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Physical Activity and Veteran Status in Obesity and Chronic Obstructive Pulmonary Disease

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Abstract

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Dissertation Submitted in Partial Fulfillment

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Abstract

There are few data available regarding the relationship between physical activity and veteran status in those with combined chronic obstructive pulmonary disease (COPD) and obesity. COPD is a common illness and a leading cause of death in the United States. Veterans represent a distinct subpopulation in the United States and are more likely to have COPD, which is a disease with a high rate of comorbidities such as obesity. Physical activity can improve outcomes for those with COPD and obesity. However, recommendations for physical activity for those with COPD and obesity are vague. This study, based on the self-determination theory, sought to explore the relationship between average weekly physical activity and veteran status while controlling for age, sex, race, ethnicity, smoking status, body mass index (BMI), education level, and annual household income in those with comorbid COPD and obesity. Also, the relationship between not meeting, meeting, and exceeding physical activity recommendations and veteran status, while accounting for variation in for age, sex, race, ethnicity, smoking status, BMI, education level, and annual household income, was explored. A case-control study was done to answer the research questions using multiple regression and ordinal regression analyses, respectively, using data from 1,430 participants from the 2015 BRFSS. Veteran status was not significantly associated with physical activity nor was it significantly associated with falling below, at, or above recommended physical activity amounts. However, it was found that increased BMI was associated with decreased physical activity. The results from this study can be used to inform policies, refine recommendations, and guide interventions for those with COPD and obesity.

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Chapter 1: Introduction to the Study

This chapter provides background information to support the purpose of this research study, which was to explore the relationship between veteran status and physical activity in individuals with chronic obstructive pulmonary disease (COPD) and obesity. This study addressed a significant gap in literature surrounding physical activity and veteran status in those with COPD and obesity, which may aid in informing programs for this specific population. The theoretical framework underpinning this study is described in terms of the research questions. Additionally, this chapter includes statements regarding the nature of the study, key definitions, assumptions, and the significance of the study.

Background

Veterans

A veteran is a person who actively served in the United States' military who was not dishonorably discharged (38 U.S.C. § 101). According to the United States Census Bureau (2015), veterans account for about 8.0% of the population and represent a unique subpopulation of the total population. Veterans differ from the general population in many ways. A clear majority, 94%, of veterans are male and they are also significantly older, with a median age that is 20 years higher than civilians (National Center for Veterans Analysis and Statistics, 2017). Veterans, as a whole, are less likely to claim Hispanic heritage, to have a higher median income, and are more likely to be insured than nonveterans (National Center for Veterans Analysis and Statistics, 2017). It is important to consider all possible confounding factors when studying the veteran population.

Despite increased attainment of health insurance coverage, veterans experience some notable health disparities, as evidenced by disproportionate rates and risk of various morbidities. These disparities exist even though there may be selection bias towards healthier individuals joining the military, having to meet and maintain mental and physical standards as part of military service (National Center for Veterans Analysis and Statistics Statistics, 2017). There are organizations that primarily cater to the needs of the veteran population such as the United States Department of Veterans Affairs (2015) with a mission to care for veterans. These organizations are uniquely situated to address these health disparities.

Chronic Obstructive Pulmonary Disease

An example of a disease that is found more in veterans than nonveterans is COPD. It has been estimated that 8.8% of veterans suffer from COPD (Thompson & St-Hilaire, 2010) while 6.3% of the entire United States population report being diagnosed with COPD (Centers for Disease Control and Prevention, 2012). Additionally, the rate of COPD increased 43% from 2003 to 2011 in the veteran population (Pugh et al., 2016). This highlights the importance of this specific disease, as not only is COPD highly prevalent, it is also increasingly prevalent.

COPD is characterized by restricted breathing due to blockage and is comprised of emphysema, chronic bronchitis, and some cases of asthma (Centers for Disease Control and Prevention, 2016b). Smoking is an important risk factor in terms of COPD. Veterans who smoke are 3.18 times more likely to have COPD than veteran nonsmokers

(Thompson & St-Hilaire, 2010). Other risk factors for COPD include increased age and decreased education (Rycroft, Heyes, Lanza, & Becker, 2012).

The gold standard for diagnosing COPD is spirometry. Spirometry involves measuring the amount of air that goes in and out of the lungs (Global Initiative for Chronic Obstructive Lung Disease, 2017). This is considered the gold standard as it directly measures lung function (Global Initiative for Chronic Obstructive Lung Disease, 2017). More specifically, lung function testing should be done following inhalation of an adequate dose of a short-acting bronchodilator (Global Initiative for Chronic Obstructive Lung Disease, 2017). A Tiffeneau-Pinelli index that is less than 0.7 is required for a COPD diagnosis (Global Initiative for Chronic Obstructive Lung Disease, 2017). It is estimated that 81.4% of all cases that meet the spirometric definition of COPD go undiagnosed (Bernd et al., 2015). The Global Initiative for Chronic Obstructive Lung Disease revised their recommendations in 2017 to go beyond lung function tests when assessing COPD patients to further explore the impact of COPD symptoms on the patient using tools such as the COPD Assessment Test (CAT™) or the COPD Control Questionnaire (CCQ©). Having a standard by which to diagnose patients with this disease is a key component to understanding the impact of COPD.

It is also important to be able to consider severity of COPD, as there are clinical differences by severity grade. Those with mild COPD may have distinct characteristics as compared to those with increasing severity. In order to further stratify COPD by severity, the Global Initiative for Chronic Obstructive Lung Disease (2017) suggested comparing the forced expiratory volume in one second, or FEV_1, of the patient to an expected value.

The proportion of individuals with COPD in each severity group can vary a study showed that 30.6% of those with COPD were mild, 51.4% were moderate, 15.3% were severe, and 2.7% were categorized as very severe (Bednarek, Maciejewski, Wozniak, Kuca, & Zielinski, 2008). It is important to stratify COPD based on severity; however, examining the impact as a whole is also important.

COPD is progressively important in the United States aside from the increasing prevalence. COPD is the fourth leading cause of mortality in the United States and increased from 21.0 deaths per 100,000 in 1963 to 42.2 deaths per 100,000 in 2013 (Ma, Ward, Siegel, & Jemal, 2015). COPD impacts quality of life as well, with 33% experiencing some sort of physical limitation and up to 18% of individuals with the disease experiencing some limitations at work (Patel, Nagar, & Dalal, 2014). There is also a significant financial burden associated with COPD with $9.9 billion annual estimated lost due to productivity associated with this illness (Patel et al., 2014). In the veteran, population those with COPD have total annual costs that are $2,780 higher than the remaining population (Sharafkhaneh et al., 2010). These costs reflect the impact of COPD and do not necessarily represent significant comorbidities associated with COPD.

A hallmark of COPD is the concurrence of other illnesses. Those with COPD are more likely to have a clinically relevant comorbidity as compared to the remaining population (Schnell et al., 2012). Over 96% of individuals with COPD have at least one clinically relevant comorbidity (Schnell et al., 2012). Over half of patients with COPD have four or more clinically relevant comorbidities (Smith & Wrobel, 2014). Hypertension was found in 51% of individuals with COPD, 41% had hyperlipidemia, and

21% had osteoarthritis (Putcha et al., 2013). Comorbidities associated with COPD have varying impact on quality of life as those with co-occurring obstructive sleep apnea, stroke, and gastresophageal reflux disease have reported decreased quality of life (Putcha et al., 2014). Being diagnosed with COPD had a higher correlation with having arthritis, depression, osteoporosis, cancer, and heart disease (Schnell et al., 2012). A specific comorbidity that has a complex relationship with COPD is obesity.

Obesity

Obesity is described as having excessive body fat and is defined by having a body mass index (BMI) greater than or equal to 30 (Centers for Disease Control and Prevention, 2010). However, there are more accurate ways to assess adiposity, such as skinfold thickness or dual energy x-ray absorptiometry, but BMI is widely used, convenient, and relatively easy to calculate, as it is the result of dividing weight in kilograms by the square of the height in meters (Addo, Pereira, & Himes, 2012). As BMI is not a direct measure of adiposity and more so of body mass, the Centers for Disease Control and Prevention (2016b) stated that BMI is more appropriately used as a screening tool than a diagnostic tool. As a screening tool, it is useful to establish the epidemiology of obesity.

Overall, the age-adjusted prevalence of obesity in the United States was 35.7% (Flegal, Carroll, Kit, & Ogden, 2012). Even more alarming than the rate of obesity is the increase in prevalence, where prevalence rose by more than 3% over a 2-year period (Centers for Disease Control and Prevention, 2010). Increasing body mass is associated with morbidity, such as heart disease and stroke, and mortality (Centers for Disease

Control and Prevention, 2010). As prevalence of obesity rose it became necessary to subdivide obesity into classes, as increasing BMI led to increased levels of certain diseases, like cancer, and different outcomes such as mortality (Centers for Disease Control and Prevention, 2016c). About 20% of the United States population has a BMI between 30 and up to but not including 35; 9% of individuals have a BMI between 35 and up to 40; and a BMI greater than or equal to 40 was found in 6.3% of the population (Flegal et al., 2012). Even when limiting to the obese population it is important to consider increasing BMI as a factor as there are differences in population distribution and can influence varying health outcomes. With an obesity epidemic, risk factors need to be examined.

The Centers for Disease Control and Prevention (2010) identified increased caloric consumption and decreased physical activity as key drivers of the obesity epidemic. There are many other risk factors associated with obesity. Increasing obesity rates were negatively associated with higher income, increased access to health insurance and health care services, and increased graduation rates (Doty, 2008). Racial and ethnic minorities in the United States also have significantly increased rates of obesity as compared to the White and non-Hispanic population (Centers for Disease Control and Prevention, 2010). In the veteran population, it was estimated that 41% of veterans were obese (Breland et al., 2017). Using self-reported data, it was found that veterans were more likely to be overweight than the general population, but not necessarily obese (Koepsell, Littman, & Forsberg, 2012). Physical activity is an important factor associated with obesity along with other risk factors.

While obesity is the seventh most common comorbidity associated with COPD, and is found in 23% of individuals with COPD, the full clinical impact of comorbid obesity and COPD has not been established (Smith & Wrobel, 2014). While both COPD and obesity can significantly contribute to mortality, increased body mass in those with COPD has been associated with decreased mortality (Galesanu et al., 2014). The phenomenon where increased body mass potentially conveys health benefits is called the obesity paradox.

Obesity paradox. The obesity paradox has been established for all-cause mortality, when normal-weight men were 1.65 more likely to die than their obese counterparts (Greenberg, 2013). This paradox has also been evaluated in other conditions. Even though those that are obese are more likely to experience heart disease, those that are overweight and obese are less likely to die from heart failure (Lavie et al., 2013). Obese cancer patients undergoing therapy were found to live 0.57 years longer than those of normal weight (Gonzalez, Pastore, Orlandi, & Heymsfield, 2014). The obesity paradox has also been studied in the veteran population; each 1-unit increase in BMI conveyed a 3% increase in survival (McAuley, Myers, Abella, & Froelicher, 2007). However, it is imperative to not automatically generate a false equivalence that a higher BMI is better. Further clarification in the relationship between COPD, obesity, and outcomes is necessary.

One important consideration in exploring the relationship between COPD and obesity is if any weight loss is intentional. For example, if a disease like COPD is associated with wasting, such as cachexia or sarcopenia, then the weight loss may reflect increased disease severity and worse outcomes (Kastorini & Panagiotakos, 2012). Indeed, a negative relationship between abdominal circumference and sarcopenia has been established in individuals with COPD (van de Bool, Rutten, Franssen, Wouters, & Schols, 2015). Those that were obese with COPD had an average FEV_1 that was 46% of predicted while normal weight individuals had a FEV_1 that was 35% of predicted, indicating that those with less severe COPD have a higher BMI (Galesanu et al., 2014). A study of individuals with COPD showed that those with obesity did tend to have better performance on lung functions tests (Cecere et al., 2013). However, physical activity may be a key mediator in the relationship between outcomes and combined COPD and obesity.

Physical Activity

Physical fitness is an attribute of health that can be attained through behaviors involving physical activity. Fitness may be a key factor in the obesity paradox (Lavie, De Schutter, & Milani, 2015). In a group of veterans, underweight men with low fitness were 4.5 times more likely to die while highly fit, overweight men had the lowest risk of mortality at 0.4 (McAuley, Kokkinos, Oliveira, Emerson, & Myers, 2010). When limiting an analysis to those with high levels of physical fitness the obesity paradox had disappeared (De Schutter, Lavie, & Milani, 2014). More research is needed to understand outcomes in those with comorbid COPD and obesity in relation to physical activity (Chittal, Babu, & Lavie, 2015). Additionally, while it has been demonstrated that veterans are more likely to engage in moderate intensity physical activity (Bouldin &

Reiber, 2012), this has not been established in the population with both COPD and obesity.

In summary, veterans are a unique subpopulation due to a host of factors such as exposure to active duty service in the military or differences that result from standards to be selected for and maintain service in the military. One difference between veterans and the remaining population is the increased prevalence of COPD, a lung disease that often co-occurs with obesity (Pugh et al., 2016). The combination of obesity and COPD can influence outcomes and is possibly affected by physical activity. However, not much is known about physical activity in relation to veteran status in comorbid COPD and obesity, highlighting the need for this study.

Problem Statement

The veteran population is a unique subgroup of the United States population that can significantly differ from the general population. Veterans are more likely to have COPD than their civilian counterparts (Pugh et al., 2016) and have a higher BMI when using self-reported data (Koepsell et al., 2012). Obesity is a burden in the veteran population with 41% of veterans being diagnosed as obese (Breland et al., 2017). As a result, programs have been developed to promote weight loss, specifically aimed at reducing diabetes related outcomes (Jackson et al., 2015).

