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Cardiovascular Exercise Participation and Obstructive Sleep Apnea among Adults Over Normal Weight in the United States

Marytherese Agwara
Walden University

Walden University

College of Health Sciences

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Marytherese O. Agwara

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Review Committee
Dr. Katie Callahan, Committee Chairperson, Public Health Faculty
Dr. Gudeta Fufaa, Committee Member, Public Health Faculty
Dr. Shanna Barnett, University Reviewer, Public Health Faculty

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Abstract

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Marytherese O. Agwara

MS, Argosy University, 2011

BS, Mercer University, 2009

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health- Epidemiology

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Abstract

Obstructive sleep apnea (OSA) is a type of sleep apnea that is common, complicated, and a major contributor to cardiovascular diseases, neurocognitive impairment, and mortality. This disease has additional negative impacts on patients' lives by contributing to daytime sleepiness and low productivity at work as well as absenteeism and work-related injuries. Several studies have been conducted to assess the relationship between cardiovascular exercises and OSA; however, a definite conclusion is lacking. The purpose of this quantitative cross-sectional study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA as well as the relationship between body mass index (BMI) and OSA among adults over normal weight in the United States. Secondary data from the National Sleep Research Resource (NSRR) were used for analyses. Logistic regression was used to test the hypotheses. The Social-Ecological Model (SEM) guided the study. The findings of the study suggested that doing moderate cardiovascular exercise participation per week (0.1 and 200 minutes) had no relationship with OSA while doing higher cardiovascular exercise participation (>200 minutes) per week had relationship with OSA by increasing the odds (AOR = 2.1, CI: 1.048-4.060) of having severe OSA. BMI had no relationship with OSA. Individuals with OSA and a higher BMI could use the findings of this study to participate in an exercise program that might benefit their health and decrease the risk of exacerbated symptoms which could lead to an improved quality of life and decreased burden associated with OSA.

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Dedication

My son, Blessing gave up a lot during my academic pursuit. He worked so hard to support me, and encouraged me not to give up throughout the stressful period of this process. Thank you, my son. I love you. God has answered our prayers. I dedicate this dissertation to you my boy. I had loving parents, but death took them away. I dedicate this dissertation to my late parents, Chief Vincent I. Agwara and Lolo Magdalen N. Agwara, who inculcated among other values, educational values in me. They believed that I could achieve whatever I set my mind on, and that the sky was my limit. They were absolutely right. My parents are in heaven, and they can now rest in perfect peace knowing that I have in my palm; the desired academic excellence. To my entire family, I am highly grateful for your support, encouragement, and prayers. Finally, I dedicate this dissertation to adults living with obstructive sleep apnea in the United States and beyond.

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I praise the Almighty God for making this dream come through. I am grateful and appreciative to Dr. Ernest Ekong, the Committee Chair, DrPH. Katie Callahan- Myrick, the Committee Member, and Dr. Gudeta Fufaa, the University Research Reviewer for their suggestions and guidance throughout the dissertation journey. I acknowledge Dr. Chinaro Kennedy for her suggestions. Dr. Blessing Agu, I appreciate you for encouraging me and believing that I can finish this process. Dr. Taiyee Quenneh, thank you for your explanations whenever I call you. Dr. Ferdinand Nsengimana, I thank you for your suggestions. Special thanks to Dr. Shanna Barnett and the entire team who worked hard when my committee chair died to help me complete the process. I acknowledge all Walden instructors/staff who directly or indirectly contributed to this great academic achievement. I also acknowledge the National Sleep Research Resource (NSRR) for providing secondary data for this study. Finally, I thank Walden University officials for well outlined dissertation platform.

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Chapter 1: Introduction to the Study

Introduction

Obstructive sleep apnea (OSA) is a type of sleep apnea that is common and complicated. OSA is a life-threatening sleep disorder that surfaces with repetitive occurrence of partial or complete collapse of the upper airway during the hours of sleep (Filomeno, Ikeda, & Tanigawa, 2016; Spicuzza, Caruso, & Di Maria, 2015). OSA is characterized by intermittent hypoxia, frequent arousals, and sleep fragmentation as well as hypercapnia (Andrade & Pedrosa, 2016). OSA is a major contributor to cardiovascular diseases, neurocognitive impairment, and mortality (Park, Ramar, & Olson, 2011; Peppard et al., 2013). OSA has negative impacts on patients' lives, and contributes to low productivity at work as well as work absenteeism and injuries coupled with serious economic burdens (Allen, Bansback, & Ayas, 2015; Schmidler, 2013). OSA has been recognized as a disease, and has sometimes been referred to as obstructive sleep apnea syndrome (OSAS) due to its involvement with clinical manifestation of excessive daytime sleepiness (Ratnakumar & Manuel, 2016).

This disease has been linked to severe health problems, economic loss, and poor quality of life. The accumulating burden has serious adverse effects on the diagnosed, undiagnosed, and the entire nation (Iftikhar, Kline, & Youngstedt, 2014). OSA requires continuous lifelong care, and adults living with this disease should seek treatment especially because of the neurocognitive impairment involved (Lal, Strange, & Bachm, 2012). Over the last twenty years, OSA has been on the rise. This disease is more dangerous and complicated when it is undiagnosed and untreated (National Institutes of

Health [NIH], 2012a). OSA is predominant in elder adults; 1 out of 10 adults older than 65 years had OSA (Mabry, 2013). Giovanni at el. (2013) stated that the increase in obesity prevalence among adults had a great impact on the manifestation of OSA.

Somnolence and fatigue associated with OSA have been attributed to be the major causes for the inability of OSA patients to participate in aerobic exercises, and obesity could cause such symptoms as well (Butner et al., 2013). OSA patients have a variety of options in terms of managing and treating the disease; however, researchers and clinicians have started focusing and recommending physical activity and exercise (Marciel, Andrade, Pedrosa, & Pinto, 2016). Marciel et al. (2016) claimed that active participations in exercise could produce anti-inflammatory results in patients who were obese, but such definite attribute has not been made on OSA with exercise. Besides, there has been no study that ascertained or validated exercise as a direct independent therapy for reducing OSA severity among adults over normal weight.

The purpose of this study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA as well the relationship between BMI and OSA among adults over normal weight in the United States. The outcome of this study might be beneficial to adults over normal weight living with OSA because they would be aware of the impacts of cardiovascular exercise participation. The findings of this study might also promote social change by motivating adults over normal weight to adopt a behavioral change by engaging in structured cardiovascular exercise participation which could aid them in reducing weight. Other sections in this chapter include: study background, problem statement, purpose of the study, research questions, hypotheses, theoretical framework, nature of the study, definitions of terms, assumptions, scope and delimitations, limitations and significance of the study, contributions to social change, and the summary.

Background of the Study

OSA is a common type of sleep apnea that occurs through different types of etiologies, and has several symptoms and health complications. Butner et al., (2013) examined the relationship between the severity of OSA with determinants of exercise capacity and health related quality of life (HRQoL) among overweight and obese male and female adults. Butner et al., (2013) concluded that OSA severity in adults had no independent relationship with exercise capacity or HRQoL. Other researchers such as Iftikhar et al. (2014) conducted a meta-analysis to evaluate data from 5 studies with 6 cohorts on effects of supervised exercise training on OSA among adults. Iftikhar et al. (2014) claimed that, there was an association between exercise and the reduction of OSA severity with little changes in weight loss; however, they further reported that the mechanism was not clear.

Going by the concept of sleep related breathing disorder (SRBD) continuum, the most favorable treatment for OSA must eradicate OSA, upper airway resistance syndrome (UARS), and snoring while using continuous positive airway pressure (CPAP) for treatment (Wickramasinghe & Rowley (2017). SRBD continuum was a concept first introduced by Elio Lugaresi. SRBD continuum are those sets of clinical conditions that occur between snoring and other severe types of OSA. This continuum states that with time, snoring increases (Wickramasinghe & Rowley, 2017). Therefore, SRBD continuum should be recognized when seeking treatment for positive outcome on clinical issues that include snoring. When implying that exercise participation can reduce the severity of OSA, SRBD continuum should be considered. In addition, there are other OSA etiologies such as nasal polyps, craniofacial, and anatomical factors that play integral roles in the obstruction of the upper airway (Pang &Tucker, 2011). These types of OSA etiologies play integral roles in obstructing the upper airway, but the mechanisms through which exercise participation can reduce their actions to the upper airway is yet to be known.

Gap in Knowledge

The findings on the studies conducted by Butner et al. (2013) and Iftikhar et al. (2014) were based on their target population, and generalization of the findings were not centered on adults over normal weight. There is a need to further investigate the relationship between cardiovascular exercises and OSA in terms of managing the severity, and identifying the type of cardiovascular exercises that can reduce the severity. A gap in knowledge still exists, which suggests that further investigation should commence regarding finding the relationship between cardiovascular exercise participation and OSA among adults over normal weight. Obesity aggravates OSA through a variety of mechanisms and vice versa. Overwhelming evidence exists through epidemiological studies on the role of obesity on OSA patients (Bonsignore, McNicholas, Montserrat, & Eckel 2012; Ogilvie, & Patel, 2017). Obesity is not only a risk factor for

OSA; it is also a disease with comorbidities and complications that has been noted as epidemic in the United States (Fock & Khoo, 2013).

Researchers are now paying more attention and recommending physical activity/exercises to OSA patients because of its benefit in reducing adverse outcomes associated with OSA and its comorbidities (Andrade, & Pedrosa, 2016; Beitler et al., 2014). Downey (2017) ascertained that weight gain was detrimental to the health of OSA patients, and postulated that losing up to 10% of weight would alleviate the respiratory disturbance index (RDI) by 26%. Exercise independently can not help in attaining weight loss goals; however, physical activity may help in maintaining weight loss achieved through dietary and other means (Fock & Khoo, 2013). Researchers claimed that OSA severity could be reduced through exercise training, but no data has shown how loss of weight through exercise training aided in reducing or eradicating hypopnea, apnea, or upper airway abnormalities. This shows that a gap regarding the association between cardiovascular exercises and OSA exists.

I examined the relationship between total cardiovascular exercise participation per week and OSA to understand how cardiovascular exercise participation could reduce the severity of OSA among adults over normal weight. The overall consequences of OSA are harmful, and any method of prevention or treatment that can reduce the burden among adults over normal weight, public health system, and the nation’s healthcare costs on OSA will be widely acceptable. Findings of this study might bring OSA awareness that would trigger behavioral changes among target population. Awareness of this disease might lead to early detection, and early detection could prompt proper treatment which might decrease the burden of comorbidities coupled with the reduction of morbidity and mortality. When researchers postulated how exercise could reduce the severity of OSA, it became paramount for the public to know exactly what part of the upper airway is being corrected as well as the mechanism in order to avoid ambiguity.

