739), whereas 6MWT end distance was the next strongest (.688), and BMI difference was the third strongest predictor (.586), refer to Table 8.

Table 8

Structure Matrix

Structure Matrix

| | Function |
|---|---|
| | 1 |
| 6MWT_start | .739 |
| End_MWT | .688 |
| BMI_diff | .586 |
| PEFR_diff | .189 |
| LOS | -.033 |
| 6MWT_diffa | -.001 |

Finally, the cross-validation grouping showed that 74.2% of the cases were classified correctly, as shown in Table 9. The grouping of the patients was determined to be 248 NR patients and 85 R patients, suggesting that 74% of the patients had never been readmitted whereas 26% had. The answers for the three questions to be answered by this study were determined as well. The primary question of which variable was the best predictor for readmission into a pulmonary rehabilitation program determined that the 6MWT was the strongest predictor. The secondary question of how well did each variable predict, concluded that that the predictors examined were not particularly good at predicting readmission into a pulmonary rehabilitation program. The final question was which assessment test, 6MWT or PEFR, was better at predicting readmission, and it was deduced that the start and end 6MWT was the better predictor for readmission.

Table 9

Classification Results

| | | | Predicted Group Membership | | |
|---|---|---|---|---|---|
| | | Readmitted | Never | Readmit | Total |
| Original | Count | Never | 248 | 0 | 248 |
| | | Readmit | 84 | 1 | 85 |
| | % | Never | 100.0 | .0 | 100.0 |
| | | Readmit | 98.8 | 1.2 | 100.0 |
| Cross-validateda | Count | Never | 247 | 1 | 248 |
| | | Readmit | 85 | 0 | 85 |
| | % | Never | 99.6 | .4 | 100.0 |
| | | Readmit | 100.0 | .0 | 100.0 |

# CHAPTER V

# DISCUSSION

Pulmonary rehabilitation has been around since the 1960s and has been shown to be an effective tool in managing COPD, and patients who have participated in such programs have been shown to have an expedited recovery (Man et al., 2004). Typically, when patients entered and exited the inpatient pulmonary rehabilitation program, they were required to perform initial assessment tests in order to determine their level of functioning. In this particular study, these initial assessments came in the form of 6MWT and PEFR. The purpose of this study was to determine whether or not there was a difference between those patients being readmitted into pulmonary rehabilitation and those patients who were not readmitted. In addition to the overall purpose, this study examined specific variables that might aid in predicting whether a patient would be readmitted into a pulmonary rehabilitation program or not. The three questions to be answered were: which variable was the best predictor for readmission into a pulmonary rehabilitation program, how well did each variable predict, and which assessment test, 6MWT or PEFR, was better at predicting reentry? Thus we examined the dependent variable of reentrance to pulmonary rehabilitation as it was influenced by the independent variables of 6MWT difference, PEFR difference, start 6MWT, end 6MWT, BMI difference, and LOS. The discriminate analysis showed important, although non-significant, mean differences between the NR group and the R group in the predictors of the start 6MWT and the end 6MWT, but a non-significant association between all the predictors and the NR and R groups.

The main finding of this study was that even though it was not significant, the strongest predictor for readmission was the start 6MWT. The end 6MWT and BMI difference were the second and third strongest predictors respectively, although also non-significant. The second question, which was how well did each variable predict, was answered by the fact that none of the predictors were significantly different between groups, indicating that no predictor was particularly strong at predicting readmission. Finding no significant predictors suggests there are many factors that influence the readmission to pulmonary rehabilitation, and that perhaps many of these fall outside the scope of what are considered traditional characteristics of pulmonary inadequacy.

However, a non-significant but possibly important finding was the difference between the start and end 6MWT between the NR and the R groups. The mean 6MWT taken at the start and end of pulmonary rehabilitation for the NR group was 770 ft. (235 m) and 996 ft. (304 m), respectively. While the mean 6MWT taken at the start and end of pulmonary rehabilitation for the R group was 672 ft. (205 m) and 898 ft. (274 m), respectively. The differences between the start 6MWT and the end 6MWT for both groups were increased approximately 226 ft. (69 m). According to Redelmeier et al. (1997) and Puhan et al. (2008), an increase of 226 ft. (69 m) for the 6MWT is an important change when considering the patient's self-perception of their overall health; such a distance is perceived by the patient as being significant, in that it instills in them the idea that they are approaching the performance level of a healthy population. Furthermore, Redelmeier et al. (1997) reported that 54 m was seen as the point in which patients interpreted their performances to be changed in a practically significant manner. Another study by Puhan et al. (2008) found that the 6MWT should change by approximately 35 m for patients with moderate to severe COPD in order to represent a minimally important difference as interpreted by the patient in order to be aware of the efficacy of pulmonary rehabilitation on their health. With the patients of the current study showing an increase of 226 ft. (69 m) for each group, the changes in the 6MWT were viewed as important for the patient's perception of their overall health and their view on the efficacy of the pulmonary rehabilitation program.