However, the obesity paradox has shown that those that are obese with certain comorbidities, like COPD, have better outcomes, such as lower mortality, than those that are of a normal weight (Greenberg, 2013). While the precise mechanisms guiding the obesity paradox are still being explored, one hypothesis is that the increased body mass protects against cachexia associated with comorbidities such as heart failure and COPD, thus reducing mortality (Lavie et al., 2013). Researchers did show cardiovascular fitness, as opposed to weight loss, may result in better outcomes for veterans with obesity and comorbidities associated with the obesity paradox (Lavie, De Schutter, Archer, McAuley, & Blair, 2014; Myers et al., 2014). There are few data addressing the combination of COPD and obesity (Cecere et al., 2011); differences in physical activity for obese veterans with COPD as compared to the general population have not been established. The recommended exercise amounts for those with COPD vary and can be vague. The Cleveland Clinic (2017) suggested 20-30 minutes a week 3-4 times per week, the COPD Foundation (2017) limited the recommendation to 3 days per week, and the American Lung Association (2017) suggested 30 minutes of activity a few times a week. For this study, 60-120 minutes of exercise per week will be used as the recommended amount as it reflects the range suggested by the Cleveland Clinic. More information to inform and guide healthcare services is needed specifically for obese veterans with COPD.

Purpose

There is a significant gap in the literature regarding COPD, obesity, and physical activity overall, and particularly regarding veterans. The purpose of this study was to improve the understanding of exercise habits of obese veterans with COPD as compared to their civilian counterparts. This study used a quantitative study design of secondary data. The dependent variable was physical activity, the independent variable was veteran status, and the covariates were sex, age, income, education, race, ethnicity, BMI, and smoking status.

Research Questions and Hypotheses

Research Question 1: Is there a statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI?

$H_0$1: There is no statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

H_a1: There is a statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

Research Question 2: Is there a statistically significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI?

$H_0$2: There is no significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

H_a2: There is a significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

Theoretical Framework

The theoretical base for this study was the self-determination theory (SDT) developed by Deci and Ryan (year). The SDT is a macrotheory of motivation that posits that humans have a basic need for competence, relatedness, and autonomy that was first introduced in 2000 (Ryan & Deci, 2000) and has been refined, with the most recent major revision in 2008 (Deci & Ryan, 2008). The SDT differentiates types of motivation, such as autonomous and controlled motivation within the context of these needs (Deci & Ryan, 2008). Edmunds, Ntoumanis, and Duda (2006) successfully applied the SDT to the physical activity domain, finding that intrinsic motivations for physical activity successfully fulfilled the need for autonomy. When the location of motivation for physical activity is internal as opposed to an external motivation then individuals are more likely to engage in physical activity (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). For example, an internal aspiration of gaining health as opposed to an external motivation to appear thinner to others, would have better outcomes per the SDT. Additionally, if an extrinsic motivator is well internalized is has been shown to also be effective in increasing physical activity using the SDT, this is especially beneficial in a situation where the reward for the behavior is not immediately experienced as often occurs with physical activity (Wilson, Mack, & Grattan, 2008).

The SDT has also been used in conjunction with obesity and COPD. When the SDT was applied to a population of obese adolescents, it was further supported that intrinsic motivation fulfilled the need for autonomy and was associated with increased physical activity (Gourlan, Trouilloud, & Sarrazin, 2013). Hospes et al. (2009) used the SDT to motivate COPD patients to engage in increased physical activity. The SDT frames motivation for physical activity in those that are obese with COPD as intrinsic as it provides increased health.

Nature of the Study

The nature of this study was a quantitative analysis on pre-existing secondary data set. Quantitative analysis allowed for the comparison of amounts of physical activity, the dependent variable, between the veteran and nonveteran population, the independent variable, with COPD and obesity, which was the primary focus of this dissertation. Covariates included sex, age, income, education, race, ethnicity, BMI, and smoking status. More specifically, a secondary data analysis from the existing 2015 Behavioral Risk Factor Surveillance System, or BRFSS, utilizing a matched case-control study design was applied to the research question. While it was observational in nature, and therefore not as strong as another method such as a randomized controlled trial, case-control studies can be beneficial in associations that have not been well established or have not been thoroughly studied and matching can help control for potential confounders (Rose & Van der Laan, 2009). This design allowed for the control of variables associated with veteran status, obesity, and COPD. Matching is useful when there are dramatic differences between the case and control populations, as is the case between veterans and civilians (Rose & Van der Laan, 2009).

Definition of Key Terms

Behavioral Risk Factor Surveillance System (BRFSS): An annual telephone-based survey, which mainly uses disproportionate stratified sampling to determine health practices and behaviors associated with chronic illnesses and other conditions in noninstitutionalized adults in the United States (Centers for Disease Control and Prevention, 2016a).

Body Mass Index (BMI): A tool to estimate adiposity calculated using the formula of (Weight (kg)/ height $(m)^2$) (Centers for Disease Control and Prevention, 2010).

Chronic Obstructive Pulmonary Disease (COPD): A chronic disease that is characterized by restricted breathing due to blockage (Centers for Disease Control and Prevention, 2016b).

Forced Expiratory Volume in One Second (FEV_1): A critical measurement of lung disease that reflects the maximum volume of air that can be breathed out in one second (Global Initiative for Chronic Obstructive Lung Disease, 2017).

Full Vital Capacity (FVC): A critical measurement of lung disease that reflects the maximum volume of air that can be breathed out following a deep breath (Global Initiative for Chronic Obstructive Lung Disease, 2017).

Mild COPD: Actual FEV_1 greater than or equal to 80% of expected FEV_1 (Global Initiative for Chronic Obstructive Lung Disease, 2017).

Moderate COPD: Actual FEV_1 between 50% and up to but not including 80% of expected FEV_1 (Global Initiative for Chronic Obstructive Lung Disease, 2017).

Obese: Having a BMI greater than or equal to 30 (Centers for Disease Control and Prevention, 2010).

Pulmonary Rehabilitation Program (PRP): Programs designed to improve outcomes for those with chronic respiratory issues (National Heart, Lung, and Blood Institute, 2010).

Self Determination Theory (SDT): A macrotheory of motivation that posits that humans have a basic need for competence, relatedness, and autonomy (Ryan & Deci, 2000).

Severe COPD: Actual FEV1 between 30% and up to but not including 50% of expected FEV_1 (Global Initiative for Chronic Obstructive Lung Disease, 2017).

Six Minute Walking Test or 6MWT: A test of functional capacity for individuals with impairment which is measure the distance an individual can walk on a flat surface over a 6-minute time span (Enright, 2003).

Very severe COPD: Actual FEV_1 less than 30% of expected FEV_1 (Global Initiative for Chronic Obstructive Lung Disease, 2017).

Veteran: A person who actively served in the United States' military who was not dishonorably discharged (38 U.S.C. § 101).

Tiffeneau-Pinelli index: A ratio of the FEV_1 and the FVC (Global Initiative for Chronic Obstructive Lung Disease, 2017).

Assumptions

A major assumption of this study was that the participants sampled from the BRFSS were representative of the population of the United States. The BRFSS mainly utilized disproportionate stratified sampling of noninstitutionalized adults who then self-reported health practices and behaviors associated with chronic illnesses and other conditions (Centers for Disease Control and Prevention, 2016a). The assumption was that the participants accurately reflect the total population of the United States and that the responses were truthful which is necessary as the appropriate steps were taken to achieve a random sample.

Scope and Delimitations

The scope of the study was limited to the population that participated in the 2015 BRFSS survey. This restricted the study to individuals who achieved the age of majority, 18 years, and who were not institutionalized. This survey mainly utilized disproportionate stratified sampling to determine health practices and behaviors associated with chronic illnesses and other conditions in noninstitutionalized adults in the United States (Centers for Disease Control and Prevention, 2016a). These delimitations restricted the ability to generalize any findings of the study to the entire population of the United States or to different times.

Limitations

There were some limitations to this study. This study was limited to a single year’s data from the BRFSS, which made generalizability to other time frames difficult. As such, care was taken not to extend generalizations beyond the time from of the source data. Additionally, the study did not control for severity of COPD. As lung function tests were not done as part of the initial data collection, this was a known limitation. There were other potential limitations associated with this study.

Recall bias may have been present if the information that the participants were asked to supply had not been recent. Care was taken to select BRFSS responses that did not address specific questions regarding events that occurred some time ago. Also, social desirability bias could influence responses to questions involving smoking status and weight, however, given the participants were anonymous, this bias was minimized.

Significance

This study filled a gap in understanding by focusing on physical activity habits of obese veterans with COPD. This research is unique because there are limited data available on this topic. For those who are obese the objective is often to lose weight through diet and exercise; however, when looking at those with certain comorbidities, such as COPD, those who are obese often have a lower mortality rate (Greenberg, 2013). Improving physical fitness through physical activity as opposed to weight loss has been associated with better outcomes for those that are obese with conditions associated with the obesity paradox (Lavie et al., 2014; Myers et al., 2011). It had been unclear what role veteran status plays in the relationship between COPD, obesity, and physical activity.

Quantifying physical activity between veterans and civilians allow healthcare systems specifically serving veterans, such as Veterans Affairs medical facilities, to tailor interventions for comorbid COPD and obesity to this population. Also, given that obesity and COPD are burdens in the veteran population and that current recommendations for physical activity are unclear and do not reach consensus this study could provide information to understand current practice and guide future programs and policy.

Positive social change could result from this study in the form of identifying key factors associated with physical activity in those with COPD and obesity, which could be used to tailor interventions. Using the foundation of the SDT a motivation that is easily internalized could be identified to aid in increased physical activity using significant factors identified in the study. Also, the information from this study can inform policy so that key stakeholders can create evidence-based guidelines.

Summary

This chapter showed that veterans are a unique subgroup of the United States. It also established COPD as a significant burden in both the general and veteran populations of the United States. Comorbid obesity even further complicates this complex disease. The level of physical activity completed may impact outcomes for those with both COPD and obesity and the precise role of veteran status in this dynamic was unclear. The following chapter reviews literature that covers these topics. A distinct gap in literature is made evident thus supporting the significance of this study.

Chapter 2: Literature Review

Introduction

The purpose of this study was to investigate the relationship between physical activity and veteran status in those with COPD and obesity in the United States of America. The intention was to contribute to the body of literature regarding this topic and to provide information so that interventions can be specifically tailored for this population. Given the dearth of information on this topic, it is important to shed light on this significant gap in the literature.

This chapter provides details regarding the methodology used to identify existing literature on the topic. Following is a literature review of the key concepts associated with this topic. This provides a synthesis of existing information and includes a focus on areas where there is a lack of consensus.

Strategy

The following databases were used to identify literature for this review: Academic Search Complete, CINAHL Plus with Full Text, Cochrane Database of Systematic Reviews, Google Scholar, MEDLINE with Full Text, Military and Government Collection, PsycARTICLES, SAGE Premier, and ScienceDirect. The key words used in the search were *COPD or chronic obstructive pulmonary disease, physical activity or fitness or exercise, obesity, veteran,* and *SDT or self-determination theory*. An initial search was done using all key terms except SDT or self-determination theory in the most recent 5-years. When the search was limited to titles of peer-reviewed journal articles there were no hits. The lack of hits necessitated further research.

The updated search was for the most recent 5-year time frame of peer-reviewed journal articles using all search terms except SDT or self-determination theory anywhere within the text of the article. There were 1,476 hits. Upon reviewing the abstracts for these articles, it was determined that the time frame needed to be expanded and that the SDT was a candidate for a theoretical framework for this study. The search was then expanded to include any time frame, as there were few applicable studies, and SDT or self-determination theory was included as a search term. A total of 2,872 articles were reviewed for inclusion in this literature review. Only 3.4% of the articles were deemed appropriate for this study and Table 1 describes the count of articles by key concept addressed in the article, noting that multiple key terms could be included in a single article.

Table 1

Count of Articles by Key Term

Key Term	Count
COPD or chronic obstructive pulmonary disease	62
Physical activity or fitness or exercise	56
Obesity	53
SDT or self-determination theory	16
Veteran	15

Chronic Obstructive Pulmonary Disease

COPD was the search term that most commonly appeared in the literature search. There are certain aspects of this disease that have a high level of consensus. The literature that surrounds the surveillance of COPD nationally and internationally is robust. BRFSS data from 2011 were used to establish a 6.3% prevalence of COPD nationwide (Centers for Disease Control and Prevention, 2012). A meta-analysis including data from the BRFSS, NHANES, and other government sources documented the age-adjusted prevalence to be 5.7% (Ford et al., 2013). Race, ethnicity, age, and sex are important factors associated with COPD as non-Hispanic Blacks had the highest prevalence of COPD with 6.2% as compared to 6% in non-Hispanic Whites and 4.3% in the Hispanic population (Ford et al., 2013). Ford et al. also found that women had a higher prevalence than men with 7.0% prevalence as compared to 4.3% respectively and those between the ages of 65-74 years had the highest prevalence of 10.3%. The literature was consistent that COPD is a common illness in the United States but varies by age, sex, race, and ethnicity.

There was a disconnect in the literature in terms of mortality associated with COPD. Ford et al. (2013) estimated that mortality associated with COPD is 65.5 per 100,000 and there has not been a significant change in this rate from 1999 to 2011. A joinpoint analysis of national vital statistics data from 1969 to 2013 indicated that the age-adjusted mortality rate for COPD increased 100.6% over this time span, going from 21.0 to 42.2 deaths per thousand (Ma et al., 2015). Another estimate from a literature review puts COPD mortality at around 111 per 100,000 (Rycroft et al., 2012). This is a wide range, 42.2 deaths per 100,000 individuals to 111 deaths per 100,000 individuals. One potential source of discordance is the disparate data sources. Ford et al. (2013) utilized a variety of government sources to attain their estimate, while Ma et al. (2015) used vital statistics, which may not provide a complete picture of all factors associated with death. Finally, Rycroft et al. (2012) did a literature review using two databases. Each of these studies also include slightly different time points and do not control for factors, such as age, in the same manner, which can also contribute to varying estimates of death rates associated with COPD.

The literature review did reveal that COPD has a significant impact in terms of healthcare utilization and associated costs (Ford et al., 2013; Hillas, Perlikos, Tsiligianni, & Tzanakis, 2015). Hillas et al. (2015) found that COPD patients used 3.4 times more health care resources than those without COPD. Ford et al. (2013) established that 516.1 per 10,000 office visits and 73.6 per 10,000 emergency department visits were due to COPD. The Center for Disease Control and Prevention (2012) estimated that 17% of individuals with COPD have at least one emergency department visit per year. Hillas et al. sound that inpatient utilization was the key driver of direct costs, accounting for 87% of the $29.5 billion in annual direct costs attributed to COPD. However, these studies do not account for indirect costs, which would provide the most accurate portrayal of economic impact associated with COPD. A key limitation of generalization is that past economic data would need proper adjustments applied to reflect current costs. Despite these limitations, literature reveals a significant burden associated with COPD in terms of utilization and costs.