Problem Statement

OSA is a growing problem that constitutes a public health concern. OSA is associated with myriad of comorbidities and sequelae such as cardiovascular diseases, hypertension, cognitive impairment, and metabolic disorders (Beiter et al., 2014; Butner et al., 2013; Iftikhar et al., 2014). This disease has additional negative impacts on patients' lives by contributing to daytime sleepiness and low productivity at work as well as absenteeism and work-related injuries (Allen et al., 2015). In addition to adverse health outcomes, OSA is also associated with serious economic burdens on healthcare costs among undiagnosed, treated, and untreated individuals (Knuaert, Naik, Gillespies, & Kryger, 2015). Although Kline et al. (2011) reported that cardiopulmonary exercises could reduce the severity of OSA, Beitler et al. (2014) stated that OSA impaired the ability to exercise.

Kline et al. (2011) examined the effect of a 12-week exercise training program on the reduction of the severity of OSA and to improve quality of sleep among forty-three sedentary, overweight, and obese adults aged 18 to 55 with moderate to severe OSA. Kline et al. (2011) concluded that the program had moderate treatment effect on reduction of AHI. Beitler et al. (2014) examined 15 participants with moderate to severe OSA and 19 controls to see if OSA was associated with impaired cardiopulmonary exercise capacity, and the authors concluded that there was an association between OSA and impaired cardiopulmonary exercise capacity.

There have been conflicting and confusing conclusions regarding the effects of cardiovascular exercises on OSA that have made the association between cardiovascular exercises and OSA unclear. Tuomilehto et al. (2012) postulated that although weight loss could reduce OSA symptoms, no definite exercise for OSA treatment has been proposed. Because the burden of the disease is evident and enormous, a method to reduce its severity is paramount. Finding the relationship between total cardiovascular exercise participation per week and OSA may aid in reducing severity of the disease among adults over normal weight living with OSA in the United States.

Purpose of the Study

The purpose of this quantitative study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA as well as the relationship between BMI and OSA among adults over normal weight in the United States. The independent variables for the study were total cardiovascular exercise per week and BMI. The dependent variable was OSA. The covariates were age, gender, race, neck circumference, and employment.

Research Questions and Hypotheses

The research questions and hypotheses associated with the study are as follows:

RQ1: Is there a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0$1: There is no statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders.

Ha1: There is a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders.

RQ2: Is there a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0$2: There is no statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

H_a2: There is a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

Theoretical Foundation

The Social Ecological Model (SEM) proposed by McLeroy, Steckler, and Bobeau (1988) was used as a framework for this study. The SEM is well-recognized in public health practice for its role in health promotion interventions. This model stipulates that individuals have an impact on their environment and vice versa. The SEM identifies multi-levels of influences, and these influences are the sources of interaction based on five factors: intrapersonal, interpersonal, institutional, community, and public policy levels (Golden & Earp, 2012). This theoretical framework was used to influence a health behavioral change, understood factors affecting the variables, and to guide the study. Due to the complexity of OSA, treatment regimen should include strategies to combat the disease in order to achieve effective outcomes (Romero-Corral, Caples, Lopez-Jimenez, & Somers, 2010). In examining the association between cardiovascular exercise participation and OSA among adults over normal weight, this study incorporates intrapersonal, interpersonal, institutional, community, and public policy factors.

Intrapersonal Factors

Intrapersonal factors include biological and personal history factors such as knowledge, behavior, developmental history as well as gender, race/ethnicity, and age (American College Health Association [ACHA], 2015). These intrapersonal factors are necessary for the process of behavioral change, especially for adults who are over normal weight living with OSA. The main focus is to be aware of the prevention strategies that can reduce the severity of OSA through gaining full knowledge of the disease and seeking better treatment options. The developmental characteristics of this factor can motivate an OSA patient to understand the complexity of the disease, have the self-efficacy to engage in a structured cardiovascular exercise program, and learn skills to perform a structured exercise (McLeroy et al., 1988).

Interpersonal Factors

The relationships formed at this stage with families, neighbors, and friends are very helpful because they provide health-related support through a social environment although they can also adversely influence an individual. The influence of informal social networks or formal groups can enable any adult over normal weight living with OSA to participate in a structured exercise program, especially when trust is involved and gained (Golden, McLeroy, Green, Earp, & Lieberman, 2015). Group participation in a structured exercise program encourages motivation and support, and can stimulate commitment to losing weight (Perry, Saelens, & Thompson, 2011). The influences that come with interpersonal factors such as peer pressure can also motivate OSA patients to participate in exercise programs.

Institutional Factors

Rules and regulations include organizational norms that have tremendous influence on adults' way of life. For instance, most organizations require employees to take time and exercise while working. The worksite health intervention has been beneficial to those companies because their employees are minimizing callouts, sick leave, and productivity is on the rise (Pescud at al., 2015). Such worksite health intervention can have a positive influence and may provide a suitable opportunity for adults over normal weight suffering from OSA to engage in any physical activity or exercise program to reduce weight.

Community Factors

Community factors include shared social relationships among institutions, neighbors, and the built-in environment. OSA affects peoples' lives in a negative way, and the social relationships that exist within these settings can greatly influence their motives to seek relief by seeking to lose weight through exercise (Mardas et al., 2016). Community factors through social relationships can also adversely impact obese adults living with OSA through stigmatization where they may choose not to exercise due to name calling, fat shaming, and depression. Community factors can also positively influence obese adults living with OSA through physical activity or exercise such as walking to the park or shopping center, jogging, running, or bicycling around the community.

Public Policy Factors

Public policies are laws that are meant for health promotion and prevention coupled with allocation of resources (ACHA, 2015). Local, State, and Federal policies can positively influence adults over normal weight suffering from OSA, and this necessitates them seeking healthier behavior to reduce the severity of OSA. Most people living with OSA are unaware of the disease and are untreated, which sometimes constitute induced drowsy driving or public hazard (Toostani, Tanit, Nami, & Claudio, 2017). Public policies regarding induced drowsy driving will mandate OSA patients to be involved in behavioral interventions such as structured exercises that may help in reducing the severity of the disease. OSA is a neglected chronic disease among the general population, and lack of policies that could improve screening and treatment posed a challenge (William et al., 2006).

Nature of the Study

This study was quantitative and cross-sectional. The quantitative approach helped in answering specific research questions. The cross-sectional design was appropriate for this study because no causal outcome was expected. Moreover, this study was descriptive and associations between variables were examined which were characteristics of the design. One of the advantages of using a cross-sectional design is that it allows researchers to examine the outcome and exposure among the participants at the same time which provides less cost and time. One of the characteristics of the study design is allowing researchers to strictly adhere to the inclusion and exclusion criteria (Setia, 2016).

The independent variables of interest in the study were total cardiovascular exercise participation per week and BMI. OSA was the dependent variable. The other independent variables (covariates) were: age, race, gender, neck circumference, and employment. Secondary data on the Heart Biomarker Evaluation in Apnea Treatment study from the National Sleep Research Resource (NSRR) was used. A data access and use agreement (DAUA) was submitted to the NSRR on August 23, 2017. Authorization was granted on August 30, 2017 before I accessed the data. The data was accessed after Walden University IRB approval. The statistical analysis tool used was SPSS version 25, and the statistical test for analysis was logistic regression.

Definition of Terms

Apnea: This occurs when airflow in an adult is blocked by an obstruction from the throat, and no breathing occurs for 10 seconds. It usually lasts for 30 seconds or longer (Downey, 2016).

Apnea-Hypopnea index (AHI): The combined average numbers of apnea and hypopnea that usually occur during each hour of sleep, and used to measure OSA (Asghari & Mohammadi, 2013).

Body Mass Index (BMI): BMI is used to measure obesity by dividing an individual's weight in kilograms and the height in meters squared (kg/m^2) (World Health Organization, 2016a).

Cardiovascular Exercise: Cardiovascular exercises are those types of physical activities that raise the heart and make it beat faster (NIH, 2013).

Hypopnea: A reduction of 50% less airflow for up to 10 seconds followed by 3% oxygen desaturation or awaking from sleep (Downey, 2016).

Obesity: Obesity is an excessive accumulation of body fat that can produce adverse health outcomes. The measurement of adult obesity depends on the BMI above 30 kg/m^2 (WHO, 2016a).

Obstructive Sleep Apnea (OSA): OSA is a life-threatening disease known for repetitive occurrence of partial or complete collapse of the upper airway and episodes of nocturnal cessation of airflow during sleep causing sleep fragmentation, oxygen deprivation, and arousal (Filomeno et al., 2016; Spicuzza et al., 2015).

Assumptions

In the process of analyzing the relationship between cardiovascular exercise participation and OSA as well as BMI and OSA among adults over normal weight, several assumptions were made. It was assumed that the participants were properly screened for OSA, and information from them were reliable. Further assumption was that the data would be cleaned and recoded, that the secondary data contained variables appropriate for this study, and that data were collected among target population. The research also assumed that missing values would be handled appropriately.

Scope and Delimitations

The conflicting and confusing conclusions from researchers that have made the association between cardiovascular exercise participation and OSA unclear was one of the reasons that motivated me to embark on this research. My interest in the secondary data from the NSRR was because of the exercise variables they included that aided me in formulating and answering the research questions. The exercise variables aligned with the topic and the purpose of the study. The scope of using the secondary data containing the Heart Biomarker Evaluation in Apnea Treatment study variables from the NSRR was limited to examining the association between cardiovascular exercise participation per week and OSA, as well as relationship between BMI and OSA. The scope also was limited to adult patients between the ages of 45 and 75 who had cardiovascular diseases or multiple risk factors for cardiovascular diseases screened for OSA as well as adults who were over normal weight.

Since the data for this study came from a randomized controlled trials study and this was a cross-sectional study, method and generalizations differed. Although the study population was from the United States, participants were not selected from all parts of the United States; rather, they were selected from three states (Cleveland, OH, Baltimore, MD, and Boston, MA) in the U.S. Participants who did not have complete information or had missing data were excluded. The theoretical framework that guided this study was the SEM. The use of the SEM framework helped to view and explain cardiovascular exercise participation, OSA, and adults over normal weight through the five factors (intrapersonal, interpersonal, institutional, community, and public policy factors). This theoretical framework helped to define how behavior is shaped by the social and built-in environment through the five levels of influences. A favorable environment makes healthy behaviors easier to adapt.