Other researchers have found increases in the 6MWT as well, such as Spencer, Alison, and McKeough (2008), who had 44 subjects perform multiple 6MWT: two prior to pulmonary rehabilitation, two immediately after 8-weeks of pulmonary rehabilitation, and two 3 months after the completion of pulmonary rehab. The authors found a significant improvement in 6MWT performance when comparing pre- and post- pulmonary rehabilitation values with those taken 3 months later. The results of this study were similar for the pre- and post- 6MWT to the findings of Spencer et al (2008), although this study has non-significant results. The 6MWT start and end distances for each group of this study indicated a difference of 97 ft. (30 m) from pre- to post-rehabilitation, with a greater distance being covered by the NR group in comparison to the R group. When the two groups were compared, the change in 6MWT difference was negligible, along with no discriminating change in PEFR difference between the NR and R groups. Although, the 6MWT difference was not the best predictor compared to the PEFR difference, the start and end 6MWTs were greater in the NR group, suggesting that the start and end 6MWTs were better predictors than the PEFR difference itself, however none of the “predictors” were significant. This finding answered the third question, which assessment test, 6MWT or PEFR, was better than the other, by indicating that the 6MWT was a better predictor than PEFR.

The 6MWT start and end distances were compared to predicted normal values for the same healthy demographic of a similar age, height, and BMI, which was determined using equations taken from Jenkins et al. (2009; appendix C). A comparison to the predicted norms for both the start and end 6MWT distances for male and female subjects was examined. The male subjects had a start 6MWT and end 6MWT distance of 745 ft. (227 m) and 971 ft. (296 m) respectively, whereas the normal value for healthy comparable males is 2108 ft. (643 m). The differences between the current male subjects and the healthy comparable males for the start 6MWT and end 6MWT distances were found to be 1363 ft. (416 m) and 1137 ft. (347 m), respectively. The female subjects showed similar deficiencies, walking 716 ft. (218 m) for the start 6MWT and 927 ft. (282 m), for the end 6MWT whereas the normal value for healthy comparable females was 1885 ft. (574 m). The differences between the female subjects from this study and the healthy comparable females were 1169 ft. (356 m) and 958 ft. (292 m) for the start and end 6MWT distances, respectively. It is therefore clear that a comparable healthy population was predicted to walk a great deal farther than the COPD patients involved in pulmonary rehabilitation, which should be expected considering the lack of pulmonary constraints for a healthy demographic. The 6MWT should still be considered a good measure of pulmonary rehabilitation since it is able to have a predicted normal value to compare with and is able to view the differences made pre- and post-pulmonary rehabilitation. With similar 6MWT differences between groups and a greater start 6MWT distance for the NR group, it may be suggested that the further the patient's start 6MWT is from the norm (i.e., the shorter their walking distance), the more likely to be readmitted later, but currently there is inadequate evidence to confirm this.

Past studies have observed similar results to those found in this study, with increases in the 6MWT while the PEFR remains unchanged. Hui and Hewitt (2003) found that after an 8-week pulmonary rehabilitation program there were no significant changes in patient lung functions; however the 6MWT distances were increased by 90 m. Ige et al. (2010) also found that after a 6-week pulmonary rehabilitation program walking tests were improved by 33 m yet no improvements were found in the patient's ventilatory tests. Ferrari et al. (2004) used a rehabilitation program to examine the effects on exercise tolerance and quality of life in patients with COPD. The rehabilitation included an education program, upper and lower limb exercise, and stretching for a 12-week program. The rehabilitation showed that there were no significant variations in the pulmonary tests when comparing pre- and post-values, even though the exercise tolerance was increased. Finally, Ries et al. (1995) compared pre- and post-rehabilitation values over 72 months and found that pulmonary rehabilitation produced significant changes in endurance exercise testing, but no statistically significant change in pulmonary function. The above studies support the notion that PEFR does not always reflect changes in patient performance or provide the same information as the exercise capacity tests do. Furthermore these studies suggest that the results of the PEFR and the 6MWT may be somewhat independent of one another, which is in agreement with the findings of the current study. Our results, while non-significant, suggested that there was a small difference between the NR and the R groups with the PEFR difference, but none for the 6MWT difference. However, there was an important difference in 6MWT distance covered at the start of the program when compared to that at the end (30 m), whereas there was no difference in starting and ending PEFR values. These findings may suggest that the start or end 6MWT scores alone more effectively discriminate between readmission groups than do the differences for 6MWT and/or PEFR.