There is some debate regarding the characterization of COPD in the literature. Lung function testing, which is the gold standard for diagnosing COPD, was done in approximately 76% of those with a diagnosis (Centers for Disease Control and Prevention, 2012). However, it is the combination of lung function testing, questionnaires, and symptoms that may be most helpful in diagnosing and treating COPD

(Brusasco, Barisione, & Crimi, 2015). Using 331 patients with COPD, subcategorizing patients has been attempted using symptoms, with 43.2% of COPD patients with emphysema, 44.7% with chronic bronchitis, and 12.1% with COPD and asthma (Izquierdo-Alonso et al., 2013). An argument has been made using literature review that those that are obese with COPD represent a unique phenotype (Hanson & LeVan, 2017). Putcha et al. (2015) also attempted to develop a clinical phenotype using a variety of characteristics such as comorbidities. However, developing clinical phenotypes for COPD is not a widely accepted practice seen in the literature.

A widely accepted risk factor for COPD was identified in the literature. Smoking has been identified as one of the most, if not most, important risk factors associated with COPD (Diaz-Guzman & Mannino, 2014; Putcha et al., 2014; Rycroft et al., 2012). However, Rycroft et al. (2012) also noted that there may be occupational and environmental exposures that can impact COPD as well, but these were not discussed in this retrospective literature review. Smoking as a risk factor has been significantly associated with obesity as a comorbidity; specifically, a case-control study of smokers versus nonsmokers with COPD indicated that 36.8% of smokers were obese compared to 33.3% of nonsmokers (Putcha et al., 2013). When it comes to risk factors, comorbidities should be a consideration.

There have been several studies dedicated to identifying comorbidities associated with COPD (Hillas et al., 2015; Negewo, McDonald, & Gibson, 2015; Putcha et al., 2014; Smith & Wrobel, 2014). A vast majority, 97.7%, of individuals with COPD also have a clinically relevant comorbid condition and over half, 53.5%, have four or more comorbidities (Smith & Wrobel, 2014). Hillas et al. (2015) produced similar estimates, with 94% having a single comorbid condition and 46% having three or more comorbid conditions. Smith et al. (2014) stated that even with these high estimates of comorbidity there is a distinct likelihood that comorbidities are under-reported. A few examples of comorbidities associated with COPD are hypertension (50.6%), hyperlipidemia (41.4%), and osteoarthritis (20.7%) (Putcha et al., 2013). While comorbidities are a hallmark of COPD, not all comorbidities were the same in terms of burden and outcomes.

Different comorbidities impacted COPD in different ways. For example, a case-control study of 10,192 individuals showed that obstructive sleep apnea, stroke, and gastroesophageal reflux disease significantly decrease quality of life and obstructive sleep apnea, congestive heart failure, and stroke are associated with increased dyspnea (Putcha et al., 2014). Hillas et al. (2015) agreed that comorbidities play a crucial role in quality of life associated with COPD. Putcha et al. (2014) demonstrated that comorbidities have varying impacts across different racial groupings where African Americans with COPD have a higher risk for comorbid diabetes and hypertension. Obesity is a comorbid condition that is found in 23% of the population with COPD, which is higher than the general population (Smith & Wrobel, 2014). Negewo, McDonald, and Gibson (2015) put this estimate slightly higher at a range of 25-42%. Despite having several articles regarding conditions that are comorbid with COPD, there was still a need to understand how these comorbidities contribute to the homogeneity of COPD (Putcha et al., 2014). Smith and Wrobel and Negewo et al. echoed this sentiment, stating the full clinical impact of comorbidities on COPD is not established. Comorbidities, such as obesity, are extremely important when studying COPD.

COPD is a common disease with an increasing prevalence that has a significant economic impact. In addition to the economic impact, COPD is also associated with increased mortality and morbidity. One specific comorbid condition that is found more commonly in those with COPD is obesity.

Obesity

When researching comorbid COPD and obesity, it is important to understand the epidemiology of the two conditions together (García-Rio et al., 2014; Putcha, Drummond, Wise, & Hansel, 2015; Schnell et al., 2012; Vozoris & O'Donnell, 2012). However, there is some variation around the proportion of individuals estimated to have both COPD and obesity. Obesity was estimated to be present in 29% to 43% of individuals with COPD based on a literature review (Putcha et al., 2015). In a Spanish population of 3,797 individuals aged 40 to 80 years, only 382 had COPD and of those, only 10% had comorbid obesity (García-Rio et al., 2014). A nationally representative sample of 995 individuals with COPD from 1999 to 2008 produced an estimated proportion of comorbid obesity to be 40.3% (95% CI [36.4%, 44.4%]) (Schnell et al., 2012). A national survey of 650,000 Canadians from 1995 to 2007 reported obesity to be 24.6% in individuals with COPD (Vozoris & O'Donnell, 2012). While the rate of co-occurrence of COPD and obesity varies by study obesity remains an important comorbidity associated with COPD.

For the studies that occurred out of the United States, population differences could contribute to the varied estimates of comorbid obesity and COPD (García-Rio et al., 2014; Vozoris & O'Donnell, 2012). However, there are other potential sources of variation. Putcha et al. (2015) determined that COPD severity is a significant factor when examining comorbid COPD and obesity, where higher severity was associated with lower rates of obesity. Based on this information, the estimate of 29% to 43% of comorbid obesity with COPD is appropriate (Putcha et al., 2015). When consulting the literature regarding comorbid COPD and obesity, it appeared that there was room for improvement in terms of documenting comorbidities or accounting for factors that could impact the prevalence of comorbid COPD and obesity.

The literature review also unveiled other factors associated with combined COPD and obesity. One interesting relationship is that those that are obese with COPD appear to be at greater risk for misdiagnosis of COPD (Collins et al., 2014; O'Donnell, Ciavaglia, & Neder, 2014). Misdiagnosis in those with comorbid COPD and obesity may be due to decreased sensitivity of spirometry associated with increased BMI (O'Donnell et al., 2014). Misdiagnosis may also be attributed to increased perception of dyspnea in obese patients as those that are obese are more likely have higher scores on dyspnea scales (*OR* =4.9, 95% CI [1.8, 13.4]) (Cecere et al., 2011). However, the dyspnea was not significantly related to quality of life in a cross-sectional analysis of 364 veterans with COPD, which could be limited by the fact that there were possible sources of selection bias as the population the sample was pulled from was referred for pulmonary rehabilitation (Cecere et al., 2011). A retrospective cohort of 5,493 veterans with a COPD diagnosis showed that obese individuals were significantly less likely to have therapy decreased after a normal spirometry reading as compared to those with normal weight (*RR*=0.60 95% CI [0.57, 0.63], *p*=0.001) (Collins et al., 2014). The literature highlighted the importance of appropriate diagnosis in those with COPD and obesity.

Misdiagnosis can lead to other outcomes such as increased utilization. Darnell et al. (2013) did a multivariate analysis of 3,263 veterans with COPD, finding that BMI was significant associated with higher healthcare costs (*p*=0.025). This study used a looser definition of COPD and did not use spirometry to confirm the diagnosis (Darnell et al., 2013). However, a study using multiple logistic regression of 364 veterans with confirmed COPD did not find a difference in medication usage by weight class (Cecere et al., 2011). It is possible that increased utilization occurs in other areas of healthcare outside of pharmacy, contributing to increased costs. Costs do not necessarily translate into outcomes, though. In fact, Cecere et al. (2011) did not find any difference in outcomes by weight class. However, a study of a prospective cohort of 212 patients with COPD used an adjusted Cox model to show that the risk of death following use of noninvasive ventilation was only decreased in the obese population (*HR*=0.5, 95% CI [0.2, 0.9]) (Borel et al., 2014). This prospective study performed by Borel et al. (2014) utilized convenience sampling, whereas, random sampling would be preferable to decrease limitations on generalizability. The combination of COPD and obesity could lead to higher costs, but likely not in pharmacy, and outcomes could be impacted by comorbid COPD and obesity depending on the outcomes of interest and other factors.

Risk of death was studied in relation to comorbid COPD and obesity and a protective effect of obesity has been described (Cao et al., 2012; Divo et al., 2014; Lainscak et al., 2011). A meta-analysis covering 22 studies including 21,150 participants found that the relative risk of mortality was lowest for those that were obese compared to those of normal weight (*RR*=0.6, 95% CI [0.4,0.9]). A prospective cohort of 1,659 individuals with COPD who were followed over a median of 51 months found that percent of mortality ranged from 28% to 60% for the lowest weight class to the highest weight class respectively ($p<0.001$) (Divo et al., 2014). This relationship holds true even in data from outside of the United States. In Slovenia, it was found that BMI was an independent predictor of mortality in a retrospective cohort of 968 patients (Lainscak et al., 2011). This relationship went against conventional wisdom as obesity is associated with higher mortality and morbidity, but in COPD it is associated with lower mortality. This phenomenon has been dubbed the obesity paradox.

Obesity Paradox

There is literature to support the existence of the obesity paradox. Lavie et al. (2015) asked the important question if obese individuals could be considered healthy and attempted to answer this question with a literature review. Healthy obesity was also explored in other reviews (Karandish & Shirani, 2015). Just because those that are obese have lower mortality rates with certain disease states does that make them healthier? Examining literature regarding other disease states associated with the obesity paradox helped shed light on this topic.

There are other conditions that have been associated with the obesity paradox aside from COPD such as cancer (Gonzalez et al., 2014) and heart disease (De Schutter et al., 2014; Lavie et al., 2013). The researchers did a multivariate cox regression of 175 cancer patients and showed that obese patients lived a little over half a year longer than normal weighted cancer patients but this only applied when the patients were not sarcopenic (Gonzalez et al., 2014). This supports the idea that certain disease states may lead to wasting impacting the relationship between obesity and outcomes. Lavie et al. (2013) found the obesity paradox only in situations with patients with heart failure. Similarly, the authors of a study of the obesity paradox in individuals with cardiovascular disease described that the paradox disappeared when fitness was high (De Schutter et al., 2014). Determining what other factors may be associated with the obesity paradox was shown to be important.

The factors associated with the obesity paradox were of interest to several authors (Greenberg, 2013; Karandish & Shirani, 2015; Kastorini & Panagiotakos, 2012). Kastorini and Panagiotakos set out to identify factors associated with the benefits of obesity with certain comorbidities and found that those of lower weight may have higher mortality especially if those individuals experienced unintentional weight loss. In this case, lower weight is a symptom of cachexia related to comorbidity. A retrospective observational study done by Greenberg using NHANES data, theorized that obese men received more medical attention than their normal weight counterparts, which results in better outcomes, attributing differences to surveillance bias. It is important to determine if these observations hold true in COPD.

The obesity paradox has been studied with COPD in terms of mortality (Chittal et al., 2015; Galesanu et al., 2014; Hanson, Rutten, Wouters, & Rennard, 2014; O'Donnell, O'Donnell, Webb, & Guenette, 2012; van de Bool et al., 2015). Chittal, Babu and Lavie (2015) explored possible reasons for the obesity paradox, describing one potential explanation of decreased physical activity associated with increased glucocorticoids. The glucocorticoids may be a better prognostic indicator for COPD, however, the impact of weight loss on the mortality risk in obese individuals with COPD is not clear (Chittal et al., 2015). Galesanu et al. did a survival analysis on a prospective cohort of 190 patients with COPD and found that obese individuals had significantly higher lung function as measured by FEV_1 percent of predicted (M=46, SD=13) as opposed to normal weight individuals (M=35, SD=12, p<0.001), higher muscle mass and more exercise capacity, however, these are not causes, just factors associated with obesity and COPD. The study did not establish causation due to the nature of the study; also, another limitation is a small sample size, as there were only 190 patients included (Galesanu et al., 2014). Also, it is difficult to establish a cause for the obesity paradox as the COPD population is heterogeneous (Hanson et al., 2014).

Another potential explanation for the obesity paradox in COPD is that increased body mass may protect against sarcopenia (van de Bool et al., 2015). Van de Bool et al. did a cross-sectional study of 505 Dutch patients with COPD and found that 86% of patients had sarcopenia and lower physical functioning while 78% had abdominal obesity, which was related to higher physical functioning. This higher physical functioning could lead to increased lung functioning which has been noted in those with

COPD and obesity (O'Donnell et al., 2012). Regardless of potential explanation for the obesity paradox there is evidence to support that physical activity is a key factor.

Fitness appears to be the most important factor in terms of prognosis (Lavie et al., 2014; Lavie et al., 2015; McAuley et al., 2007; McAuley et al., 2010). McCauley et al. (2010) did a cox regression using data from 12,417 veterans that showed that mortality rates were similar for those with moderate fitness no matter what weight class the veterans were in. However, McAuley et al. (2007) did a different survival analysis and found that there was still lower mortality in veterans with higher weight classes even when controlling for cardiorespiratory fitness. This indicates that identifying and controlling for potentially confounding factors is important.

Overall the literature regarding obesity and COPD indicates that obesity is commonly found with COPD. The combination of these disease states can increase costs and influence outcomes. In terms of mortality, those that are obese had decreased death rates. This has been dubbed the obesity paradox, but the exact cause has only been theorized never proven. The literature does indicate that physical activity is an important factor when studying COPD and obesity. Physical fitness can alter the relationship between adiposity and long-term health outcomes, specifically in terms of the obesity paradox, however, the exact role of physical fitness is unknown (Lavie et al., 2015).

Physical Activity

As the research regarding the obesity paradox showed, increasing physical fitness is extremely important in terms of those with COPD and obesity, independently and together (Lavie et al., 2015). This is especially important as dieting has limited effectiveness (Karandish & Shirani, 2015). According to the literature the method of measurement of physical activity is important and physical activity can be measured in many ways.

Accelerometers have been shown to be useful, as they measure movement and are unobtrusive, but they do not capture all movement such as upper arm movement (Moy, Matthess, Stolzmann, Reilly, & Garshick, 2009). A prospective cohort of 173 patients with moderate to severe COPD were followed for up to eight years (Garcia-Rio et al., 2012). It was shown that use of an accelerometer to measure physical activity decreased mortality risk (adjusted hazard ratio=0.98, 95% CI [0.98, 0.99]) when controlling for confounders (Garcia-Rio et al., 2012). But not all factors were accounted for in this analysis, such as smoking, which has been determined to play a significant role in those with COPD. However, there were drawbacks to using the accelerometer such as there were no set guidelines for using accelerometers, for example, it is not clear how long they should be worn for maximum efficacy (Byrom & Rowe, 2016).