Limitations

In every study, there are limitations especially when secondary data is used. The data for this study was not originally collected for this study. The method of how the secondary data was collected or self-reported information from participants might have contributed to bias. The data used was from a randomized controlled trials and given the nature of such study, it might have constituted loss to follow-up which must have affected the validity of the study. In addition, it might be possible that the target population were not fully represented which could have introduced another type of bias and could affect generalization of findings. Acknowledging limitations in a study is ethical and appropriate because it signifies that the researcher has control over the study, and it creates avenue for further research (Puhan et al., 2012).

Significance

Taking proper measures to reduce accumulated fat can be challenging and beneficial to individuals trying to lose weight. Chen et al. (2014) stated that obesity and OSA had an adverse effect on peoples' lives. The necessity of indulging in cardiovascular exercise participation should be apparent among adults over normal weight living with OSA. This study may help people living with OSA to either indulge in daily cardiovascular exercise or avoid cardiovascular exercise entirely. Although there are more randomized controlled trials on the way to evaluate the long-time effects of continuous positive airway pressure (CPAP) used to combat OSA for those who tolerate the therapy, any effective treatment of OSA to decrease the disease as a public health burden considering its high prevalence should be widely acceptable.

The confusing and conflicting notions regarding whether exercise can reduce the severity of OSA might be resolved if the findings of this study showed an association between cardiovascular exercise participation and OSA. This study might provide helpful information regarding cardiovascular exercise participation and OSA that could be beneficial to treatment therapy. If cardiovascular exercise participation could aid in adjusting the level of OSA severity, it might serve as a treatment alternative to CPAP which has not been tolerated by many OSA sufferers. One of the most significant expected outcomes of this study were to create an opportunity for adults over normal weight to manage the severity of OSA better by indulging in a routine and structured exercise program.

Summary

OSA is a common type of sleep apnea and a serious medical condition. OSA affects children, adolescents, and adults in the United States and globally. A major concern of OSA involves not only the disruption of breathing during sleep or the economic loss, but the overwhelming impact on the body systems which is devastating (Sacchetti & Mangiardi, 2013). Being overweight/obese/extremely obese poses a major health concern, and continuous increase in obesity prevalence would promote the incidence of OSA (Stansbury & Strollo, 2015). In addition, public policies that can moderate culture sensitivity, encourage physical activity/exercise, and access to healthy food may reduce the problem of accumulated fat among adults. The prevalence rate of global overweight/obesity calls for cohesive collaboration, and effective interventions are needed to aid nations who are severely affected by the overweight/obesity epidemic. Inactivity leads to obesity, and obesity has a serious impact on OSA.

Chapter 2: Literature Review

Introduction

The purpose of this quantitative study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA as well as the relationship between BMI and OSA among adults over normal weight in the United States. OSA is a disease with serious health issues and complications, and it is a public health problem. About 29.5 million people above the age of 30 suffer from mild to severe OSA, and 13 million adults above the age of 30 are living with OSA in the United States (Knuaert et al., 2015). About 20% of the general population has OSA (Sharma et al., 2015). Peppard et al. (2013) examined rates of OSA in the United State from 1988 to 1994 and 2007 to 2010, and concluded that OSA was a disease that could cause adverse health complications.

In this chapter, I discussed the literature search strategy, literature on OSA as a global issue, the theoretical foundation, historical perspective of OSA, epidemiology and occurrence of OSA, and other OSA-related issues as well as subsequent discussions regarding cardiovascular exercise, OSA, BMI, and adults over normal weight in the United States.

Literature Search Strategy

In this chapter and through the literature review search, I had the opportunity to garner information that enabled me to thoroughly delineate the relationship between cardiovascular exercise participation per week and OSA as well as the relationship between BMI and OSA among adults over normal weight. The basis of the literature search was mainly from peer-reviewed articles, journals, Google, and Google Scholar. The peer-reviewed articles were published between 2012 and 2016. The articles used were from Medscape, PubMed, Science Direct, and Medline.

The search words used were obstructive sleep apnea, sleep apnea, sleep disordered breathing, continuous positive airway pressure, apnea hyperpnoea index, obesity, body mass index, exercise, physical activity, cardiovascular exercise, cardiorespiratory exercise, and aerobic exercise.

Theoretical Foundation

SEM

The use of The SEM and its multifactorial levels as a framework to guide this study was appropriate due to the multifactorial etiology nature of OSA. The surroundings of adults over normal weight are strongly influenced by social and physical environments, and social involvement enhances the wellbeing of adults. While these two types of environments have no unified definition, social environment incorporates interpersonal relationships and physical environment involves neighbors, homes, and the urban designs (Gao, Fu, Li & Jia, 2015). The SEM is a framework that has five levels of factors (influences, intrapersonal, interpersonal, institutional, community, and public policy levels) that impact peoples' health, lives, and their environments. Understanding, cardiovascular exercise participation, OSA, and abnormal weight entail looking into social and ecological influences that may contribute to risk factors and non-compliance with healthy behaviors.

The multilevel of SEM by McLeroy et al. (1988) was more tailored to health behaviors. Interventions to control OSA, implement exercise program, and reduce weight can be explained through the five levels of SEM. For instance, Mehtala, Saakslahti, Inkinen, and Poskiparta (2014) used social- ecological model as a framework in a systematic review to promote physical activity intervention in a childcare setting. Mehtala et al. (2014) believed that physical activity could be evaluated through the levels of ecological model and that the model aided in enhancing physical activity   From a social-ecological perspective, interventions tailored toward the challenges that impact (intrapersonal, interpersonal, institution, community, and policy factors may enhance sleep and encourage physical activity/exercise participation among adults who are over normal weight (Swift et al., 2013). Ohri-Vachaspati et al. (2015) used the SEM to predict childhood obesity, and to recommend intervention programs. The authors found out that using the SEM to predict childhood weight revealed practical strategies that could aid in designing appropriate interventions.

Sahoo et al. (2015) argued that although environmental factors, lifestyle choices, and cultural environment added to the high prevalence of obesity, other factors such as sugar intake through soft drinks, and increase in calorie and fat intake were contributory. Older adults have the tendency of being sedentary and less active which can increase the chances of being overweight, obese, or extremely obese; therefore, using a framework that has multiple factors that may impact their behaviors is appropriate. Kerr et al (2012) used social- ecological model to promote multi-level physical activity interventions among older adults living in a retirement home, and the authors discovered that the five influences of SEM had great impact on the older adults which helped to increase the rate of compliance in participation. In order to attract the attention of adults over normal weight to participate in physical activity/exercise, public health system should recognize those personal and social factors that sometimes pose life challenges (Ibrahim, Karim, Oon, & Ngah, 2013).

A growing body of evidence exist that shows the effect of being overweight, obese, or extremely obese on older adults. Interventions geared toward promotion of physical activity have the potentials of reducing adult obesity (Simon et al., 2014). To reduce the severity of OSA among adults over normal weight, all the five factors of the SEM should reflect and guide their behaviors. When behavioral changes are embedded in a theoretical framework, they become less difficult and manageable.

Historical Perspective of OSA

Some researchers postulated that OSA was first known in the 1970s; however, the disease did not become a major concern of public health until 20 years later. The recognition of sleep apnea was delayed due to numerous misconceptions, and the disease was originally seen as an insomnia which was attributed to bed side manners (Shaw et al., 2012). Further evaluation to identify OSA was challenged because of sleep study environment. Shaw et al (2012) confirmed that in addition to study environment, another challenge in evaluating OSA was privacy issues. OSA was also initially termed as men's disease; however, the disease affects both men and women although with varying symptoms (Wimms, Ketheeswaran, & Armistead, 2014).

Over the years, many authors and researchers used different names to describe OSA and its associated symptoms. For instance, Sir William Osler devised the word “Pickwickian” in an attempt to describe obese drowsy patients in 1018. Another classic example was the story about a fat boy who snored and was constantly drowsy as described by Charles Dicken in his “posthumous papers of the Pickwick club” from 1812-1870 (Thorpy, 2011). Despite technological innovation that aids in diagnosing OSA and series of treatment options, there is need to reduce the severity.

OSA

OSA is a type of sleep disordered disease and sleep apnea that affects children, young, and adults globally. OSA is associated with partial or complete collapse of the upper airway at the hours of sleep coupled with airflow reduction, and has contributed to huge health issues in the United States and other parts of the world (Spicuzza, Caruso, & Di Maria, 2015). The prevalence of the disease is rapid in the United States and globally (Mieczkowski & Ezzie, 2014). About 29.5 million people above the age of 30 suffer from mild to severe OSA, and about 13 million adults above the age of 30 years are living with OSA in the United States (Knuaert, Naik, Gillespies, & Kryger, 2015). In Shanghai, China, prevalence of OSA was 3.62%. About 0.54% individuals were under treatment, and 85% living with symptoms were yet to be diagnosed (Zou et al., 2013). In North America, the increase of OSA prevalence was estimated up to 20- 30 % in male and 10-15 % in females (Tareen, 2016). Since the past 2 decades, there has been a great increase on the prevalence of OSA in the United States, and adults are disproportionately affected.

Ansarin, Sahebi, and Sabu (2013) asserted that in comparison to developing countries, there were more incidents of OSA in the United States.

Senaratna et al. (2016) reported that the increase in OSA prevalence in the United States was due to elevated body mass index. A study done on the general population showed a significant increase on OSA prevalence in countries with increasing aging population (Senaratna et al., 2016). Although the prevalence of OSA is on the rise, number of studies on the general population to determine the actual rate of prevalence is limited. A growing body of evidence showed the adverse impact of OSA on health and health costs. In addition, there are developments of comorbidities and sequelae that affect majority of the general population coupled with the impact on quality of life in general (Knauert et al., 2015). The major concern of OSA is not only the disruption of breathing at the hours of sleep, or the economic loss, but the overwhelming impact on the body systems which is devastating (Sacchetti & Mangiardi, 2013).