While a significant improvement in lung function following pulmonary rehabilitation is uncommon, a few studies have indicated an improvement in both lung function tests (e.g., PEFR, $FEV_1$) and 6MWT. Haave, Hyland, and Engvik (2007) had 92 patients enrolled in a 4-week pulmonary rehabilitation program and found significant improvements on the walking test and lung function test. However, the authors concluded that the improvements on the walking test were independent of the changes in lung function. Similarly, Riario-Sforza et al. (2005) compared between two groups involved in a 4-week pulmonary rehabilitation program, with one group consisting of 37 patients with exacerbations and the other group consisting of 37 patients without exacerbations. The patients experiencing no exacerbations had significant improvements in the 6MWT with an increase of at least 54 m and significant improvements in the lung function test. However, the authors found that the patients experiencing exacerbations had no significant difference for the 6MWT and less significant lung function tests than the no exacerbation group. Contrary to the above findings, there was little consistent data that proved that pulmonary rehabilitation was able to significantly improve lung function, and that the progressive decline in lung function in COPD patients cannot be prevented by treatment (Riario-Sforza et al., 2005). However, pulmonary rehabilitation may provide a valuable role in slowing the decline of lung function and limiting the effects seen, despite not fully preventing or reversing the loss of lung function.

Other factors such as drug treatments may be the underlying cause of the improvement in respiratory performance instead of pulmonary rehabilitation alone. Therefore, when considering these respiratory performance changes following pulmonary rehabilitation, it is difficult to determine the exact mechanism underlying such adaptation (Riario-Sforza et al., 2005). If drug treatments are responsible for driving the change in pulmonary function, perhaps they should be accounted for and taken into consideration for future assessment of pulmonary rehabilitation. However, the pulmonary function tests could be used to determine the effectiveness of a particular drug intervention on pulmonary performance. Finally, Wehrmeister et al. (2011) had a review of the literature on COPD patient rehabilitation, and 12 analyses were obtained that included pre- and post-rehabilitation pulmonary function. Out of those 12 analyses, 6 showed rehabilitation to have overall favorable results, but only 1 of those 6 analyses was due to an increase in pulmonary function from pre- to post-rehabilitation. These studies suggest that 6MWT often increase despite little change in PEFR. Although, the possibility of simultaneous adaptation in 6MWT and PEFR exists, it was not observed in the current study. Furthermore, researchers must take caution when interpreting the data of medicated patients, as their current level of drug treatment may influence the likelihood of one or both variables showing improvement.

The BMI difference between the start and end of pulmonary rehab was the third best predictor found in this study, although it was not significant. However, the changes were small: a 0.15 kg/m$^2$ increase for the NR group and a 0.26 kg/m$^2$ decrease for the R group. These results were consistent with those from other studies. For example Sava et al. (2010), found that the changes in BMI after rehabilitation were small and not statistically significant. However, such small changes in BMI may have positive implications, as Celli et al. (2004) have shown that even small change in BMI can provide a survival advantage to COPD patients. Such minimal alterations in BMI suggest that although it may be important for predicting mortality, it is not an effective predictor of patient readmission into pulmonary rehabilitation.

The LOS was also found to have little predictive strength regarding the return of patients to pulmonary rehabilitation. There were no significant differences between the NR and R groups, as the mean LOS was 155 days for each group. Green, Singh, Williams, and Morgan (2001) compared a 4-week pulmonary rehabilitation program to a 7-week program and found that the 7-week program resulted in enhanced patient health and walk test performance, but not enhanced pulmonary function. The study by

Green et al. (2001) suggests that the longer the LOS for patients involved in a pulmonary rehabilitation program the greater the benefits for the patients. The current study showed a similar LOS for both groups, suggesting that although the LOS might be a logical predictor of readmission into pulmonary rehabilitation, the data collected for the purpose of this study do not support such a notion.