Regardless of how physical activity is measured, the literature regarding physical activity shows that those with COPD get less physical activity (Park, Richardson, Holleman, & Larson, 2013; Watz et al., 2008). Park et al. showed that age, gender, race, level of education, working status, shortness of breath, self-reported health, and BMI were significantly associated with increased sedentary time and decreased physical activity. Decreased physical activity in veterans was associated with an increased BMI (Yaghoubi, Esmailzadeh, & Yaghoubi, 2013). Another study of 74 patients with COPD had a similar conclusion that decreased physical activity was significantly associated with increased body weight and decreased fat free mass (Monteiro et al., 2012). Given that those with COPD tend to get less physical activity examining the benefits of physical activity and ways to increase physical activity could have increasing importance.

An increase in physical activity had a significant relationship with decreased inflammatory markers (Moy et al., 2009). The authors of a review study on this topic came to the same conclusion that increasing physical activity decreases inflammatory markers leading to better outcomes for COPD patients (You, Arsenis, Disanzo, & LaMonte, 2013). These results accentuate the importance of physical activity. A randomized controlled trial of 232 overweight and obese veterans aimed at increasing physical activity through counseling showed that participants were more likely to get more than 150 minutes of activity per week at 12 months (OR=2.86, 95% CI [1.03, 7.96], p=0.04) (Gao et al., 2016). However, there were other considerations revealed through literature review when studying physical activity in individuals with obesity and COPD.

Bouldin et al. (2012) showed that veterans may be more likely get physical activity than their nonveteran counterparts, however, this research does not look at those with COPD, so this jeopardizes the ability to apply this study to the COPD population. A large nationally representative sample of veterans had more average minutes of weekly moderate exercise (M=57.2, SE=0.6) versus nonveterans (M=53.5, SE=0.3) which holds when controlling for race, sex, educational household income, and BMI (Bouldin & Reiber, 2012). While mean amounts of physical activity between groups may vary significantly, if both groups are not getting the recommended amounts of exercise then physical activity should be increased across all groups to meet guidelines. However, no literature was found to indicate if recommended amounts of physical activity are being attained in those with COPD and obesity, regardless of veteran status.

When studying physical activity in COPD and obesity it is extremely important to link the research to theory, also disease severity should be a consideration (Leidy et al., 2014). Overall the lack of quality studies regarding physical activity including both COPD and obesity was noted (Leidy et al., 2014). Li, Caughey and Johnston (2014) echoed similar sentiments. Many ways to measure physical activity exist. Self-reported physical activity has been used, however, there is promise when using accelerometers. What has been shown in the literature is that physical activity can positively impact COPD and obesity, however, those with COPD are not getting enough physical activity. Also, the factors that are considered when studying COPD, obesity, and physical activity are important.

Exercise Testing

While measuring physical activity is important, it is also important to consider if the individuals with COPD and obesity have the capacity to engage in physical activity. Exercise testing can be done to measure this capacity. This testing examined measures associated with exercise such as time spent exercising, exercise performance, and lung function. One type of testing involves use of a stationary bicycle. Another example of an exercise test is the 6-minute walking test or 6MWT. There is research that shows that results are similar regardless of the type of test used (Ciavaglia, Guenette, Ora, et al., 2014; Mador & Modi, 2016). While exercise testing does not look at typical physical activity, it does help to determine if physical activity is possible.

In studies where the 6MWT was done in obese patients it was demonstrated that obese individuals have better lung function (Bhandari, Jelinek, Butler, Laghi, & Collins, 2014; Cecere et al., 2013; Hernandez et al., 2017; Rodríguez et al., 2014). An observational study of 251 patients with COPD from 2004 to 2006 reported that the obese group had higher FEV_1 values as compared to nonobese patients (1.7, 95% CI [1.3, 2.1] vs. 1.5, 95% CI [1.0, 2.0], $p<0.001$) (Rodríguez et al., 2014). This may not apply to the United States as Rodríguez et al. (2014) studied a cohort from Spain. A case-control study of 24 patients with COPD age matched to controls showed that obese study participants had a higher Tiffeneau-Pinelli index than controls (48%, 95% CI [35%, 61%] vs. 40%, 95% CI [29%, 51%], $p<0.01$) (Bhandari et al., 2014). However, this study had an extremely small sample size making generalization difficult. This was not the only study that had the same limitation. In translating lung function to symptoms, a sample of 12 patients with COPD showed no difference in dyspnea related to obesity during lung function testing (Ciavaglia, Guenette, Langer, et al., 2014). While the sample was small, a standardized tool to measure dyspnea was used, strengthening the results of the study. However, a literature review has indicated that dyspnea does increase in those with obesity but obesity alone is not an indication for exercise testing (Dreher & Kabitz, 2012). Breathing and associated symptoms are not the only differences in COPD patients in terms of obesity and exercise testing.

While obese patients had better lung function, a study of 596 patients showed that obese patients, on average, covered less distance than normal-weighted individuals (Cecere Feemster et al., 2013). A study of 111 men with moderate to severe COPD showed that those that are obese had a significantly shorter walking distance average in meters as compared to those of normal weight (*M*=391, *SD*=101 vs. *M*=454, *SD*=104, *p*=0.018) (Hernandez et al., 2017). However, it appears that this relationship can be attenuated following intervention (Li, Caughey, & Johnston, 2014). Li, Caughey, and Johnston found that even when obese individuals were more likely to walk a shorter distance, this did not hold after intervention to increase physical activity. It is possible that the obese individuals are walking less because those with higher adiposity tend to have lower muscle quality (Maddocks et al., 2014), hence intervention increased muscle quality resulting in better outcomes in exercise testing.

Similar to physical activity overall, exercise testing has several considerations. For example, disease severity should be considered as it can impact exercise capacity and obesity (Gloeckl, Marinov, & Pitta, 2013; O'Donnell et al., 2012). Another important factor is age as a retrospective study of 57,085 individuals revealed that average exercise capacity decreased as age increased (Blaha et al., 2016). Exercise testing can be used to set the stage for interventions to influence outcomes for those with COPD such as pulmonary rehabilitation.

Pulmonary Rehabilitation

Pulmonary rehabilitation, or PR, is a multidisciplinary intervention consisting of exercise, education, and other supportive activities to improve outcomes in COPD patients. Proof of concept was established for PR programs, but many vary in quantity and quality of the various interventions (McDonald et al., 2016). PR programs are especially important for those with COPD as this disease is associated with limb muscle atrophy and interventions are needed to improve muscle quality (Ribeiro, Thériault, Debigaré, & Maltais, 2013).

Several studies have shown the efficacy of PR in those with COPD and obesity (Aiello et al., 2014; Gimeno-Santos et al., 2014; Reis et al., 2013; Torres-Sánchez et al., 2016). Obese patients from a 44-patient case-control study had significantly higher peak workload (M=94, SD=36) as compared to normal-weight patients that underwent PR (M=74, SD=24) (Aiello et al., 2014). Not only was exercise tolerance preserved in those that were obese, they had higher performance. Following an 8-week PR program mean heart rate recovery increased by 2 beats (Gimeno-Santos et al., 2014). A case series of 41 COPD patients followed over 2-year reported that dyspnea as measured by the Borg scale significantly decreased (M=4.3, SD=0.1 to M=1.5, SD=0.6, p<0.05) following PR (Reis et al., 2013). A randomized controlled trial showed that a multimodal PR intervention could increase exercise capacity (Torres-Sánchez et al., 2016). Physical activity in any form, can improve outcomes for those with COPD and obesity.

There are few studies looking at amounts of average physical activity in those with COPD and obesity. The studies that were included did show that those with COPD tend to be more sedentary and get less physical activity overall. There are more studies that look at the exercise capacity of those with COPD. While those with COPD and obesity may have less than average exercise capacity, this can increase with PR, which typically includes increased physical activity. This research project specifically examined the veteran population; as such, the literature involving this specific population was analyzed.

Veterans

There were no studies that specifically address physical activity in veterans with COPD and obesity. Very few of the included studies included veterans or veteran status as part of the sample at all. Of the studies that do include the veteran population there were significant limitations that can make synthesis difficult.

Most of the literature regarding veterans included in this study was quantitative in nature, however, a qualitative study was done that utilized a focus group to evaluate the perception of COPD amongst veterans with the disease (Panos, Krywkowski-Mohn, Sherman, & Lach, 2013). This study did indicate that COPD affected all aspects of veterans' lives which resulted in significant consequences in terms of care and management of the disease (Panos et al., 2013). While the authors did highlight important areas of focus for veterans with COPD, the study occurred at a single site and had a relatively small sample size, which were not unique threats to generalizability when it came to studies involving veterans.

Several studies with veterans as the population of interest had relatively low sample sizes, ranging from 17 to 83 participants (Bhandari et al., 2014; Moy et al., 2009; Yaghoubi et al., 2013). These studies do provide value; however, small samples can make detection of effect sizes difficult (Ellis, 2010). For example, Bhandari et al. (2014) reported significantly higher lung function in obese veterans with COPD (Tiffeneau-Pinelli index of 48%) as compared to their normal-weighted counterparts (Tiffeneau-Pinelli index of 40%) in a total of 48 participants. However, a different study of 1,578 described poorer respiratory outcomes associated with increased BMI (Vinnikov, Blanc, Alilin, Zutler, & Holty, 2017). While other methodological differences could account for the contradictory conclusions regarding the impact of respiratory outcomes in comorbid COPD and obesity in veterans, sample size was certainly a possible explanation.

Another limitation seen in 20% of the included studies with veterans as the sample population was that it only occurred at a single site (Cecere et al., 2011; Darnell, Dwivedi, Weng, & Panos, 2013; Gao et al., 2016). This made generalizing to the entire nation difficult, as there may be differences at the geographic level that contribute to the findings. Darnell et al. used multivariate analysis to examine costs associated with the care of 3,263 veterans with COPD and found that annual average healthcare costs were $6,546 with $1,004 specifically attributed to COPD (Darnell et al., 2013). However, this occurred in a VA medical center in Cincinnati in 2008, cost of living adjustment and inflation adjustments would be needed to apply this to the nation. But, it does highlight that COPD represents a significant financial burden in the veteran population.

Even if a study goes beyond a single site and covers a region, generalizability is still difficult. For example, a study of 5,493 veterans in the Pacific Northwest found that veterans that are obese of more likely to be misdiagnosed with COPD (Collins et al., 2014). But this still may not apply to the entire veteran population of the United States, as there may be regional difference that could influence the relationship between BMI and COPD misdiagnosis. However, there were studies that were derived from national samples that had large sample sizes.

One study compared health indicators between veterans and civilians using BRFSS data from 2010 for 169,390 American men (Hoerster et al., 2012). Hoerster et al.

determined that while veterans had more access to health care than civilians, they were more likely to report having poor health and more likely to smoke. This supported that veteran-serving organizations may need to increase efforts to serve this population and even further, prevention efforts should be considered when individuals are still in active duty prior to becoming veterans (Hoerster et al., 2012). While the researchers did multivariate analysis to control for some potential confounders, women were not included in this analysis. Studies that control for a factor as opposed to excluding an entire sex may be preferable when looking at a national sample.

Observational studies from large national samples were also used to show differences in BMI classes in the veteran population as compared to the nonveteran population. Two studies, one using BRFSS data from 2009 (Bouldin & Reiber, 2012) and one using NHANES, National Health and Nutrition Examination Survey, data (Koepsell et al., 2012), both found that veterans were more likely to be overweight than nonveterans. Bouldin and Reiber (2012) controlled for sex, race, ethnicity, income, and education and found that 44.7% of veterans were overweight while 35.2% of nonveterans were overweight. Koepsell et al. (2012) found that 44.3% of veterans were overweight while only 41.0% of nonveterans fell into the same BMI class when controlling for age, gender, race, ethnicity, and education level. Both studies found similar rates of overweight in the veteran population but had differing rates of overweight in the nonveteran population. This could be attributed to controlling for differing factors or different time frames or even different methods of measuring BMI, where the BRFSS uses self-reported data and the NHANES directly measures height and weight. However, these results highlight the importance of controlling for factors such as age, sex, race, ethnicity, income, and education when studying the veteran population.

Prospective cohorts consisting of large samples of veterans were used to explore the link between obesity and mortality when controlling for factors such as age, race, and medical history (McAuley et al., 2007; McAuley et al., 2010). McAuley et al. (2007) and McAuley et al. (2010) both performed survival analyses to show that veterans with increased BMIs had higher survival rates. The earlier of the studies followed veterans for an average of 7.5 years over the course of a 16-year period and found that a 1-unit increase in BMI conferred a 3% survival benefit (McAuley et al., 2007). In other words, there was a 20% decrease in risk of death for each increase in BMI category (McAuley et al., 2007).

In a similar study of 12,417 male veterans ranging from 40-70 years of age, the relationship between mortality and obesity was examined as was the role of fitness (McAuley et al., 2010). McAuley et al. found that overweight men with high fitness had the lowest mortality, risk of 0.4 (95% CI [0.3, 0.6]), when compared to normal weighted veterans with high fitness. And underweight men with low fitness had the highest mortality rate of 4.5 (95% CI [3.1, 6.6]), when compared to the same control group. Both studies may have a certain degree of selection bias as the samples were made up of veterans referred for exercise testing, indicating the possibility of some underlying morbidity. Neither of these studies specifically addresses COPD in veterans; however, they illuminate an important relationship regarding outcomes and obesity in veterans.

While prospective cohorts are a relatively strong study design compared to strictly cross-sectional designs they are still not as strong as randomized controlled trials.

Veterans comprised the sample of two randomized controlled trials that evaluated efficacy of programs that aimed to increase physical activity (Gao et al., 2016; Martinez et al., 2014). While one program focused on physical activity in veterans with COPD (Martinez et al., 2014) the other focused on obesity (Gao et al., 2016), however, both showed promise but were published before the trials were complete. Additionally, Martinez et al. (2014) were the only authors to include a theoretical basis in a research study involving veterans, the self-regulation theory.