Epidemiology of OSA

Epidemiological researchers are increasingly reporting the prevalence of OSA in their studies. Documented evidence has shown that prevalence of OSA is higher in older adults especially after the age of 65 (Jindal, 2017). As of 2016, the prevalence of adult living with OSA was 29.4 million, 5.9 million diagnosed, and 23.5 million undiagnosed (Frost & Sullivan, 2016). As the prevalence of OSA increases, the percentage and ratio among males and females shift as well. Previous OSA data on gender prevalence rate showed 4% for males and 2% for women; however, recent evidence showed an elevation of 9% for males and 4% for females. More evidence showed that among adults between

30-60 years of age, OSA prevalence increased from 9- 24% for males and 4-9% for females (Downey, 2017). The estimated prevalence among men was 1 out of 4 men and 1 out of 9 females for assessment of mild OSA cases. For moderate, the ratio was 1 out of 9 males and 1 out of 20 for females (Olson, Chung, & Seet, 2016).

Judging from the available data, OSA affect males more than females. Although males are more likely to have OSA than females, evidence showed that females do suffer from certain sequelae more than males (Mehra, 2017). Evidence also showed that males were more affected by OSA than females due to the hormones on the upper airway muscles and its collapsibility, gender differences in the body fat distribution, and pharyngeal anatomy and function differences. The pathogenesis of OSA in females is influenced by hormonal effect because females in their post menopause ages have higher prevalence than the pre-menopausal women (Franklin & Lindberg, 2014). Researchers articulated that OSA was more seen in the males than females in the general population with estimated ratio of 2:1. (Franklin & Lindberg, 2014). However, both males and females need to take appropriate measures to reduce the severity and prevalence of OSA. An awareness, early diagnosis, and proper treatment of OSA will aid in reducing the severity and complications.

Occurrence of OSA

OSA patient experiences abnormality in breathing due to partial or complete closure of the upper airway. The episodes of OSA at the hours of sleep starts when the back muscles of the throat closes, and this causes obstruction of air (Ho & Brass, 2011). On a person without OSA, the upper airway stays open, and air passes through the throat and goes to the lungs (Strohl, 2017). The nose, mouth, throat, and windpipe made up the upper airway which aids in the flow of oxygen and carbon dioxide. For an OSA patient, air flow is either limited (Hypopnea) or totally stopped (Apnea) during sleep (Strohl, 2017; Schmidler, 2013). Clinicians and investigators indicate that the collapsibility of the upper airway occur at the hours of sleep, and reopen when the patient wakes up (Pham & Schwartz, 2015). The narrowing and obstruction of the upper airway could be prompted by several mechanical factors (Rotenberg & Tucker, 2013).

The collapsibility of the upper airway slows the flow of air thereby constituting sleep fragmentation, arousals, and oxygen desaturation which leads to comorbidities and sequalae (Sutherland, Lee, & Cistulli, 2013; Schmidler, 2013). When apnea events occur, air is limited to the obstructed area which reduces blood flood to the brain. This action sends message to the brain to wake the body up from sleep for the body to breathe. When the breathing gets smaller, the oxygen becomes low and the level of carbon dioxide increases making the individual to wake up. The occurrence of several episodes of apnea at the hours of sleep constitutes deficiency of oxygen (intermittent hypoxia) through the narrowing of the airway which makes it hard for the patient to breath. The episode of obstruction decreases oxygen level in the arterial blood; however, the insufficiency of oxygen increases when the airway becomes at ease (Bradford & Halloran, 2013).

Arousal

Arousal has been attributed to upper airway collapse when an OSA patient goes back to sleep and has been associated with many other negative outcomes on the upper airway (Jordan et al., 2015). Although there are various types of arousals with varying levels, intensity, and its effect on sleep and breathe, investigators have reported that cortical arousal was necessary for the opening of the airway. This conception has been adopted as part of the development of OSA. Cortical arousal plays an integral role at the end of OSA's breathing event by returning air flow and blood gas disturbance (Eckert and Younes, 2014). When the opening of airway fails to include cortical arousal, clinicians usually assume that it must have occurred somewhere without notice (Jordan et al., 2015). Eckert and Younes (2014) reported that some patients may benefit from some aspects of arousal while some patients may not benefit due to the adverse effect of arousal on breathing at the hours of sleep.

Severity of OSA

The level of OSA severity serves as a biomarker for clinicians to determine how a patient needs to be diagnosed, and the severity has impact on the type of treatment the physician will recommend to the patient. The International Classification of Sleep Disorder (ICSD) uses the frequency of apnea events, the level of oxygen desaturation, and the severity of daytime sleepiness to define the severity of OSA (Siesing & Tabacchi, 2013). The AHI is used to define the severity of OSA, and it is calculated by the number of events of the obstruction per hour during sleep from overnight monitoring (Spicuzza, Caruso, & Di Maria, 2015). Although several researchers have used AHI to measure the severity of OSA, there have been arguments whether AHI was an appropriate tool to measure the severity of OSA and to make proper treatment decisions (Asghari & Mohammadi, 2013). The controversy on AHI was centered on how burdensome the quality of life for OSA patients was, and there has never been a study that showed correlation between AHI and quality of life of the patients with OSA (Asghari & Mohammadi, 2013). Classifications of AHI is as follows: normal ≤5, mild 5–15, moderate 15–30, severe 30-60, and very severe ≥60 (Hooper, 2016).

While the above scores on OSA severity are used by some clinicians and researchers, the American Academy of Sleep Medicine (AASM) has a different way of scoring the severity of OSA which is also widely used. The classification is as follows: mild 5-15, moderate 15-30, and severe >30 (Labib, Riad, & Ghaly, 2014).

Clinical Manifestation of OSA

OSA patients experience variety of symptoms. OSA starts with a clinical manifestation of snoring, snorting, gasping for air at night, or breathing interruption. Subsequent symptoms are: dry or sore threat, morning headache, and witnessed apnea (Downery, 2016). Additional daytime symptoms include excessive daytime sleepiness, fatigue, loss of concentration; confusion, memory loss, irritability, and anxiety. Nocturnal symptoms include: choking, restless sleep; insomnia, nocturia, obstructive breathing, and night sweat (Downery, 2016; Stansbury, & Strollo, 2015).

Etiology

The pathogenesis of OSA is very difficult to understand and varies among patients. Although lack of the upper airway patency during the hours of sleep was attributed to be the cause, the etiology of OSA is multifactorial. Some suggested causes of OSA by researchers include: genetic, structured and nonstructural, and environmental exposure factors (Downery, 2016). Since obesity is under nonstructural factors, and it has been projected on this study as the major risk factor, this study adopts the nonstructural factors. The accusing finger at obesity as a major risk factor has been attributed to adipose tissue deposition of the tongue, enlargement of the neck circumference, and lateral walls of the pharynx (Pang & Tucker, 2013). Environmental exposures that can cause OSA are allergens (Downey, 2017). Halperin (2014) postulated that nocturnal environmental noise also had adverse health outcomes and could influence biological systems as well. Schwartz, Vinnikov, and Blanc (2017) asserted that OSA has been associated with occupational solvent exposure.

Risk Factors of OSA

Genetic

A growing body of evidence had shown that genetic factor was linked to OSA. Genetic factors relating to neural control of the upper airway, body fat distribution, and craniofacial structure have been shown to make OSA more pronounced (Center for Sleep Disorder, 2014). Researchers say that about 40% of the discrepancy on AHI might be due to the genetic factors. Evidence has shown that family members might have similar type of sleep apnea which confirmed that OSA was hereditary. Genetic determinants of OSA can be noticeable through craniofacial structures such as oral cavities, face, and skull (Sleep Apnea Treatment Center of American, 2014). These genetic features are responsible for people being predisposed to OSA syndrome. Chi et al. (2014) asserted that craniofacial structures were associated with OSA.

Structural and Nonstructural

Several structural factors are associated with the pharyngeal collapse in people living with OSA. Some structural factors include: inferior displacement of the hyoid, mandibular hypoplasia, and innate anatomic variations (Downey & Rowley, 2016). The craniofacial bony anatomy is considered under structural factor of OSA as well as the tonsillar hypertrophy, and the deformities of the jaw (Winokur & Kamath). The deviated nasal septum, polyps, tumors, and the nasal obstruction are all anatomical abnormalities grouped under structural factors (Winokur & Kamath, 2015). The non-structural factors include: obesity, age, male gender; smoking, alcohol, and sedatives prior to the hours of sleep (Loo et al 2015).

Diagnosis of OSA

The management of OSA first starts with proper diagnosis, and then followed by determining the level of severity (Strohl, Collop, & Finley, 2016). A formal physical examination should be done by a physician who will check the mouth, neck, and throat. If the physician suspects OSA, a polysomnography test would be requested. Because OSA is associated with adverse health outcomes, early diagnosis is paramount. A well-known test for OSA diagnosis is the polysomnography (PSG) which is done overnight in a sleep center, and it provides information based on the severity of the OSA and the extent of the sleep fragmentation (Su, Chen, Chen, Wang, & Hsiao, 2012). The American College of Physicians (ACP) provided a guideline for the screening and diagnosis of adult OSA, and recommended that sleep study should be done on patients who had unintentional manifestation of daytime sleepiness (Qaseem et al., 2014).

This test requires an overnight sleep attendant who must be effective in measuring upper airway air flows as well as the respiratory events (Su et al., 2012). Subsequent diagnostic test is the Home Sleep Apnea Testing (HSAT) which can also be called out-of- center testing or portable monitoring. The test is less expensive than the PSG, and requires no sleep study personnel attendant. In order to properly access daytime sleepiness and fatigue, clinicians use Epworth Sleepiness Scale (ESS) because patients often mistake the two symptoms (Strohl et al., 2016).

Treatment of OSA

The functional changes associated with obstructive sleep apnea are complicated, and that makes the treatment options confusing (Sengul, 2013). In a study conducted by Williams et al., (2014), the authors explicated that African Americans had increased prevalence of OSA, and hardly inclined to taking treatments in comparison to whites. When treating OSA, the goal is to reduce or eradicate nocturnal apneic events and the intermittent hypoxia (Spicuzza et al., 2015). There are numerous treatment methods OSA patients use to manage the disease such as Continuous Positive Airway Pressure (CPAP), oral therapy (Mandibular Advancement Devices), clinical surgeries, and weight loss. There is a treatment therapy called Upper Airway Stimulation (UAS) for those who are unable to use CPAP (American Sleep Apnea Association, 2015). Since this disease impacts the brain, heart, and the general health badly, immediate treatment is highly necessary.