### Limitations

The limitations of this study involved the literature reviewed, study location, and data collection. The existing available literature comparing readmission and pulmonary rehabilitation was limited to only readmission into a hospital bed setting (e.g., emergency room or over-night stay) and not back into a pulmonary rehabilitation program. There are also a limited number of studies specifically examining the relationship between BMI and pulmonary rehabilitation. The sample used in this study was very limited regarding demographic background, due to the geographical location of data collection. For example, our homogenous sample consisted of a vast majority (98%) of Caucasian patients over the age of 60, so this data may not be able to be generalized to the greater population. The method used to document records of pulmonary rehabilitation was changed after 2005 in the Altru hospital database. This change in systems limited the available pool of data used for this study due to the inability to access the older records. Along with the database change for pulmonary rehabilitation, not all medical records were available in the same system as the pulmonary rehabilitation records, which limited the information collected including the medications that the patient was taking at the time of admission and if the patient was transferred to another hospital or died. For these reasons a patient was not included in this study if they did not fully complete pulmonary rehabilitation at Altru Health System's pulmonary rehabilitation unit.

Future researchers should consider whether or not pulmonary rehabilitation patients may have transferred to another facility or passed away prior to readmission into rehabilitation, because the records from the other facilities or death records may not have been submitted to the original hospital to update the patient's medical records. Greater focus on the main causes to the readmission of a patient into pulmonary rehabilitation, such as disease, exacerbations, or lifestyle changes, might be more predictive than pulmonary function data taken at the start and end of the program. More studies should also be conducted to test whether drug treatments, including inhaled corticosteroids and broncholdilators, increase the lung function tests from pre- to post-rehabilitation and correlate with the walking tests. These lung function tests, while on medication, may create better predictors for readmission into a pulmonary rehabilitation program.

## Conclusion

The current study attempted to determine the likelihood for readmission into a pulmonary rehabilitation program by asking the following questions: which variable was the best predictor for readmission into a pulmonary rehabilitation program, how well did each variable predict, and which assessment test, 6MWT or PEFR, was better at predicting readmission? The findings for the primary question revealed that out of the variables collected at the start and end of pulmonary rehabilitation; the 6MWT start was the strongest predictor. However, in answering our second question, it was clear that the predictors examined were not particularly good at predicting readmission into a pulmonary rehabilitation program. Finally, the answer to the third question was that the 6MWT was a better predictor than PEFR.

Considering the fact that most patients (74%) were never readmitted, and that the majority of 6MWT were increased by 226 ft. (69 m), pulmonary rehabilitation appears to still be an effective tool in managing COPD. The results provided showed that there was not one specific predictor that strongly indicated the likelihood for readmission, suggesting there are perhaps a plethora of variables outside of those linked specifically to pulmonary rehabilitation may be influencing a patient with COPD. However, the findings from this study seem to suggest that the further the start and end 6MWT was below the normal values, the more likely it was that a patient would be readmitted into the pulmonary rehabilitation program.

APPENDICES

APPENDIX A
THE BORG SCALE

The Borg Scale

| | |
|---|---|
| 6 | No exertion at all |
| 7 | Extremely light |
| 8 | |
| 9 | Very light |
| 10 | |
| 11 | Light |
| 12 | |
| 13 | Somewhat hard |
| 14 | |
| 15 | Hard (heavy) |
| 16 | |
| 17 | Very hard |
| 18 | |
| 19 | Extremely hard |
| 20 | Maximal exertion |

APPENDIX B
BEFORE AND AFTER REHABILITATION SF-36 SCORES

**TABLE 2**
*SF-36 scores before and after rehabilitation*

| SF-36 Scale | Before Rehabilitation | After Rehabilitation | *P* Value[a] |
|---|---|---|---|
| Physical function | 56.4 ± 17.3 | 72.1 ± 13.3 | <0.01 |
| Physical role | 30.4 ± 36.2 | 60.4 ± 29.1 | <0.01 |
| Bodily pain | 82.3 ± 23.5 | 83.3 ± 24.2 | NS |
| General health | 38.3 ± 17.7 | 62.9 ± 18.2 | <0.01 |
| Vitality | 46.4 ± 26.5 | 69.3 ± 22.4 | <0.01 |
| Social function | 51.8 ± 8.0 | 51.9 ± 11.6 | NS |
| Emotional role | 56.6 ± 45.5 | 81.7 ± 35.4 | <0.01 |
| Mental health | 56.9 ± 23.3 | 76.0 ± 17.1 | <0.01 |

Values are mean ± standard deviation.

[a]*P* values were obtained by two-tailed test comparing value before and after training within the same group.

APPENDIX C
EQUATION FOR PREDICTED NORMAL VALUES FOR THE 6MWT

Predictive equation for males: 6MWD(m) = 867 - (5.71 age, yrs) + (1.03 height, cm)

Predictive equation for females: 6MWD(m) = 525 - (2.86 age, yrs) + (2.71 height, cm) - (6.22 BMI).

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