There were no studies that specifically address physical activity in veterans with COPD and obesity. While the literature involving veterans indicated that veterans were more likely to be overweight, that obesity in veterans may convey a survival benefit especially when paired with high levels of fitness and that veterans were more likely to smoke it does also point to deficits. One shortfall was that there might be a lack of consensus regarding the exact role of obesity in terms of lung function in veterans with COPD. Also, there was a lack of studies covering physical activity in veterans with COPD and obesity with a large sample size, from a nationally representative sample and grounded in a theoretical framework.

Self-Determination Theory

A few theories served as foundations for the literature used in this review. Leidy et al. (2014) compared the health belief model, transtheoretical model, and the theory of reasoned action and planned behavior in terms of physical activity in those with COPD.

And Martinez et al. (2014) applied the theory of self-regulation to a program designed to increase physical activity in veterans. However, none were as applicable to this study as the SDT. Deci and Ryan (2008) were the first to describe the self-determination theory, or SDT. The SDT is a macrotheory of motivation that posits that humans have a basic need for competence, relatedness, and autonomy that was first introduced in 2000 (Ryan & Deci, 2000) and has been refined, with the most recent major revision in 2008 (Deci & Ryan, 2008). The SDT differentiates types of motivation, such as autonomous and controlled motivation within the context of these needs (Deci & Ryan, 2008). From the point of inception, the theory has been expanded upon and researched further. Edmunds, Ntoumanis & Duda determined that regulation was a significant predictor of behavior (2006) and that there was a positive correlation between self-efficacy and adherence to behavior (2007). This theory stood apart from other because it considers the quality of the motivator in terms of behavior (Wilson et al., 2008). Power et al. (2013) The SDT has been successfully applied to many different areas, including physical activity (Fortier, Duda, Guerin, & Teixeira, 2012; Hagger & Chatzisarantis, 2008; Hospes, Bossenbroek, ten Hacken, van Hengel, & de Greef, 2009; Silva et al., 2008; Silva et al., 2010; Standage, Sebire, & Loney, 2008; Teixeira et al., 2012).

The SDT had been used to increase physical activity (Fortier et al., 2012) by explaining the motivation for exercise behavior (Hagger & Chatzisarantis, 2008). Using the construct of the SDT the need for competence associated with physical activity is associated with increased self-regulation, decreased external regulation, and increased satisfaction (β=0.28, 95% CI [0.19, 0.24], p<0.05) (Gourlan et al., 2013). There was a correlation that was found between motivation to exercise and bouts of moderate intensity exercise showing the motivation can translate into the desired behavior (Standage et al., 2008). In general, identified regulation is crucial to initial adoption of a behavior such as physical activity and intrinsic motivation is required for long term maintenance of the behavior, so the SDT is useful not just for adoption but continuation of the behavior (Teixeira et al., 2012).

High quality studies have been done applying the SDT to physical activity with great success. Silva et al. (2008) described a 1-year randomized controlled trial that applied a behavioral program based on the SDT to the intervention arm of the study while controls received basic education. After 1-year the intervention group exercised more minutes per day (M=138, SD=26) than controls and took more average steps per day (M=2,049, SD=571, $p<0.001$) (Silva et al., 2010). In terms of the SDT, the intervention had higher average intrinsic motivation (M=24.0, SD=3.89 vs. M=18.9, SD=5.62, $p<0.001$), and mean motives for exercise were significantly higher for fitness (M=4.06, SD=0.72 vs. M=3.81, SD=0.78, $p<0.05$) as measured by the SDT psychometric battery (Silva et al., 2010). Hospes et al. (2009) performed a pre-post trial based on the SDT and found that the intervention increased average steps of cases by 785 per day and that motivation for physical activity significantly increased. The SDT can increase physical activity by influencing intrinsic motivation.

The SDT is a macro theory of human behavior that has been successfully applied to physical activity. The literature showed that the quality of the motivation is important when considering the desired behavior. Even though physical activity was not associated with veteran status and other significantly facts another significant factors could be investigated in depth. In terms of this study, if significant differences in physical activity are found between veterans and nonveterans with comorbid COPD and obesity then motivations for physical activity that are internal should be investigated separately for each group.

Summary

This chapter reviewed existing literature regarding physical activity, COPD, obesity, and veteran status. However, there were no studies that describe the difference in physical activity between veterans and nonveterans with COPD and obesity. The impact of exposure to active duty military service was linked to increased COPD, a disease that has a high mortality rate and represents a significant burden in terms of prevalence and economics. Studies showed that this disease has a high level of comorbidity with obesity being an important comorbidity.

Obesity had an interesting role in comorbid COPD, as those individuals with a higher BMI tend to have lower mortality, as obesity may prevent mortality associated with cachexia. However, physical fitness played an important role in the relationship between COPD and obesity. Higher fitness led to better outcomes perhaps by decreasing inflammatory markers, however, COPD can make physical activity more difficult by decreasing exercise capacity. Those with obesity and COPD had better lung function than those of normal weight, however, they tend to perform less exercise during testing which can be explained by muscle atrophy. This can be addressed through physical activity, often in the form of pulmonary rehabilitation. The SDT can be used to tailor interventions by identifying motivators most likely to impact behavior change. This research study provided motivation. However, it is immensely important to control for possible factors associated with physical activity, veteran status, COPD, and obesity such as age, sex, income, income, smoking status, race, and ethnicity.

Chapter 3: Research Method

Introduction

This chapter details the methodology that was used to answer the research question if there is a significant difference in physical activity between veterans and nonveterans when controlling for possible confounding factors. The variables from the data source are identified and any transformations and recoding are described. A detailed description of all steps to be taken in the analytic process is explained and logic behind research decisions is provided.

Research Design and Rationale

Case-control studies have been used to identify risk factors associated with COPD (Putcha et al., 2013; Putcha et al., 2014) and investigating interactions between exercise capacity in those with COPD, obesity, and fat-free mass (Aiello et al., 2014). In this study, the cases were veterans and the controls were nonveterans. Matching a case to a control can aid in reducing confounding, as differences between the two groups are reduced (Pearce, 2016). Matching is especially beneficial when sample size is a concern or when there are drastic differences between the case and control populations (Rose & Van der Laan, 2009). As previously discussed, veterans differ widely from the remaining population in terms of sex, age, race, and ethnicity (National Center for Veterans Analysis and Statistics, 2017). Based on this, cases were matched to controls on these demographic factors.

However, even when matching is done appropriately to reduce confounding, it is still possible that these actions can introduce another level of confounding, necessitating statistical control during the analytic process (Pearce, 2016). As such the analysis controlled for the matching variables of sex, age, race, and ethnicity as well as other potential confounders. Smoking and BMI are two important risk factors associated with COPD and other health outcomes that should be accounted for (Putcha et al., 2013). Additionally, prior research addressing physical activity in veterans and nonveterans demonstrated that sex, race, ethnicity, household income, and education level are potential confounders (Bouldin & Reiber, 2012).

A case-control design using secondary data was sufficient to answer the research question, especially when using matching. A matched case-control study conveyed benefits of increased efficiency to address potential confounders, especially when little was known of the relationship between the exposure and the outcome and the case and control populations are disparate (Rose & Van der Laan, 2009). However, matching does not eliminate the need to control for potential confounders. For this study, statistical analysis was used to control for age, race, ethnicity, sex, smoking status, BMI, household income, and educational level (Pearce, 2016). A case-control design was appropriately applied to this study to address the research questions.

Sample and Sample Size

The study sample was from the 2015 BRFSS study data. The BRFSS is an annual telephone-based survey that takes place across the United States with the purpose of collecting uniform data on chronic disease and related health behaviors that occurs over the course of 1-3 months (Centers for Disease Control and Prevention, 2016a). The sampling methodology for the BRFSS was disproportionate stratified sampling in all areas except Guam and Puerto Rico where simple random sampling was used (Centers for Disease Control and Prevention, 2016a). The Centers for Disease Control and Prevention weighted the data to ensure that the sample data more accurately represented the entire population.

G*Power was used to calculate the sample size (Faul, 2014). A 2-tailed multiple linear regression using random effects with nine predictors, a population multiple correlation coefficient of 0.05 (Kelley, 2008), a null multiple correlation coefficient of 0, a probability of a Type I error of 0.05 and 80% power requires a minimum sample size of 359 (Faul, 2014). The null multiple correlation coefficient, probability of a Type I error, and power are standard measures used in a priori power analyses. However, a larger sample size was desirable as it would allow for the detection of smaller effect sizes (Ellis, 2010).

Inclusion and Exclusion Criteria

To be included in this study valid responses were required for the independent, dependent, and matching variables. In other words, the following variables could not be missing or unknown: total minutes of physical activity per week, veteran status, sex, race, and ethnicity. As the study population consisted of obese individuals with COPD, to be included in the study the participants must indicate that a clinician had told them that they have COPD and had a BMI that is greater than or equal to 30. This also meant that the participants must have supplied a valid height and weight to calculate BMI. If the participant indicated that she was female and that she was pregnant at the time of the survey, she was excluded from analysis as weight gain from the pregnancy may impact BMI. The remaining participants were included in the analysis.

Data Analysis Plan

IBM© SPSS© Statistics Version 23.0.0.0 was used to carry out the data analysis plan. The 2015 BRFSS data was downloaded from the CDC’s website. The exclusion criteria were applied, and the appropriate variables were selected and transformed. When possible, categories with less than 5% of the weighted percentage were collapsed into other groups to preserve sample size. Table 2 details the variables that will be used for further analysis.

Table 2

Description of Variables

Variable	Source Name	Level of Measurement	Categories
Total minutes of weekly physical activity	PA1MIN	Interval-Integer	None
Recommendations for physical activity	PA1MIN	Ordinal	1=Did not met (<60 minutes) 2=Met (60-120 minutes) 3=Exceeded (>120 minutes)
Veteran status	VETERAN3	Dichotomous	1=Veteran 2=Nonveteran
Age group	AGE_G	Ordinal	1=18-44 2=45-64 3=65 and older
Sex	SEX	Dichotomous	1=Male 2=Female
Race	PRACE1	Categorical	1=White 2=Black/African American 3=Other
Ethnicity	HISPANIC	Dichotomous	1=Hispanic 2=Not Hispanic
Smoking status	SMOKER3	Categorical	1=Current smoker 2=Former smoker 3=Never smoker 9=Missing/Unsure
Education	EDUCAG	Categorical	1=Did not graduate high school 2=High school graduate 3=Some college 4=College graduate 9=Missing/Unsure
Income	INCOMG	Ordinal	1=<$25,00 2=$25,000 to <$50,000 3=$50,000+ 9=Missing/Unsure
BMI	BMI5	Ratio	None

The data set was separated into a veteran group and a nonveteran group. Everyone in the nonveteran group was assigned a random number and then sorted on that number. Each member in the veteran group was matched to a member of the nonveteran group with identical responses for age group, sex, race, and ethnicity variables in order of the sorted random number. This ensured that matches were made only on the selected variables. Those in the nonveteran group that were not matched to a veteran were excluded. The data sets were then merged.

Veteran status, total minutes of weekly physical activity, BMI, age, race, ethnicity, and sex all had valid values based on inclusion criteria; however, smoking status, household income, and education level may have had missing or refused values. If the missing and refused values accounted for less than 5% of the sample, then they were excluded. If the missing and refused values account for more than 5% of the sample, then a subsequent analysis was performed. For a variable with 5% of more missing or refused variables two groups were created, those with valid values and those without. An independent sample *t* test was performed comparing average total weekly physical activity, the dependent variable, by the new grouping. When the *p* value was greater than 0.05 then the missing values would be excluded, and only complete cases would be included. If the valid responses differ significantly from the nonvalid responses on the dependent variable then the missing data was imputed by selecting the mode of those with identical values for veteran status, age group, sex, race, and ethnicity (Sterne et al., 2009).

For those remaining in the analysis, descriptive statistics were calculated. For all dichotomous, ordinal, and categorical variables frequencies for each category within the variable were reported along with the corresponding percentages of the sample. For BMI and total minutes of weekly physical activity means with standard deviations and medians were reported. The data analysis plan was followed in order to prepare the data to answer the research questions.

Inferential Statistics

Inferential statistics, such as regression analyses, were done to answer the research questions. For this study, a *p* value that was less than 0.05 was considered statistically significant. To answer the first research question multiple linear regression was performed. Ordinal regression was done to answer the second research question.

Research Question 1: Is there a statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI?

Research Question 2: Is there a statistically significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI?

Table 3

Role of Variables in Analysis

Variable	Regression	Type
Total minutes of weekly physical activity	Multiple linear	Dependent
Recommendations for physical activity	Ordinal	Dependent
Veteran status	Both	Independent
Age group	Both	Factor
Sex	Both	Factor
Race	Both	Factor
Ethnicity	Both	Factor
Smoking status	Both	Factor
Education	Both	Factor
Income	Both	Factor
BMI	Both	Covariate

Before performing the analyses, it was determined if the assumptions for the tests had been met and if the assumptions were not met then actions would need to be taken to address these violations. Both types of regression have an assumption of no multicollinearity. This assumption was evaluated using VIF or variance inflation factors, if these values are greater than 10 for the factors then the highest would have been removed from the model and then it was rerun until all values were under 10 (Field, 2013).

The multiple linear regression had other assumptions that needed to be addressed: linear relationship between independent variables and the dependent variable, multivariate normality, and homoscedasticity (Field, 2013). These assumptions were addressed through visual inspection of various plots. Scatterplots of each independent variable against the dependent variable were done to address the assumption of linear relationships. Multivariate normality was evaluated by examining the observed value by expected normal value for each variable (Field, 2013). Finally, homoscedasticity was tested by plotting the observed cumulative probability against the expected cumulative probability of the standardized residual of the dependent variable (Field, 2013). If these assumptions were not met then the dependent variable could be transformed, such as taking the natural log of the dependent variable, and the tests for the assumptions run again.

The multiple linear regression was run as described in Table 3 in a manner where the independent variable, all factors, and covariates are entered into the model at the same time. From the output, the model fitting statistics were reported including the F statistic, mean square, degrees of freedom and p value (Field, 2013). Additionally, R^2 values will be reported to reflect the variance in the dependent variable that can be explained by variation in the independent variables (Field, 2013). Finally, the unstandardized coefficients for each parameter were reported along with corresponding standard errors, standardized coefficients, t values, and p values (Field, 2013).