CPAP

Although there are several optional ways of managing OSA, individual factors impact the use of CPAP for treatment. Sullivan et al. (1981) recommended CPAP as a treatment therapy for OSA. CPAP has been clinically proven to be safe although not tolerated by many patients. The reasons for non-compliance by some patients are due to the discomfort of the nose or face mask, pressures, and side effects (Virk & Kotecha, 2016). Several researchers have ascertained that CPAP has shown its effectiveness in minimizing symptoms and reducing health issues associated with OSA (Spicuzza et al., 2015; Watson, 2014).

CPAP works by delivering air to the airway at the hour of sleep through a face or nasal mask with a connection of tube to the pump (Sutherland et al., 2015). In other words, the machine is used by a patient through nasal or oronasal mask as a pneumatic support which aids in giving positive pressure to the upper airway; thereby, preventing the collapse of the pharyngeal airway (Spicuzza et al., 2015). CPAP is always recommended if the AHI is above 5 or below 15, and especially with patients exhibiting mood disorders, impaired cognition, and daytime sleepiness (Spicuzza et al., 2015). Virk and Kotecha (2016) stated that data from randomized controlled trials and meta-analyses confirmed the efficacy of CPAP. Evidence showed that OSA commercial drivers who were on CPAP therapy for treatment experienced 73% improvement in their driving (Carstensen, 2016).

Oral Devices

Oral devices are recommended for people who are living with OSA and for people who are not OSA patients, but have episodes of snoring (Ramar et al., 2015). For people living with OSA, the level of severity has to be mild to moderate and the patient has to comply with the dentist's directions for the devices to be effective (American Sleep Association, 2016; Ritchey, 2014)). The American Academy of Sleep Medicine (AASM) and American Academy of Sleep Dental Medicine (AASDM) formed a task force to provide guidelines for the usage of oral devices to treat OSA and snoring (Ramar et al). The aim of forming the task force was to foster quality treatment outcomes, and to minimize potential harms (Ramar et al., 2015). Ramar et al. (2015) emphasized that for an OSA patient to accomplish a complete, effective, and efficient treatment, a sleep physician must be involved with collaboration from a sleep dentist, a physician for ear, nose & throat (ENT), and a primary physician. Surgery is another treatment method, and more effective to reduce snoring than OSA (American Sleep Apnea Association, 2015).

Surgery

There are several types of surgical approaches for OSA patients such as Uvulopalatopharngngoplasty, craniofacial reconstruction, and tracheostomy (Downey & Mosenifar, 2016). Surgery is recommended for patients showing severe symptoms of OSA who could not tolerate or use CPAP, and had tried oral device without favorable outcome. The clinicians use surgical approaches to widen the upper airway (Weaver & Kapur, 2016). Although surgery is one of the recommended treatments, several researches have warned about the risk associated with it. Shin et al., (2016) warned about the postoperative respiratory problems that might require the OSA patient to use non-invasive ventilation. A report by the American Society of Anesthesiologists has shown that OSA patients were at risk for preoperative complications (Olson, Chung, & Seet, 2016). Documented evidence has shown that physicians face challenge of not knowing the part of the upper airway that was causing the obstruction (American Sleep Apnea Association, 2015). There are other types of surgeries an OSA patient may seek to reduce weight. A classic example of such surgeries is the laparoscopic gastric banding.

This surgery reduces the quantity of food one eats through a band that a surgeon will place on the upper part of the stomach (U. S. Library of Medicine, 2016).

Weight Loss

Weight loss is another recommended treatment for OSA. Treatment goals under weight loss aims at involvement in a structured exercise program, decrease in food intake, and behavioral modification (Strohl et al., 2016). Sengul (2013) mentioned that other authors have shown that reducing weight through exercise by OSA patients solely depended on the individual 's ability to lose weight. Researchers have shown that recommendation of weight loss and exercise for OSA patients living with obesity enhanced quality of life, decreased apnea hypopnea index (AHI), and reduced hypertension (Strohl et al. 2016). Empirical evidence has shown that sleep deprivation limited the metabolism which slowed the process of losing weight in some cases of obesity. Clinicians believed that when OSA is controlled and patients start getting better sleep, the hormone levels that impacted body weight would be stabilized (National Sleep Foundation, 2016).

Impact of OSA

Obstructive sleep apnea impacts patients and the general public in different ways. OSA is associated with daytime sleepiness although there are myriad of medical and non-medical issues that can cause daytime sleepiness. The frequent arousal associated with OSA leads to sleep deprivation which causes daytime sleepiness and fatigue. From a clinical perspective, OSA has been linked to motor vehicle accidents due to excessive daytime sleepiness (Garbarino et al., 2016; Slater & Steier, 2012). In a study conducted by Garbarino et al (2016), the authors confirmed that OSA was implicated as a factor to motor vehicle accidents and near miss accidents among truck drivers.

Health Impact of OSA

OSA leads to cardiovascular disease health issues such as heart attack; heart failure, arrhythmias, stroke, and high blood pressure (American Sleep Apnea Association, 2016; Qaseem et al., 2014; The National Institute of Health, 2012). The leading cause of death among men and women in the United States is cardiovascular diseases (Agarwal, 2012). A recent study showed that there was association between OSA and cardiovascular diseases, and that the adults younger than 70 years were at high risk of cardiovascular disease mortality especially if they were living with OSA (Franklin and Lindberg, 2015). OSA has also been associated with limitation on interpersonal relationships, lack of efficiency concerning school or work capabilities, and the tendency to involve in accidents (Gildeh, Drakatos, Higgins, Rosenzweig, & Kent, 2016). Researchers have established that excessive daytime sleepiness was associated with impaired cognitive function. However, empirical evidence showed that the use of continuous positive airway pressure can remedy the impairment (Emamian et al., 2016). In addition to cognitive impairment, OSA is also associated with neuropsychological impairment which has been attributed to brain structural changes (Sankri-Tarbichi, 2012).

OSA elevates systemic inflammatory processes, and this can lead to enlarged prostate thereby causing frequent night urination (Khan, 2015). This disease is also associated with sexual dysfunction both in males and females. In men, OSA has been linked to several comorbidities such as chronic prostatitis, urinary incontinence; prostate cancer, urinary calculi, and erectile dysfunction (Chung, Hung, Lin, Tsai & Kao, 2016). Khan (2015) ascertained that although OSA was associated with sexual dysfunction in women, there was no association between the severity of OSA and the severity of sexual dysfunction. In a study where the relationship between OSA and neurocognitive function among Hispanics was examined, the authors found that OSA was associated with sleep deprivation, cognitive impairment, and dementia (Gonzalez et al., 2014). Data from epidemiological studies showed that OSA was associated with endocrine disorders such as hypogonadotropic, acromegaly, hypogonadism, and hypercortisolism. These diseases could contribute to secondary osteoporosis and bone loss (Chakhtoura, Nasrallah, & Chami, 2015).

A review of literature showed that the signs of cognitive impairment associated with OSA were lack of concentration, memory loss, and psychiatric disorders in certain cases (Higgins, Rosenzweig, & Kent, 2016). The American Academy of Sleep Medicine (2016) ascertained that untreated OSA affected the white matter fiber in several areas of the brain, and this resulted to impairment of mood change and daytime alertness. Some researchers through clinical and epidemiological studies have shown that about 35 % to 91 % of people living with OSA have hypertension (Olafiranye, Akinboboye, Mitchell Ogedegbe, & Louis, 2013). A review of literature by Dal Molin et al. (2016) showed that OSA was a factor on high cancer prevalence and its mortality. This disease has also been associated with abnormal glucose metabolism and metabolic syndrome (Dal Molin et al., 2016). Dewan, Nieto, and Somers (2015) stated that there was a relationship between severity of OSA and glucose intolerance which could constitute risk for diabetes.

Researchers have associated OSA with several diseases of the eyes such as optic neuropathy, eyelid syndrome, conjunctivitis; papilledema, keratitis, and keratoconus coupled with higher chances of having glaucoma than a person without OSA (Liu, Lin & Liu, 2016). OSA is deadly: awareness of the disease, early diagnosis, and treatment are crucial.

Societal Impact of OSA

The societal consequences of undiagnosed and untreated OSA are devastating. Knauert, Naik, Gillespie & Kryger (2015) confirmed that OSA could lead to serious complications, and that the health and societal consequences have placed heavy economic burden on the nation. Subsequently, there are long term sequelae such as decreased mood and low quality of life that exist among OSA patients (Peppard et al., 2013). Some researchers have claimed that low productivity, absenteeism, and work-related injuries occurred due to OSA at work places (Garbarino et al., 2016; Jurado-Gamez, Guglielmi, Gude, & Buela-Casal, 2015). This disease results to elevated motor- vehicle accidents adverse issues, and more dangerous when the cases are untreated (Kales & Straubel, 2013). Lack of timely diagnosis and treatment of OSA among patients intensify the burden on their quality of lives (Tahmasian et al., 2016).

Documented evidence has shown that OSA was the reason for several truck, train, and airplane accidents. For instance, an oil tank driver had a head-on collision with a cargo vessel which resulted to a spill of crude oil, and about 1000-11,000 barrels of oil went to a waste as a result of that accident. A follow up investigation showed that the driver was suffering from untreated OSA (Kryger, Roth, & Dement, 2017). Carstensen

(2016) reported that one third of mild to severe sleep apnea existed among commercial truck drivers. Untreated OSA commercial drivers run the risk of being excessively sleepy while driving especially people with severe OSA (National Institute for Health & Care Excellence, 2017).

OSA has impacted most companies/organizations through economic loss, absenteeism, and regulations or recommendations (Kryger, Roth & Dement, 2017). A classic example of such organization is the Federal Aviation Administration (FAA) that considers OSA as a medical condition, and requires an employee with untreated OSA to report it. Unreported case of OSA may disqualify a potential candidate for an employment or dismiss an employee with the FAA (Kryger, Roth & Dement, 2017). In 2016, it was announced that the Federal Government might require commercial truck drivers, bus drivers, and railroad employees to be tested for OSA (Carstensen, 2016).

Economic Impact of OSA

Due to the direct and indirect related costs of OSA, it is difficult to quantify the exact cost of OSA. However, the estimated cost for diagnoses and treatment of OSA in 2015 was 12. 4 billion while the estimated cost for undiagnosed OSA same year was $30 billion not including the cost from comorbidities (American College of Sleep Medicine, 2016). Because of OSA 's link to increase in cardiovascular diseases, this has led to heavy medical costs (Tarasiuk & Reuveni, 2013). It was estimated that medical costs might increase due to the link between OSA and cardiovascular diseases (Tarasiuk & Reuveni, 2013). Watson (2016) estimated that the high costs of OSA would contribute to increased health care costs up to $49.5 billion for the treatment of adults in the United States (Watson, 2016).