The ordinal regression had different assumptions than the multiple linear regression. One such assumption was the proportional odds assumption, to address this assumption a test of parallel lines will be run and if the p value is less than 0.05 then a multinomial regression would have been run instead (Field, 2013).

From the output, the model fitting statistics were reported including -2 Log Likelihood, Chi-square statistic, degrees of freedom, and p value (Field, 2013). Additionally, the Nagelkerke pseudo-R^2 estimate was reported to reflect the variance in the dependent variable that can be explained by variation in the independent variables

(Field, 2013). Finally, the logit regression coefficient estimates for each parameter were reported along with corresponding standard errors, 95% confidence intervals, Wald statistics, degrees of freedom, and *p* values (Field, 2013).

If the multiple linear regression or the ordinal regression model was significant a final model was run. For each of these models only the parameters that contributed significantly to the original model were included. The same outputs were reported as the original models.

Threats to Validity

While every effort was made to reduce sources of bias there may be some threats to the validity of the study that should be addressed. This study used self-reported data, which can be subject to bias. For example, BMI is calculated from self-reported height and weight, however, due to factors such as fear of discrimination or judgment, there may be a possibility of under-reporting weight, especially in those that are obese (Sutin & Terracciano, 2013). In general, about one in seven individuals with an actual BMI greater than or equal to 30 will have a self-reported BMI less than 30, and this bias has remained stable in the population (Hattori & Sturm, 2013). If individuals are more likely to underestimate BMI based on self-reported data, for this study, this would indicate that those with self-reported BMIs that are greater than 30 are indeed obese (Hattori & Sturm, 2013). Similarly, the physical activity data that were used to generate the dependent variables in both research questions were self-reported and subjected to possible bias (Kwon, Wang, & Hawkins, 2016).

Recall bias may have been present when participants had to remember past events, such as historical smoking, to address this smoking categories were condensed into current, former, and never smokers so specific time frames are not needed. Misclassification bias may be present, as COPD was not confirmed with spirometry. However, COPD is often under-reported, as such, the impact of this bias may be minimal (Bernd et al., 2015). Finally, another type of misclassification bias may have existed was BMI is not a direct measure of adiposity. Although it may be more appropriate to use BMI as a screening tool for obesity, it is the most widely used and accepted proxy for adiposity (Heymsfield, Peterson, Thomas, Heo, & Schuna, 2016). While bias may not be able to be eliminated entirely, acknowledging potential sources and attempting remediation when possible are steps being taken to reduce potential threats to validity of this study.

Strengths and Limitations

A major strength of this study was that the data source is a nationally representative sample, lifting some of the barriers to generalization. Also, the BRFSS data used were from 2015, making them the most recent data available (Centers for Disease Control and Prevention, 2016a). Additionally, a case-control design with matching allowed for increased efficiency and possible control for confounding factors. However, there were limitations.

One limitation was that the data set did not provide information on the length of military service; only the presence or absence of the exposure is provided. Therefore, the impact of length of service was not known. Additionally, COPD was not confirmed by spirometry making it impossible to determine severity, which can be an important factor when researching COPD (O'Donnell et al., 2012). Also, the BRFSS data were limited to noninstitutionalized adults with telephone service, so any outcomes of this research can only be applied to this population (Centers for Disease Control and Prevention, 2016a). The study was done in 2015, which may limit the generalization to other points in time.

Another limitation is that the data were observational in nature, which limits the strength of the study. A randomized controlled trial is considered the gold standard, however, in this case, the gold standard may not be feasible, nor ethical. This was a known limitation of the study.

Ethical Procedures

Institutional Review Board (IRB) approval was sought and obtained prior to initiating any research. The Walden University IRB approval number for this study is 11-29-17-0078549. The BRFSS was generated by a federal agency and found public domain, which means that permission was not required, however, the Centers for Disease Control (2016a) will be cited as the original source. While the source data do not, and this subsequent analysis does not contain protected health information all information will be treated with the upmost respect and the data and analyses will be maintained in a password protected database for 5 years following the close of the study.

Summary

A secondary analysis using a matched case-control design was done to examine the relationship between veteran status and physical activity when controlling for related factors. The 2015 BRFSS data from the Centers for Disease Control (2016a) has all the variables needed for this analysis as well as utilizing a sampling technique that ensure representation from all subgroups across the country. The data analysis plan detailed all the steps taken to translate the source data to the dataset used for this study. Both descriptive and inferential statistics were performed. Regression analyses in the form of multiple linear regression and ordinal regression were appropriate types of analyses to answer the research questions. The information presented in this chapter was used to generate the results that are presented in the subsequent chapter.

Chapter 4: Results

Introduction

This chapter reviews the data collection process. Summary statistics follow the data collection process. Then, I summarized the results of the multiple regression and ordinal regression used to explore the relationship between average weekly physical activity and veteran status in individuals with both COPD and obesity while accounting for other important factors such as age, sex, race, ethnicity, BMI, smoking status, education level, and income level. The following research questions and hypotheses were addressed:

Research Question 1: Is there a statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI?

$H_0$1: There is no statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

H_a1: There is a statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

Research Question 2: Is there a statistically significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI?

$H_0$2: There is no significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

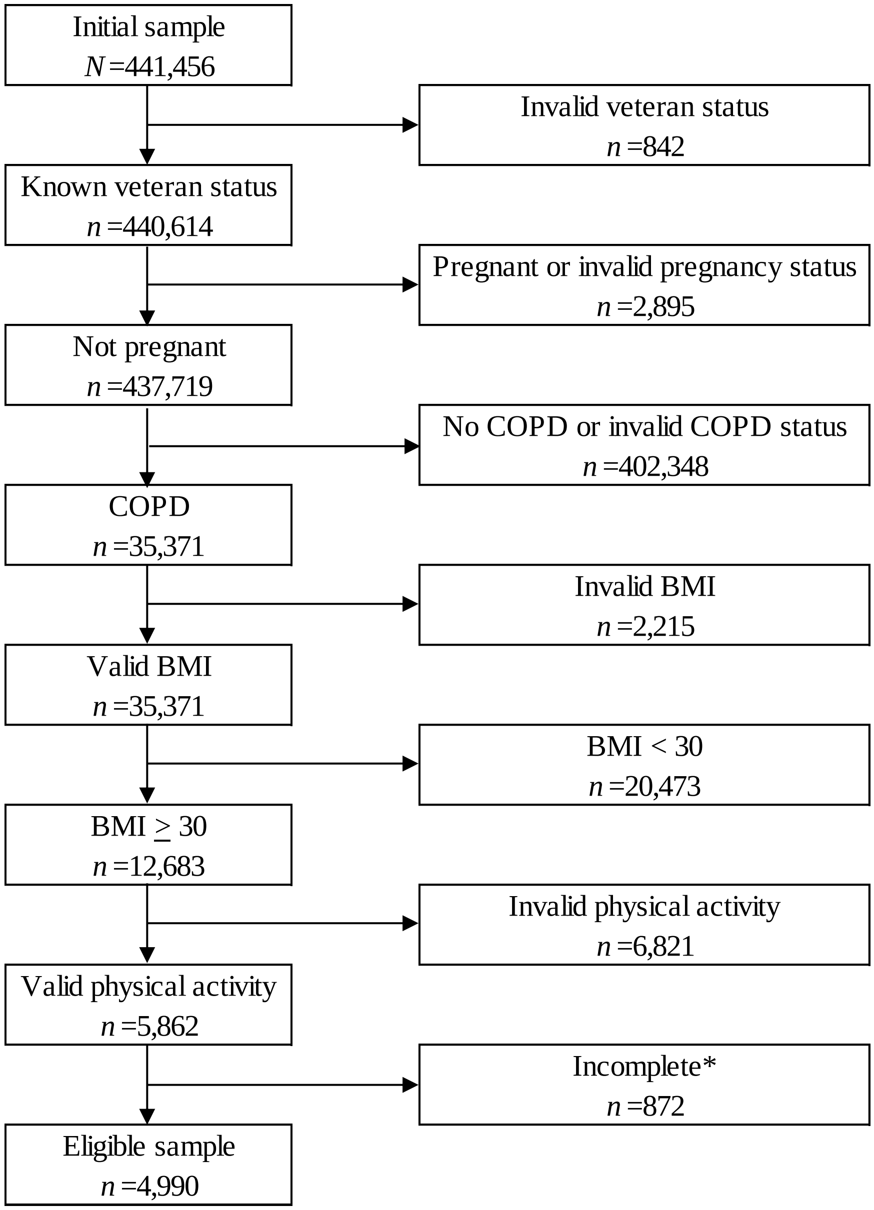
H_a2: There is a significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

Data Collection

The 2015 BRFSS data set was downloaded and extracted into IBM© SPSS© Statistics Version 23.0.0.0. Inclusion and exclusion criteria were applied to the data set to get the final cohort from which cases and controls were identified. Figure 1 shows how the 4,990 eligible participants were identified from the 441,456 total individuals in the 2015 BRFSS sample. The term *invalid* refers to data that are missing, unknown, or were refused for the purposes of this figure. For sex, age, race, ethnicity, smoking, and education those with invalid responses represented less than 5% of the sample; however, 752 (13.1%) participants of the sample had invalid household income responses. This triggered further analysis.

Per the statistical analysis plan laid out in the previous chapter, those with valid household income responses were separated from those without valid responses and an independent sample *t* test with equal variances not assumed was done to determine if there were significant difference in average weekly physical activity based on presence or absence of income data. There was no significant difference in mean average weekly physical activity between the 752 participants without valid household income responses (*M*=487.6, *SD*=1236.6) and the 4,990 with valid responses (*M*=430.0, *SD*=702.5); *t* (5,740) =-1.25, *p*=0.212). As there was not a statistically significant difference in physical activity between those with and without valid responses to household income only complete cases were included in the sample.

A matching algorithm was applied to the 4,990 in the eligible sample to match veterans to nonveterans based on age group, sex, race, and ethnicity. All of those in the sample that were not matched were excluded from final analysis. This led to a final sample size of 1,430 with 715 cases, or veterans, and 715 controls, or nonveterans. This cohort was used to answer the research questions.



*Invalid sex, age, race, ethnicity, smoking, education, or income

Figure 1. Attrition chart of initial sample to eligible sample

Results

The final cohort consisting of 1,430 individuals was used to generate descriptive statistics to further describe the study population using IBM© SPSS© Statistics Version 23.0.0.0. This same software was used to perform multiple regression and ordinal regression to answer the first and second research questions, respectively. The rejection or acceptance of the null or alternate hypotheses is reported based on the results of the regression analyses.

Descriptive Statistics

As the cases and controls are matched on age group, ethnicity, race, and sex, these statistics were reported for the whole population. Table 4 contains the frequency and percentages for age group ethnicity, race, and sex. Most, 53.1% (*n*=769), participants were 65 years of age or older and some, 41.7% (*n*=596), were between 45 and 64 years of age, and fewer, 5.2% (*n*=74), were 18 to 44 years of age. A clear majority of participants were male, 90.3% (*n*=1,292), and not Hispanic, 95.0% (*n*=1,358). White was the most commonly reported race (*n*=1,244, 87.0%), while the remaining 13% was split almost evenly between Black participants (*n*=94, 6.6%) and those of another race (*n*=92, 6.4%).

Table 4

Frequency and Percentage of Age, Ethnicity, Race, and Sex

		Frequency	Percent
Age group	18-44 years	74	5.2
	45-64 years	596	41.7
	> 64 years	760	53.1
Ethnicity	Hispanic	72	5.0
	Not Hispanic	1,358	95.0
Race	Black	94	6.6
	White	1,244	87.0
	Other	92	6.4
Sex	Female	138	9.7
	Male	1,292	90.3

There was little difference between average BMI, reported in kg/m^2, overall (*M*=35.8, *SD*=6.4), veterans (*M*=35.6, *SD*=6.6) and nonveterans (*M*=36.0, *SD*=6.3). Figure 2 shows the average and standard deviation for BMI of the study population. The median BMI of the veteran group was 33.7 while the median BMI for the nonveteran group was 34.7, which is similar to the mean. Aside from BMI, age group, sex, race, and ethnicity, other factors were collected and reported on such as income, education, and smoking status.

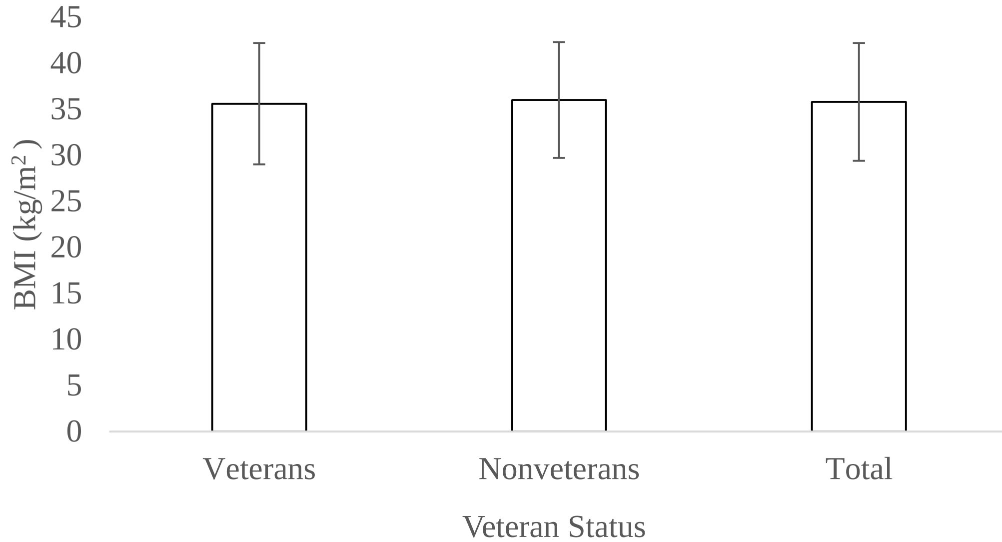


Figure 2. Average BMI by veteran status

Table 5 contains counts and percentages of descriptive statistics separated by veteran status. In veterans, the proportion of annual household income was relatively evenly distributed. In veterans, those with $50,000 or more comprise 35.8% (*n*=256) of the population while 33.7% (*n*=241) made between $25,000 and less than $50,000, and 30.5% (*n*=218) were in the less than $25,000 category. Nonveterans had a different distribution with 42.2% (*n*=302) being in the less than $25,00 category, followed by 30.9% (*n*=221) in the highest category of $50,000 or more in annual household income, and 26.9% (*n*=192) in the middle category of $25,000 to less than $50,000.