The use of CPAP therapy has added dent on the medical costs although studies on the cost of CPAP are limited. Garvey et al. (2015) noted that the estimated costs of CPAP were between $2.000 to $11.000 in a quality adjusted life-year (qaly). The estimated OSA cost for workplace related accidents was $6.5 billion while $26.2 was estimated for OSA motor vehicle related accidents (Watson, 2016). An evaluation of the economic impact of OSA through case control studies showed that medical costs of OSA were increased mainly on undiagnosed patients (Knuaert et al., 2015). The evaluation and diagnoses for OSA are costly both in time consuming and monetary aspect, and some insurance companies do not cover the disease. The disturbing aspect of OSA is that whether treated or untreated, the hallmark of financial burden still remains (Carstensen, 2016).

Morbidity and Mortality of OSA

One of the leading causes of morbidity and mortality in adults is OSA. Experts have shown growing body of evidence that untreated OSA could independently lead to morbidity and mortality. OSA is responsible for the increase in cardiovascular mortality and mortality especially among untreated OSA patients (Andrade and Pedrosa, 2016). Marshall et al. (2014) reported that high risk of mortality was among people suffering from moderate and severe sleep apnea. The mortality rate is more on adults over the age of 60 with 20 or more apnea episodes per hour during sleep and oxygen saturation that is less than 78 % at the hour of sleep (Sommers, 2013). Robichaud-Halle, Beaudry and

Fortin (2016) ascertained that severe OSA was linked to multimorbidity and sub-scores of multimorbidity.

Scientific evidence showed that higher mortality rate existed among OSA patients when compared with people living without the disease (Nisar et al., 2013). Accumulated empirical findings have shown that proper use of continuous positive airway pressure (CPAP) could decrease the high risk of mortality among OSA patients who were on moderate to severe stage (Vijayan, 2012). In another study, evidence showed that older people with severe OSA who were unable to use CPAP for treatment were at higher risk of mortality (Garcia et al., 2012). Early diagnosis and treatment of OSA may limit morbidity and mortality including associated consequences, and related economic burdens (Ansarin, Sahebi, & Sabu, 2013).

Adults Over Normal Weight in the United States

Overweight and obesity affects children, adolescents, and adults. In the United States, overweight/obesity is a public health concern and the increase in prevalence is resulting to increase in comorbidities. Overweight and obesity occur due to the increase in fat cells and size of the body (NIH, 2012c). Obesity is an excessive accumulation of body fat that can produce adverse health outcomes (WHO, 2016a). Obesity make adults weak and impairs their functional status (Villareal et al., 2017). Literature has shown that adult obesity reduces life expectancy among males and females especially in adults who are smokers (Bray, 2016). To combat overweight/obesity and reduce the associated comorbidities, weight loss among other things should be imperative yet some adults choose to be physically inactive (Foster-Schubert., 2012).

The measurement of adult obesity depends on the body mass index above 30 kg/m^{2}. The World Health Organization confirms obesity when a person has BMI of 30 and above, and the National Institutes of Health uses the following guidelines: 18.5-24.9 for normal weight, 25-29.9 overweight, 30-39.9 for obesity, and 40+ for extremely obese (NIH, 2012). Several researchers reported high prevalence of obesity with varying notions. Although there are other reasons for the high prevalence of overweight/obesity, some epidemiology researchers have shown that the rise was prompted by decreased interest in exercise and physical activities coupled with peoples' bad choice of diet. Between the years of 2011 and 2014, a self-reported survey on the prevalence of adult obesity showed 36.5% (crude estimate) in the United States (CDC, 2015). To reduce the prevalence of adults having abnormal weight in the United States, recommendations regarding physical activity for adults should be adhered to, and compliance must be monitored.

Adults Over Normal Weight and OSA

There are growing bodies of evidence that show a strong link of causal relationship between obesity and OSA, and obesity is a high risk factor for OSA severity. Pack (2015) asserted that one of the links between OSA and obesity was the enlargement of the tongue due to fat deposit that affected the airway. In the United States, many adults are struggling with overweight/obesity and sleep deprivation. In 2012, evidence showed that about 35% of adults were obese while up to 28% of adults had less than 6 hours of sleep at night. Epidemiological studies showed association between obesity and self-reported short duration of sleep (St-Onge, 2013). In a study of 2148 participants conducted by Cowan and Livingston (2012), obesity was more prevalent in participants living with OSA. There are numerous ways obesity can contribute to the development of OSA, and empirical evidence has shown their close interaction with each other (Cowan & Livingston, 2012). Genta et al (2014) argued that some biological mechanisms of an OSA patient such as tongue dimensions, neck conference, and pharyngeal length were associated with obesity.

Mechanisms between Obesity and OSA

It has been established that obesity led to the enlargement of upper airway soft tissue, and constituted elevation of the collapsibility of the pharyngeal airway especially in obese people with OSA (Genta at al., 2014). Researchers have also established that obesity was the architect of the narrowing and obstruction of upper airway (Tarbichi, 2012). Obesity has been linked to the attenuation of functional residual capacity (FRC) which might lead to the underlining of the pharyngeal collapsibility; thereby, reducing the tracheal traction of the pharynx. If this happens, one may develop a self-indulgence on appetite or craving (high calorie foods) that may impact sleep, and result to increase in weight (Cowan & Livingston, 2012). Although epidemiological researchers have shown that neck circumference has been implicated in the mechanism between OSA and obesity, an action from adipose tissue on the airway could also aid in the possibility of airway collapse (Mafort, Rufino, Costa, & Lopes, 2016). Since a growing body of literature has shown the close relationship of OSA and obesity; therefore, it is important to note that some genetic risk factors for obesity can be a risk factor for OSA as well (Schiza et al., 2012).

A review of literature has shown that OSA and obesity shared other associations through numerous mechanisms such as in hypogonadism, increased activity of the sympathetic nervous system (SNS), and elevated inflammation (Cowan & Livingston, 2012). In addition, Chakhtoura, Nasralla, and Chami (2015) asserted that there were shared mechanisms that existed between OSA and obesity through inflammation and hypogonadism. Although not all types of obesity contribute to OSA, the subcutaneous section of the abdomen and the torso in men are known predictors for the cause of OSA (Schiza, Bouloukaki, Siafakas, & 2012). Some researchers have speculated that weight loss in an OSA patient depended on a particular part of the body such as abdominal region (Dobrosielski, Patil, Schwartz, Bandeen-Roche, & Stewart, 2015). It is paramount to note that abdominal visceral fat could increase mechanical leads on the upper airways, and also produce pro-inflammatory cytokines which in turn projects system inflammation.

Cardiovascular Exercise

Despite many benefits associated with exercise and physical activity, older adults still stay inactive. Physical activity is a body movement that utilizes skeletal muscles, and involves energy expenditure (WHO, 2016c). Exercise is a type of physical activity that is designed with the intention to promote health and fitness (NIH, 2013). While exercise is a type of physical activity, not all physical activity constitutes an exercise (Office of Disease Prevention & Promotion, 2016). Both are body movements that can aid in reducing calories, and they are good for mental health and overall well-being among other benefits (NIH 2016). A study conducted by da Silva et al (2016) showed that lower odds of OSA could be achieved through structured physical exercise. Exercise in general aids in combating certain diseases such as heart diseases, diabetes, and hypertension (NIH, 2016).

Cardiovascular exercise is the type of physical activity that raises the heart, and makes it beat faster (American College of Sports Medicine, 2014). Cardiovascular exercise can also be referred as cardio or endurance activity, these types of exercises aid the cardiorespiratory and muscular fitness in functioning well especially when practiced in a regular basis (American College of Sports Medicine, 2014). Cardiovascular exercise is also known as aerobic exercise. Some examples of aerobic exercises include: running, brisk walking, and bicycling. Additional examples are: swimming, jumping, and rowing (American College of Sports Medicine, (2014). Aerobic exercise comprises three components that are known as intensity, frequency, and exercise. These components all together produce physical activity profile (Office of Disease Prevention and Health Promotion, 2016). Researchers have stipulated that although the three components of aerobic exercise were important, the time spent and the level of exercise performed were more important (Office of Disease Prevention and Health Promotion, 2016). Donnelly et al. (2013) evaluated the efficacy of aerobic exercise among men and women who were sedentary, overweight and obese, and discovered that supervised exercise resulted to a remarkable reduction of weight loss among them.

Researchers have through exercise training studies shown the benefits of physical activity through cardiovascular health benefits. In addition, empirical evidence has shown that people who indulged in moderate or vigorous aerobic exercise tremendously reduced the risk of cardiovascular diseases than people who were inactive. The reduction of cardiovascular diseases can be achieved by engaging in a physical activity lasting up to 150 minutes in a moderate or intensity manner in a week (Office of Disease Prevention and Health Promotion, 2016). The participants in this study were all adults and as adults age, their mitochondrial function decreases which leads to health issues. Researchers have recently reported that resistance training exercises could enhance mitochondrial functions in the skeletal muscle which might be beneficial to older adults (Ziaaldini, Hosseini, & Fathi, 2016). The human body has a mechanism through which it goes and accepts physiological changes when a physical contact is made. When one participates in a focused exercise training program, the physiological systems have a way of collaborating with the body depending on the level of the exercise.

Cardiovascular Exercise and OSA

Exercise is a known non-drug intervention that can enhance a person’s health, wellness, and sleep. The notion of using exercise as an intervention for reduction of OSA severity has not been cleared by researchers; however, Eylul (2013) claimed that exercise would facilitate weight loss which might reduce OSA. Documented evidence showed that some hindrances facing the utilization of exercise facilities and equipment by adults were due to the non-positive perceptions on traffic, proximity, and safety issues. These reasons distort the motivation to participate in physical activity or structured exercise programs (Vina et al., 2016). Moreover, epidemiological studies have shown that the impact of exercise on sleep apnea depended on a person’s body weight reduction and healthy lifestyle (Iftikhar et al., 2014). The management of OSA is very challenging to many people living with the disease especially among adults over normal weight who have trouble in their functional status (Villareal et al., 2017).

Yang et al. (2012) argued that exercise training could enhance sleep quality among middle aged and older adults. Weight loss through exercise or other means can not be over emphasized because it is beneficial to both OSA and adults over normal weight. Researchers have enumerated several benefits OSA patients could derive from physical activity/exercise training; however, the mechanism between OSA and exercise training is yet to be known (Andrade & Pedro, 2016). The gap to find a type of exercise training that may aid in reducing the severity of OSA still. Iftikhar et al. (2014) ascertained that exercise improved OSA and had also reduced the severity on central sleep apnea in patients living with chronic health failure. Beitler et al. (2014) claimed that there were several mechanisms through which OSA could diminish the ability to exercise.