Some differences were also seen in highest education level regarding distribution of proportions. Only 6.6% (*n*=47) of veterans did not graduate from high school while 13.4% (*n*=96) of nonveterans were in the same category, and 10.0% overall (*n*=143). For the whole study sample, 31.4% (*n*=449) graduated high school; this was the highest educational attainment for 34.4% (*n*=246) of nonveterans and 28.4% of veterans (*n*=203).

Those that had some college were the most common in the veteran group with 39.4% (*n*=282) having reached this level while 26.4% (*n*=189) of nonveterans reached this same level. Similar proportions of individuals graduated college in both the veteran (*n*=183, 25.6%) and nonveteran (*n*=184, 25.7%) groups.

Table 5

Count and Percentage of Income, Education, and Smoking Status by Veteran Status

		Veterans (*n*=715)		Nonveterans (*n*=715)		Total (*N*=1,430)	
		n	%	*n*	%	*n*	%
Annual household income	<$25,000	218	30.5	302	42.2	520	36.4
	$25,000 to <$50,000	241	33.7	192	26.9	433	30.3
	$50,000+	256	35.8	221	30.9	477	33.4
Education	Did not graduate high school	47	6.6	96	13.4	143	10.0
	High school graduate	203	28.4	246	34.4	449	31.4
	Some college	282	39.4	189	26.4	471	32.9
	Graduated college	183	25.6	184	25.7	367	25.7
Smoking status	Current smoker	159	22.2	156	21.8	315	22.0
	Former smoker	425	59.4	398	55.7	823	57.6
	Never smoker	131	18.3	161	22.5	292	20.4

The most common smoking status was former smoker (*n*=823, 57.6%), followed by 22.0% (*n*=315) of current smokers, and then 20.4% (*n*=292) were never smokers. Veterans had similar proportions of smoking status with 59.4% (*n*=425) reporting being former smokers, 22.2% (*n*=159) indicate they currently smoke, and the remaining 18.3% (*n*=131) never having smoked. A slight difference is seen with the nonveterans. While most (*n*=398, 55.7%) were former smokers, the next most common group never smoked (*n*=161, 22.5%) followed by current smokers (*n*=156, 21.8%).

There were similarities in addition to the differences. For example, similarities were seen between the two groups aside from proportion of those with a college degree. Specifically, proportion of those not meeting, meeting, and exceeding recommendations of average weekly physical activity was similar between veterans and nonveterans as seen in Figure 3. Overall participants were most likely to exceed the recommendation of 60-100 minutes of average weekly physical activity (*n*=1,000, 69.9%), which is similar to both veterans (*n*=507, 70.9%) and nonveterans (*n*=493, 69.0%). Only one more nonveteran (*n*=123, 17.2%) met physical activity recommendations than veterans (*n*=122, 17.1%) for a total of 17.1% participants meeting recommendations. The fewest participants did not meet recommendations overall (*n*=185, 12.9%), with a slightly higher percentage of nonveterans (*n*=99, 13.8%) falling into this category as compared to veterans (n=86, 12.0%).

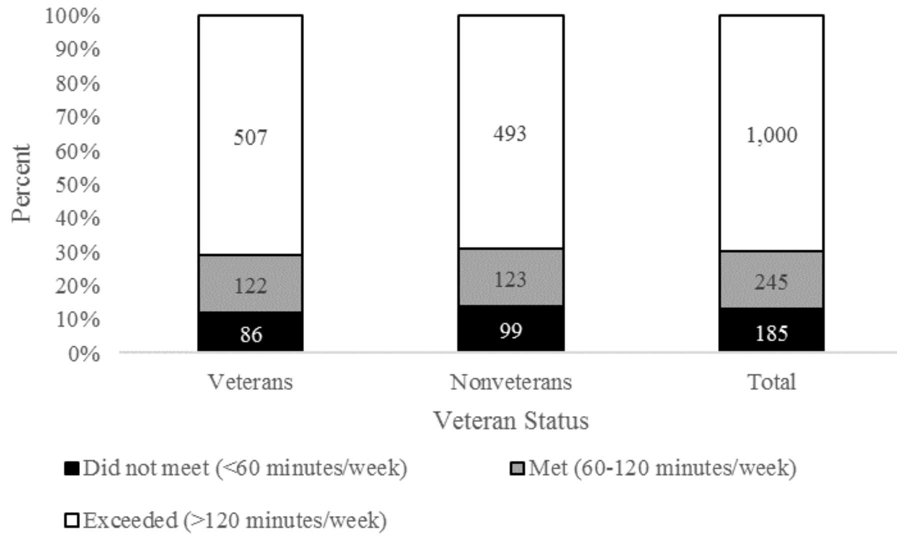


Figure 3. Proportion of physical activity category by veteran status

Overall, the average minutes of weekly physical activity was 461.3 (*SD*=658.5). For veterans this was slightly higher, up to 469.3 (*SD*=662.5) and slightly lower in nonveterans with 453.3 (*SD*=654.9) average minutes of weekly physical activity. A similar trend for median weekly physical activity in minutes was seen with 268 for veterans, 210 for nonveterans, and 210 overall. Table 6 shows the means and standard deviations of average weekly physical activity for the total sample and for veterans and nonveterans. While these descriptive statistics provide an understanding of the sample, further analytics are needed to better understand the relationship between physical activity and veteran status when controlling for sex, age group, ethnicity, race, education level, household income, and BMI.

Table 6

Descriptive Statistics of Average Weekly Minutes of Physical Activity by Veteran Status

	Veterans	Nonveterans	Total
M	469.3	453.3	461.3
SD	662.5	654.9	658.5
Median	268.0	210.0	210.0

Research Question 1

Research Question 1 posited, "Is there a statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI?"

$H_0 1$: There is no statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

$H_a 1$: There is a statistically significant relationship between average minutes of weekly physical activity and veteran status in those with COPD and obesity when controlling for differences in smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

A multiple linear regression was done to test the first research question. Weekly physical activity was the dependent variable and veteran status was the independent variable and the remaining variables were covariates or factors such as age group, sex, race, ethnicity, smoking status, education, income, and BMI. Assumptions were checked. All VIFs were less than 10 and scatterplots showing independent versus dependent variable, observed versus expected values and observed cumulative probability and expected cumulative probability were inspected to ensure assumptions of no multicollinearity linear relationships, multivariate normality, and homoscedasticity, were met.

The first regression model was significant ($F(15,414) = 2.51$, $p = 0.001$), with an R^2 of 0.0259 with details for each predictor shown in Table 7. In this table, standardized (β) and unstandardized coefficients (B) are provided along with *t* statistics and an indicator for significant values. Only BMI (β=-0.06, *p*=0.0236) and ethnicity (β=0.06, *p*=0.0497) were significantly related to average weekly minutes of physical activity.

There were two instances when a single group significantly varied from the reference category, however, they were not included in the model moving forward as the whole variable was not significant. Those of a race other than black or white were more likely to report increased weekly physical activity as compared to those who indicated their race was “White” (β=0.07, *p*=0.0172). However, no such relationship was seen when comparing the white and black segments of the study population (β=-0.03, *p*=0.2886). Similarly, those between 18 and 44 years of age did not differ significantly from those who were 45 to 64 years of age (β=0.11, *p*=0.0809). However, there was a statistically significant difference in average weekly physical activity between the young reference group and the oldest age group of 64 years and over (β=0.17, *p*=0.0073). While veteran status was not significant (β=-0.02, *p*=0.5544), the regression was run again using only the significant variables.

Table 7

Initial Linear Regression

	B	*SE*	B	*t*
Intercept	376.16	161.51		2.33*
BMI	-6.24	2.75	-0.06	-2.27*
Male (Sex reference)				
Female	-0.60	60.91	0.00	-0.01
Veteran (Veteran reference)				
Nonveteran	-20.88	35.30	-0.02	-0.59
White (Race reference)				
Black	-75.36	70.99	-0.03	-1.06
Other	177.89	74.60	0.07	2.38*
Hispanic (Ethnicity reference)				
Not Hispanic	166.22	84.60	0.06	1.96*
18-44 years (Age group reference)				
45-64 years	144.26	82.58	0.11	1.75
≥65 years	228.68	85.19	0.17	2.68**
Did not graduate high school (Education reference)				
High school graduate	-40.90	63.98	-0.03	-0.64
Some college	-70.52	65.55	-0.05	-1.08
College graduate	-89.30	68.83	-0.06	-1.30
< $25,000 (Income reference)				
$25,000-<$50,000	-47.22	43.90	-0.03	-1.08
≥$50,000	33.08	45.62	0.02	0.73
Current smoker (Smoking status reference)				
Former smoker	52.24	45.67	0.04	1.14
Never smoker	24.48	54.63	0.02	0.45

*-p<0.05, **-p<0.01

The next model used average weekly minutes of physical activity as the dependent variable and BMI and ethnicity as the independent variables. This model was significant as well, $F(2,1427) = 5.96$, $p=0.0034$, with an R^2 of 0.007918. Table 8 shows the contributions of each predictor to the model. While BMI remained significant (β=-0.07, $p=0.0061$), ethnicity was no longer a significant contributor to the overall model (β=-0.05, $p=0.0825$). As such, a final linear regression was run.

Table 8

Linear Regression

	B	*SE*	Β	*t*
Intercept	596.72	129.06		4.62*
BMI	-7.46	2.72	-0.07	-2.27*
Hispanic (Ethnicity reference)				
Not Hispanic	138.38	79.63	0.05	1.74

*-$p<0.01$

In the final linear regression model average weekly minutes of physical activity was the dependent variable and BMI was the independent variable. The model was significant ($F(1,1428) = 8.36$, $p=0.004$) with a $R^2=0.006$. Details of the final model can be seen in Table 9. BMI (β=-0.08, $p<0.01$) was significantly related to average weekly physical activity in minutes. As the coefficient was negative this indicated that, on average, for each increase of a single unit of BMI there was a -7.84 decrease in weekly minutes of physical activity, as seen in Table 9. However, the R^2 is quite low for this model, meaning that only a small fraction of variation in weekly physical activity can be explained using BMI.

Table 9

Final Linear Regression

	B	*SE*	Β	*t*
Intercept	741.72	99.54		7.53*
BMI	-7.84	2.71	-0.08	-2.89*

*p<0.01

While the final model did show that there was a variable, BMI, that had a statistically significant relationship with average weekly physical activity, veteran status did not. Given this information, the null hypothesis was not rejected, and there was no statistically significant relationship between average weekly physical activity when controlling for age, sex, race, ethnicity, education, income, BMI, and smoking status. Research question 2 was then addressed.

Research Question 2

Research Question 2 asks, "Is there a statistically significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI?"

$H_0 2$: There is no significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

H_a2: There is a significant relationship between falling below, within or above the recommended range of physical activity of 60-120 minutes per week for those with COPD and obesity and veteran status when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

An ordinal regression was run to address the second research question. The proportional odds assumption was addressed using the test of parallel lines (-2 log likelihood (*df*=15), 2254.47, Chi-square=16.70, p = 0.402), which failed to reject the null thus meeting the assumption. The ordinal regression model was run with the dependent variable as not meeting, meeting or exceeding recommendations for physical activity. Veteran status, sex, age, race, ethnicity, income, education, and BMI were the independent variables. The model was significant (-2 log likelihood 2270.16 (*df*=15), Chi-square=44.466, p<0.001), with a Nagelkerke R^2=0.038. Table 10 provides information regarding each variable in the model.

With exceeding the recommendations for physical activity as the reference there were significant differences between those that did not meet recommendations (parameter estimate 95% CI [-4.04,-2.18], p<0.001) and those that met the recommendations (parameter estimate 95% CI [-2.94,-2.18], p<0.001).

Even though the model was significant a single variable did not significantly contribute to the model alone. Two categories within separate variables were significant when compared to their respective reference categories, however, the entire variable was not significant. For example, with those 65 years of age and older as a reference, those 45 to 64 years had a statistically significant relationship with physical activity grouping (parameter estimate 95% CI [$^{-}$0.65,$^{-}$0.16], *p*=0.001), however no such relationship was found when comparing to those 18 to 44 years (parameter estimate 95% CI [$^{-}$0.77,0.31], *p*=0.407). Similarly, when compared to those that have an annual household income equal to or greater than $50,000, those with an income less than $25,000 had a significant relationship with physical activity group (parameter estimate 95% CI [$^{-}$0.66,$^{-}$0.07], *p*=0.016). There is not a relationship with the reface group when comparing the reference to those making more or equal to $25,000 but less than $50,000 (parameter estimate 95% CI [$^{-}$4.43,1.61], *p*=0.361). No other categories had a statistically significantly relationship with the dependent variable, as such no further modeling was done.

Table 10

Ordinal Regression

	df	B	*SE*	95% CI	Wald
>120 minutes PA (Physical activity group reference)					
< 60 minutes PA	1	-3.11	0.48	[-4.04,-2.18]	42.82**
60-120 minutes PA	1	-2.02	0.47	[-2.94,-1.1]	18.44**
BMI	1	-0.01	0.01	[-0.03,0.01]	1.39
Female (Sex reference)					
Male	1	-0.21	0.2	[-0.6,0.19]	1.06
Nonveteran (Veteran reference)					
Veteran	1	0.07	0.12	[-0.16,0.3]	0.4
Other (Race reference)					
White	1	-0.32	0.26	[-0.82,0.19]	1.53
Black	1	-0.34	0.33	[-0.99,0.31]	1.03
Not Hispanic (Ethnicity reference)					
Hispanic	1	0.11	0.28	[-0.44,0.67]	0.15
≥ 65 years (Age group reference)					
18-44 years	1	-0.23	0.28	[-0.77,0.31]	0.69
45-64 years	1	-0.41	0.13	[-0.65,-0.16]	10.47**
College graduate (Education reference)					
Did not graduate high school	1	-0.35	0.22	[-0.78,0.08]	2.51
High school graduate	1	0.14	0.17	[-0.19,0.47]	0.71
Some college	1	-0.18	0.16	[-0.49,0.13]	1.26
≥ $50,000 (Income reference)					
< $25,000	1	-0.37	0.15	[-0.66,-0.07]	5.79*
$25,000-<$50,000	1	-0.14	0.15	[-0.44,0.16]	0.83
Never smoker (Smoking status reference)					
Current smoker	1	-0.16	0.18	[-0.5,0.18]	0.84
Former smoker	1	0.17	0.15	[-0.13,0.47]	1.27

*-p<0.05, **-p<0.01

Veteran status did not have a significant relationship with physical activity grouping (parameter estimate 95% CI [$^{-}$0.17,0.30], p=0.529). The null hypothesis was not rejected. It was shown that there was not a significant difference between not meeting, meeting or exceeding physical activity recommendations when controlling for smoking status, age, sex, race, ethnicity, household income, education level, and BMI.