All adults are encouraged to involve in activities that will strengthen all their muscle groups. Research evidence has shown that increase in risk factors for cardiovascular diseases and mortality was due to peoples' inability to engage in cardiorespiratory fitness (Swift et al., 2013). Swift et al. (2013) asserted that there was a link between cardiorespiratory fitness and reduced cardiovascular risk factors. An outdoor physical activity that included shared places where adults could interact with others has proved more beneficial in enhancing mental health (Sullivan & Pomidor, 2015).

OSA and BMI

BMI is also known as quetelet index which was named after the person who came up with the process. Adolphe Quetelet, a statistician from Belgian was the first to come up with BMI. BMI seems to be a simpler way of categorizing weight, and the measurement does not include body fat. Although BMI can be used as an indicator of high body fat and screening tool, it does not serve as a tool to diagnose body fat (CDC, 2015a). Hooper (2016) reported that the role of body weight in obstructive sleep apnea was yet to be known. A body mass index that is greater than 40 (BMI ≥40) is classified as severe obesity and it is associated with apnea (Hooper, 2016). BMI) is used to measure obesity by dividing an individual's weight in kilograms and the height in meters squared (kg/m^2) (WHO 2016a).

BMI is further classified as follows: < 18.5 (underweight), 18.5-24.9 (normal weight), 25. 0-29.9 (overweight), 30-34.9 (obesity class 1), 35-39.9 (obesity class 11), 40.0 or Higher (obesity class 11) (NIH, 2000). Langton, Nevra, Downs, and Niebuhr (2016) examined a relationship between enlistment of BMI and the development of OSA in the U.S military, and reported that individuals with higher BMI (>35) were at increased risk of having OSA.

Summary and Conclusion

Chapter 2 was centered on review of literature regarding OSA as a global issue and the theoretical constructs of the SEM. Subsequent discussions were on cardiovascular exercise, OSA, BMI, and adults over normal weight. While I was reviewing the literature on OSA, cardiovascular exercise/physical activity, and overweight/obesity, I discovered that the relationship between cardiovascular exercise participation and OSA was still unclear and no definitive exercise has been proposed for OSA patients. OSA and obesity had similar mechanisms, and had an adverse effect on health, especially if left untreated. Adults were disproportionately affected by OSA and overweight/obesity. The outcome of this study could provide better knowledge of the relationship between cardiovascular exercise participation and OSA as well as BMI and OSA.

OSA is gradually placing a debilitating burden on American adults, and comorbidities coupled with sequelae are becoming more threatening to the general public. Currently, the public health field is seriously concerned with the adverse effects of OSA. The escalating epidemic of overweight/obesity is also a global and public health concern. If adults over normal weight living with OSA can learn how to manage the disease, the severity of OSA may subside. The research design and methodology of this study were presented in chapter 3.

Chapter 3: Research Method

Introduction

The purpose of this quantitative study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA, and the relationship between BMI and OSA among adults over normal weight in the United States. The discussions in this chapter include: research design and rationale, methodological procedures, and data collection. Additional sections are the operationalization of variables, data analysis plan, and data interpretation plan. Final discussions are on threats to validity, ethical procedures, and a summary

Research Design and Rationale

Study Variables

This study had one dependent variable, two independent variables of interest, and five independent variables treated as potential confounders. The independent variables of interest in the study were total cardiovascular exercise participation per week and BMI. The exercise variables used to construct total cardiovascular exercise per week were: walking, jogging, running, and bicycling. The dependent variable was OSA. Other independent variables treated as potential confounders were: age, gender, race, neck circumference, and employment.

Table 1

Cardiovascular Exercise Variables, Unit, and Level of Measurement

Variable	Unit	Level of measurement

Bicycling duration	Minutes per week	Ratio
Jogging duration	Minutes per week	Ratio
Running duration	Minutes per week	Ratio
Walking duration	Minutes per week	Ratio
Total Cardiovascular Exercise	Minutes per week	Ratio

Table 2

Study Variables, Unit, and Level of Measurement

Variable	Unit	Level of measurement
Age	Years	Ratio
Gender		Nominal
Race		Nominal
Body mass index	Kg/m^2	Ratio
Neck circumference	cm	Ratio
Employment		Nominal

Research Design

The design for this study was cross-sectional. The cross-sectional design was suitable for this study in that the data aided in measuring or comparing the independent variable of this study against the dependent variable as well as allowed for multiple outcomes to be assessed. This design also allow researchers to control multiple confounders (Thiese, 2014). Researchers widely use the cross-sectional design because of its inexpensiveness and quickness and the ability it gives a researcher to take measurements at one point in time (Setia, 2016).). In public health, the cross-sectional study is suitable for descriptive epidemiological studies (CDC, 2012). The Cross-sectional design is also used to provide baseline information and demographic data as well as explain the sample of the study, and allows the use of multiple variables to find their relationships (Allen, 2017; Fink, 2010). This study therefore provided descriptive and predictive relationships among the variables and no cause and effect relationship was expected.

Research Questions and Hypotheses

The research questions and hypotheses associated with the study are as follows:

RQ1: Is there a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0 1$: There is no statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders.

Ha1: There is a statistically significant relationship between total cardiovascular exercise participation per week and obstructive sleep apnea among adults over normal weight in the United States while controlling for potential confounders.

RQ2: Is there a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0 2$: There is no statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

H_a2: There is a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

Methodology

Population

The target population for this study were adult patients with ages ranging from 45 to 75 who had cardiovascular disease or multiple risk factors for cardiovascular disease such as obesity. The target population were recruited from four different medical centers in three cities and states (Cleveland, OH, Baltimore, MD, and Boston, MA) of the United States, and were screened for OSA. The population consisted of 219 males and 80 females.

Sampling and Sampling Procedures

A sample is a subset of a bigger group known as a population (Fink, 2010). Quantitative study is used to measure variables and generalize findings, and this can be done through a sample from target population (Yilmaz, 2013). The original study, Heart Biomarker Evaluation in Apnea Treatment was a phase II randomized controlled trials conducted in cardiology clinical practices at four medical centers (Brigham and Women's Hospital, Boston, MA; Case Western Reserve University, Cleveland, OH; Johns Hopkins University, Baltimore, MD; and VA Boston Healthcare System, Boston, MA). Participants were randomly assigned for three interventions after baseline evaluation, a stratified permuted block design was used. The sample included three different groups of 281 adults of mixed ethnicity from 45-75 years of old who had cardiovascular diseases or multiple risk factors and screened for OSA. The intervention comprised three treatment arms: Health Lifestyle & Sleep Education (HLSE) group (n=97), Continuous Positive Airway Pressure (CPAP) group (n=90). and Nocturnal Supplementary Oxygen (NSO) group (n=94).

Inclusion Criteria

The criteria for inclusion were (a) Adults from ages 45-75, (b) Patients with documented coronary heart disease (prior myocardial infarction or coronary artery revascularization or angiographically documented >70% stenosis of a major coronary artery) or 3 or more of the following established cardiovascular risk factors such as obesity (>30 kg/m^2), hypertension (SBP >140 or DBP >90 or use of antihypertensive medication), diabetes mellitus, and people with dyslipidemia (total cholesterol >240 mg/dl, LDL >160 mg/dl, HDL <45 mg/dl or using lipid medication), and (c) Berlin questionnaire score of 2 or 3.

Exclusion Criteria

The exclusion criteria were: (a) Participants with uncontrolled of (SBP >170 or DBP >110), (b) Uncontrolled diabetes (HbA1c >9.0%), (c) Participants with resting oxyhemoglobin saturation <90%, (d) Established heart failure, (e) Participants with known myocardial infarction, coronary revascularization procedure done within 3 months, or stroke, (f) A resting oxyhemoglobin saturation of <9 %, (g) High level of somnolence with ESS, (h) Participants (females) who were expecting or planned to be with 6 months, (i) Failure to sign informed consent (j) Medical issue that could impact the ability of a participant in the study, (k) Patient currently using supplementary oxygen,

(l) Patient who used or currently using CPAP or had surgery for sleep apnea treatment, and (m) A medical issue that the researchers thought would distort the participation of the study. Additional criteria for randomization based on home sleep testing were: (1) Patients with AHI ≥15 events per hour, and (2) None of the following sleep study based exclusive criteria AHI >50 events per hour, oxyhemoglobin saturation <85% for >10% of the recording, and central apnea index >5 events per hour.

Power Analysis and Justification of Effect Size

Power analysis was used to identify sample size that was sufficient to detect an effect if there was an effect in a study (Fink, 2010). A priori G*Power 3.1.9.2 software (Faul, Erdfelder, Lang, & Buchner, 2007) was used to calculate the minimum sample size required at 80 % (0.80) power under the following assumptions: Two tailed hypothesis., odds ratio of 1.5, 40 % (0.4) of the population had severe AHI, and the other independent variables explained approximately 20 % of the variation in AHI and were drawn from a normal distribution. Under these assumptions, the minimum required sample size was 269. If I were to ignore the confounders, the minimum required sample size would have been 215.

I assumed that 40% has severe AHI which is conservative relative to the findings of Young, Peppard, & Taheri (2005) who reported that the incidence of moderate to severe sleep apnea was much higher among individuals with BMI over 25 kg/m^2 roughly 60%. Lipsey (1990) classified effect size for logistic regression in three groups: small, medium, and large. An odd ratio of 1.2 was regarded as a small size effect, 1.72 was regarded as medium size effect, and 2.48 was regarded as large size effect. In this study, I chose an odd ratio between small and medium which was 1.5 between small and medium effect size.

Recruitment, Participation, and Data Collection

Recruitment

The recruitment and data collection from NSRR on a randomized control trial study started in February 2010, and ended in September 2011. A follow -up visits for 3 months ended in January 2012. The participants signed consent form which was reviewed by the data and safety monitoring board. The initial number of participants were 5747 and after serials of inclusion and exclusion criteria considerations, 318 participants were enrolled for the study (baseline). A total of 281 (follow-up) participated in an intervention (24-hour hypertension monitoring for 12 weeks). Participants were recruited from cardiology clinical practices at four medical centers namely: Case Western Reserve University, Cleveland, OH; John Hopkins University, Baltimore, MD; Brigham and Women's Hospital, Boston, MA, and VA Boston Healthcare System, Boston, MA. The screening included completion of Epworth sleepiness scale (ESS) with scores from 0- 24, and the American Academy of Sleep Medicine's guideline was used to score the sleep studies. At baseline visit, participants received face –to - face healthy sleep and lifestyle education by the research staff. A 6 slide presentation was used and copy of the slides were given to the participants.