Summary

This chapter provided descriptive and inferential statistics regarding physical activity and veteran status while accounting for potentially confounding. Data from 715 veterans with COPD and obesity were matched to the exact same number of nonveterans with the same age, sex, race, and ethnicity. The null hypothesis was not rejected for the first research question indicating that veteran status did not have a statistically significant relationship with average minutes of weekly physical activity in those with COPD and obesity when accounting for differences in age, sex, race, ethnicity, smoking status, BMI, income, and education. While there was no significant relationship with veteran status, the was a significant relationship with BMI, indicated the higher the BMI the lower the average weekly minutes of physical activity. The second research question had a similar conclusion where the null hypothesis was not rejected and there was no statistically significant relationship between veteran status and category of physical activity.

A deeper interpretation of the results is presented in the following chapter. Further interpretation, limitations, and recommendations are presented. Finally, the next chapter addresses implications of this research and associated results.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this quantitative case-control study was to determine if there was a statistically significant relationship between veteran status and physical activity in those with comorbid obesity and COPD when controlling for age, sex, race, ethnicity, smoking status, BMI, income, and education. Average weekly physical activity was looked at in two ways, minutes per week and if recommendations of 60-120 minutes per week were exceeded, met, or not met. This resulted in two separate research questions. The outcomes could be used to inform policy and tailor interventions for those with COPD and obesity. The results for both research questions found no significant relationship between physical activity, whether it be in the form of average weekly minutes or meeting recommendations for physical activity, and veteran status when controlling for potentially confounding factors. However, for average weekly physical activity, BMI was significantly related in a negative manner.

Interpretations of the Findings

In many ways, the finding of this study reflected existing literature. For example, the literature showed that veterans tended to be older, male, and not Hispanic (National Center for Veterans Analysis and Statistics, 2017). The veterans included in this study were over 90% male, 53% were in the highest age group ($\geq$ 65 years), and 5% were of Hispanic or Latino origin, all of which fit with what is known of this population.

During the exclusion process 12,683 (38.3%) of the total 33,156 individuals who participated in the 2015 BRFSS with COPD were obese when the other exclusion criteria were applied. This falls within the 25-42% range presented by Negewo et al. in 2015. This also aligns with the 29-43% set forth by Putcha et al. in 2015.

However, not all aspects of the results perfectly aligned with literature. Smoking was identified as being an important factor when considering physical activity in those with COPD (Thompson & St-Hilaire, 2010). However, this study found no association between smoking status and physical activity when accounting for other related factors.

When looking at obesity and physical activity, the results of the study aligned with the literature. Increased BMI had been shown to have an association with decreased physical activity in individuals with COPD (Monteiro et al., 2012). In terms of the veteran population and not accounting for COPD, it was shown that increased BMI was associated with decreased amounts of physical activity (Yaghoubi et al., 2013). For all individuals included in the study, the average BMI was 35.8 (*SD*= 6.4) and the average weekly minutes of physical activity equal to 461.3 (*SD*=658.5). This study found that for each increase of a single unit of BMI there was a 7.84 decrease in weekly minutes of physical activity. However, R^2 is quite low for this model, meaning that only a small fraction (0.6%) of variation in weekly physical activity can be explained using BMI. The information gathered from this study supported existing literature.

The was little published regarding physical activity in those with COPD and obesity and even less when aggregating by veteran status. As such, there was no true benchmark to compare physical activity. Bouldin and Reiber (2012) described a modest, yet significant, 2.2 minutes increase in moderate physical activity between veterans and nonveterans and no difference in terms of vigorous activity. These data did not consider COPD status, making comparability a challenging endeavor. In the study population, veterans engaged in 16 more minutes of physical activity per week on average; however, the standard deviation was high, 658.5, for the entire population. This indicates that the variance was high creating a great deal of noise (Bouldin & Reiber, 2012), which can make it difficult to establish statistically significance difference. High variance could aid in understanding why veteran status was not significant in the model to understand the role of prior exposure to active duty military service in physical activity while accounting for other factors in individuals with COPD and obesity.

There was one variable that was initially identified as a potential factor associated with physical activity and upon follow-up was removed from the model: ethnicity. While the assumption of multicollinearity was addressed, it is possible that other factors and covariates contributed to the significance of the ethnicity variable and when removed were no longer accounted for, meaning that the variable was dropped upon follow-up.

Most of the study population, (*n*=1,000, 70%) exceeded the recommended amount of physical activity by engaging in more than 120 minutes of weekly activity on average. An additional 245 (17%) participants met the requirements by getting 1-2 hours of exercise per week and the remaining 185 (13%) participants got less than an hour of average physical activity per week. There was little variation when aggregated by veteran status where 13 fewer veterans did not meet the recommendations as compared to nonveterans, one more veteran met the recommendation than nonveterans, and 14 more veterans exceeded recommendations as compared to their counterparts. This lack of variation could contribute to the lack of association seen in the ordinal regression model, which led to the acceptance of the null hypothesis that there is no relationship between not meeting, meeting or exceeding recommended amounts of average weekly physical activity in those with COPD and obesity when controlling for age, sex, race, ethnicity, smoking status, education level, income level, and BMI.

An additional outcome from the analysis of the study data is that the ordinal regression model was significant while none of the predictor variables were significant. This can occur when each predictor contributes to the model nominally, but if there are enough can lead to statistical significance, even when the individual predictors are not statistically significant (Field, 2013). The Nagelkerke R^2 was 0.038 and indicated that differences in the predictors only captured 3.8% of variation in distribution of not meeting, meeting, or exceeding recommendations. Even though the model was significant, it was not particularly strong. Overall, the low variation between physical activity groupings could attribute to the lack of significance seen.

In terms of the SDT, with veteran status not having a significant relationship with physical activity in those with COPD and obesity, this could potentially indicate that prior military service does not impact the need for competence or autonomy, which are two of the three psychological needs associated with this macrotheory associated with physical activity. Along the same lines, the model showed that those with a higher BMI had lower average weekly amounts of physical activity, which could mean that increased BMI could be associated with lower competence or autonomy. Those with lower BMIs may have a more internalized motivation which can lead to increased physical activity (Gourlan et al., 2013). Well internalized motivations also help to maintain a behavior such as physical activity in addition to initiative the desired behavior (Teixeira et al., 2012). This almost creates a feedback loop where if an individual who is obese with COPD engages in physical activity to improve his or her health then he or she will gain competence, which can increase the desired behavior, which can also lead to decreased BMI. The decrease in BMI aids in the need in autonomy as it establishes a cause and effect relationship, which can then lead to more physical activity. However, all results need to be considered with the limitations of the study in mind as they restrict the ability to draw conclusions from the data.

Limitations of the Study

Previously mentioned limitations include a limited study period, no control for COPD severity, lack of clinical confirmation of COPD diagnosis leading to potential misclassification, recall bias, and potential social desirability bias. Upon execution of the study another limitation became evident. As physical activity was self-reported and asked questions regarding overall timing of activities, continuity of the exercise is not captured (Troiano, McClain, Brychta, & Chen, 2014). For example, an individual could report that he or she engaged in the physical activity of walking for 60 minutes, but if he or she took several breaks within that hour he or she may still report the activity for 60 minutes but not gain the benefit of physical fitness as the effort was not consistent.

In addition to the limitations, this study is a case-control study which is not as strong as a research study that utilizes a blinded randomized controlled trial (Rose & Van der Laan, 2009). While the case-control design attempts to match cases to controls on various factors to aid in comparing the two groups (Rose & Van der Laan, 2009), there may be other factors that could have helped separate cases from controls that were not identified at the time of study. Great care was taken to reduce the risk of all areas of bias when possible and to maximize generalizability, validity, and reliability.

Recommendations

As there is little literature regarding this exact topic there are many recommendations for future research based on the existing literature and this study. For example, future studies could use a different methodology of measuring physical activity. Instead of using self-reported physical activity, an accelerometer could be used. This would address the limitation of potential lack of continuity from self-reported data covering timing of an activity. Both speed and distance could be accounted for using a tool such as an accelerometer (García-Rio et al., 2014). Accelerometer usage was associated with better outcomes, lower mortality, and hospitalizations due to COPD exacerbations (García-Rio et al., 2014) however, this was not examined by veteran status.

Additionally, it could be informative to do further research to consider physical activity from a quality perspective as opposed to a count-based focus (Troiano et al., 2014). For example, Bouldin and Reiber (2012) reported a significant difference in physical activity between veterans and nonveterans when considering moderate physical activity but not vigorous physical activity. Different types of physical activities contribute to the attribute of physical fitness in various ways, hence addressing physical activity in groupings such as endurance, strength, balance and flexibility, may also be informative in understanding the relationship between physical activity and veteran status in those with combined COPD and obesity (Ribeiro, Thériault, Debigaré, & Maltais, 2013). Further information on the types or quality of exercise associated with outcomes for those with comorbid obesity and COPD could then be used to inform policy to increase clarity regarding exercise recommendations for this specific population.

Further research could strengthen the study design while simultaneously increasing the quantification of the exposure, or active duty service. This could be accomplished by doing a prospective cohort study. Individuals that are new to military service could enroll in such a study as well as a similar control group. Both groups could be followed forward in time and assessed for COPD and obesity as well as physical activity. Prospective studies have been shown to be useful when examining potential factors associated with COPD in veterans and could be applied to the data in this study (Greene et al., 2008). Further research in the form of a prospective cohort study would provide information regarding the role of length of military service has when examining the relationship between physical activity and veteran status in those with comorbid COPD and obesity.

Also, future research could focus on refining the study population by refining the methodologies used to define obesity and COPD. As previously discussed BMI is not a direct measure of body mass, and it better serves as a screening tool than a diagnostic measure (Centers for Disease Control and Prevention, 2016b). Alternatives exist that are superior to BMI in terms of measuring adiposity such as skinfold thickness or dual energy x-ray absorptiometry (Addo, Pereira, & Himes, 2012). Further research using an alternative method to measure adiposity as opposed to mass would ensure that the increased mass is attributed to fat as opposed to another tissue type, such as muscle, which could be attributed to increased physical activity.

Another recommendation for improvement is to more clearly define smoking habits. This study broke down smoking habits into never, former or current smoker. However, there may be other ways to measure smoking that would be more meaningful. Recommendations are to include how long smoking occurred and how many cigarettes were smoked. This additional information could be helpful in establishing and clarifying the role of smoking in terms of physical activity in those with COPD and obesity.

Future research should also include lung function testing in the form of spirometry. Spirometry is the gold standard for diagnosing COPD, with a Tiffeneau-Pinelli index that is less than 0.7 representing the threshold for diagnosis (Global Initiative for Chronic Obstructive Lung Disease, 2017). With an estimated 81.4% of all cases that meet the spirometric definition of COPD going undiagnosed future studies that include spirometric confirmation of COPD diagnosis could provide a more robust population as those that were undiagnosed previously could be included (Bernd et al., 2015). Including spirometry in future studies would go beyond helping to refine the population with COPD, it would also allow for the stratification of COPD by severity. There are distinct clinical differences based on spirometrically derived severity levels of COPD (Bednarek, Maciejewski, Wozniak, Kuca, & Zielinski, 2008). This would be an important factor to include as those with severe COPD may have less exercise capacity to engage in physical activity as compared to those with mild COPD, which could impact physical activity in those with obesity between veterans and nonveterans. There are many potential routes to research that would further the understanding of the relationship between physical activity and veteran status in those with COPD and obesity.

Implications

This study fosters positive social change by describing the relationship between average minutes of weekly physical activity and veteran status when accounting for differences in sex, age, ethnicity, race, smoking status, BMI, income, and education level. While veterans engaged in 16 minute more average weekly physical activity than nonveterans and 13 fewer veterans did not meet recommendations for physical activity when accounting for variation associated with sex, age, ethnicity, race, smoking status, income, BMI, and education there was not a statistically significant relationship between physical activity and veteran status. The data from this study do not support including veteran status as a specific factor when developing interventions to increase physical activity in people with comorbid obesity and COPD. This supports that the same intervention program could be applied to both populations without having to account for alterations based on veteran status. This could help save time and resources during the development of an intervention.

Additionally, data show that on average weekly self-reported physical activity was 461.3 minutes (*SD*=658.5) and a high percentage, 87.1%, got at least 60 minutes of weekly physical activity, the lower threshold of the recommended amount. This indicates that study participants, on average, engaged in 5.7-6.7 more hours of physical activity per week than recommended. These data could inform policy perhaps to enhance existing recommendations to provide clarity around not just quality of suggested physical activity but also type, given that most individuals in this study reported high amount of weekly physical activity.

Finally, these data did support existing literature in terms of the relationship between having a higher BMI and a lower average amount of physical activity. Interventions to increase physical activity in those with comorbid COPD and obesity, if using SDT, can focus on internalizing motivation to initiate and maintain physical activity and to develop competence in this area to meet this key psychological need to continue the desired behavior.

This study could potentially impact interventions aimed at the study population in several ways. The data could be used to inform and enhance recommendations for physical activity provided by various organizations. The study information could also potentially impact individuals with COPD and obesity as these data can be used to develop interventions to increase physical activity. Given that increased physical fitness, which is the attribute resulting from the behavior of physical activity, can improve outcomes for those with obesity and COPD, any resulting increase in physical activity can be impactful.

Conclusions

There are few studies that address physical activity in those with COPD and obesity. This case-control study of individuals with comorbid COPD and obesity from the 2015 BRFSS data showed that while veteran status was not significantly associated with physical activity, BMI did. More specifically, it was a negative relationship where if one increases then the other decreases and vice versa. While no factors were significantly associated with physical activity levels, below, at or above recommendations. These findings highlight the importance of increasing or maintaining physical activity in those with combined COPD and obesity.

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