Participation: Group Assignment and Intervention

With a stratified permuted block design, the participants were randomized into three different treatment arms for intervention after baseline evaluation. A web based system was used for randomization. The three arms were: Health Lifestyles & Sleep Education (HLSE) group (n=97) for control arm, Health Lifestyles & Sleep Education (HLSE-0) plus (supplemental nocturnal) Oxygen for oxygen arm, and Health Lifestyles & Sleep Education (HLSE-P) plus Continuous Positive Airway Pressure treatment group (n=90) for CPAP arm. The participants received education on how to enhance sleep quality, reduce cardiovascular risk as well as how to diet and exercise. The oxygen Arm group received a stationary oxygen concentrator for night treatment at the rate of 2 liters per minute. Each of the oxygen concentrators had a meter that recorded cumulative hours that was used by the participants.

Sleep Study

The participants in CPAP Arm were given Embletta Gold portable home sleep test, a portable sleep monitor (an alternative to polysomnography) to use in their homes. The purpose of enrolling participants in a home sleep test was to check for OSA. The participants used the home test for a night and returned the monitor through mail. They were also given CPAP device, and the pressure was set at 4-20 cm of water for 7 days. Measurement from the home test airflow included: airflow, thoracic and abdominal movement, and finger pulse oximetry; body position and a 3-lead electrocardiogram. The respiratory events for the scoring of the baseline examination were done based on the American Academy of Sleep Medicine (AASM) guidelines.

Data Collection

The NSRR data were collected using forms and questionnaires such as: an eligibility form that included the inclusion and exclusion criteria, and a participation status. A medical outcomes study (SE-36) that contained 11 questions, a patient health questionnaire (PHQ-9) that contained 9 questions, and a health questionnaire that contained 54 questions on sleep and health history. Additionally, a physical measurement form that contained 8 headings, a final visit health questionnaire that contained 27 questions, and participant/removal form that had 3 headings were all used for data collection. A berlin sleep questionnaire was also used to screen the eligible participants for OSA. The questionnaire was based on three sections regarding risk of sleep apnea: cessation of breathing and snoring, somnolence, and obesity or hypertension. For assessment of sleepiness, an Epworth sleepiness scale was used. A Heartbeat baseline visit health questionnaire was used to assess how long the subjects participated in physical/exercise activity in a month. From the local sites, data were downloaded and taken to the central sleep reading center, Case Western Reserve University, Cleveland, OH where it was scored by a single certified scorer.

Access to NSRR Data

To gain access to NSRR secondary data, I had to request access online for full dataset. The online request for retrieval of the dataset required an individual to include some personal information, reason for the use of dataset, and detailed information on the proposed study. I requested for approval to use the NSRR secondary data in August 23, 2017, and I received approval to use the secondary data on August 30, 2017.

Instrumentation

Instruments used in the original study from NSRR included: Berlin questionnaire with three categories of questions on the risk of sleep apnea, snoring, cessation of breathing, daytime sleepiness, obesity or hypertension which was used to assess participants with risk of OSA. CPAP device was given to participants on CPAP group during the 12-week intervention. ESS was used to screen participants for daytime sleepiness. A stationary oxygen concentrator was given to the group that received supplementary oxygen for night treatment during intervention. Three- lead electrocardiography was the instrument used to monitor the participants' hearts. A portable sleep monitor was used for sleep test in the participants' respective homes.

Operationalization of Variables

Operationalization is a research methodological process when using a quantitative method that defines variables, shows their measurement, and how variables are used in the study (Allen, 2017). All the variables used in this study were not measured as was shown on tables 1 and 2 rather they were measured as categorical variables.

Cardiovascular Exercise Participation

For the purpose of this study, cardiovascular exercise participation was measured as a categorical variable. Hours performed by each participant were changed to minutes (number of hours multiple by 60) and added to minutes walked per day to obtain total minutes walked per day. I then multiplied total minutes walked per day with number of days walked per week to obtain total minutes walked per week. After using the 4 exercise variables the same way (walking, jogging, running & bicycling), cardiovascular exercise was categorized into 3 levels 0 (no exercise), 0.1-200 minutes per week (moderate exercise), and >200 minutes per week (heavy exercise).

BMI

In this study, BMI was used to measure obesity, and was treated as a categorical variable with three classifications: overweight, obese, and extremely obese. The categories used were from the NIH as mentioned in Chapter 2. However, normal weight was excluded due to insufficient data.

AHI

AHI was used to measure the severity of OSA, and was treated as a categorical variable. The AHI categories used in this study was moderate and severe because mild and very severe categories did not have sufficient observation to be treated as a category by themselves; therefore, were not included in the analysis. The 5 observations on mild AHI were combined with individuals who reported moderate AHI. One individual had very severe AHI. Since the data was insufficient to be treated as a category, it was condensed to severe AHI category.

Age

Age was used as a sociodemographic variable, and measured as a categorical variable. Age had three categories: 45-54, 55-64, 65 or older. The participants' age range used for this study was from 45-75. Age was included in the bivariate logistic regressions analysis to evaluate the relationship between age and the two levels of AHI (moderate & severe) and was included in the multivariate as a potential confounder.

Gender

Gender was a sociodemographic variable and measured as a categorical variable. Gender was categorized as male and female. Gender was included in the bivariate logistic regressions analysis to evaluate the relationship between gender and the two levels of AHI (moderate & severe). It was also included in the multivariate analysis as a potential confounder

Race

Race was a sociodemographic variable that was measured as a categorical variable, and grouped as white and non-white. This variable categorization was created due to the distribution of race within the dataset. Expanding race categories was not a possibility. The relationship between race and the two levels of AHI (moderate & severe) were examined using bivariate logistic regressions analysis. Race was included in the multivariate logistic regressions analysis as a potential confounder.

Neck Circumference

Neck circumference was measured as a categorical variable and categorized into 3 levels (<40.5 cm, 40.5-43.5 cm, & >43.5 cm). The relationship between neck circumference and the two levels of AHI (moderate & severe) was examined by conducting bivariate logistic regressions analysis. Neck circumference was also included in multivariate logistic regressions analysis as a potential confounder.

Employment

Employment was included in the analysis as a socioeconomic variable. It was measured as a categorical variable, and was group into two: employed and unemployed. The relationship between employment and the two levels of AHI (moderate & severe) was examined in bivariate logistic regressions analysis. Employment was included in multivariate logistic regressions analysis as a potential confounder.

Data Analysis Plan

The purpose of this quantitative study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA as well as the relationship between BMI and OSA among overweight adults in the United States. The analysis was done using two AHI groupings (moderate and severe AHI). Secondary data from NSRR was used.

The secondary data used for this study was not collected for this study, so before data analysis, data screening and cleaning were done. Erroneous data entries could distort analysis, so data screening and cleaning were necessary (Hussein, 2016). The data were imported in an excel spread sheet for analysis through a statistical software SPSS version 25. Descriptive statistics was done and reported with corresponding proportions of moderate and severe AHI along with 95% confidence intervals. The statistical test chosen for the main analysis was logistic regression. Logistic regression was used to estimate the odds ratios and no adjustment was done for multiple hypotheses because only two hypotheses were tested.

Handling of Missing Values

While conducting a research, missing values do occur and the handling is dependent on the reason for the data being missing, and the amount of data missing (Institute of Health & Care Research, 2015). The percentage of the missing data rate was less than 10%, so no type of imputation was needed. If the percentage of the missing data was more than 10%, multiple imputation would have been implemented (Cheema, 2014). The analysis stated with 318 individuals. After dropping individuals with information missing on any of the variables of interest, the final sample contained 299 individuals. Dropping individuals with missing information was the same as case wise deletion, whereby only cases that did not have missing values were included in the analysis (Kang, 2013). Since the minimum required sample size for this study was 269, a sample of 299 was sufficient to produce a valid result.

Research Questions and Hypotheses

The research questions and hypotheses associated with the study are as follows:

RQ1: Is there a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0 1$: There is no statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders.

Ha1: There is a statistically significant relationship between total cardiovascular exercise participation per week and obstructive sleep apnea among adults over normal weight in the United States while controlling for potential confounders.

RQ2: Is there a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0$2: There is no statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

H_a2: There is a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

Interpretation of Results

Since all the variables in the study were categorized, frequency distribution was used to describe the characteristics of the sample. Bivariate logistic regression analysis was done to assess the relationship of all variables with moderate and severe AHI. Multivariate logistic regression analysis was done to adjust for potential confounders. It is imperative to note that all levels of AHI were not assessed in this study. P- value less than .05 was used both in bivariate and multivariable analyses to indicate the significance. Subsequently, significance was indicated with a star. A sign of one star (*) indicated that $P< 0.05$ for the estimate which meant that it was statistically significant at 5% level.

Threats to Validity

Although internal and external validity are important in evaluating the validity of a study, they have different concepts. Internal validity helps researchers to establish cause and effect relationship between independent and dependent variables, and external validity is the ability of a researcher to make proper generalization on target population (Frankfort-Nachmias &Nachmias, 2008; Creswell, 2009). This research sought relationship on variables that supposed to prove or refute the hypothesis, and not causal effect. Potential issues with external validity had been minimized by the selection of representative sample in the primary study where the dataset was obtained. Another issue that would have been questionable under validity was the issue of missing data, but missing data did not pose a problem during analysis. Since this study was quantitative method, deductive explanation was needed which necessitated accurate generalization (Frankfort-Nachmias & Nachmias, 2008).

Ethical Procedures

The study followed the ethical standards set by Walden University's IRB**.** I obtained Walden IRB approval prior to conducting the study. This study was conducted with secondary data on Heart Biomarker Evaluation in Apnea Treatment study from the National Sleep Research Resource (NSRR). The previous study protocol was approved by the institutional review board of each of the four institutions that participated, and the researchers strictly abided by the research protocols. The identity of the participants was not included on the dataset, and the previous researchers already provided privacy for the participants by using codes ensuring confidentiality and privacy. To have access to the data, an authorization letter was written on 8/23/17 to NSRR for DAUA, and authorization was granted on 8/30/17. There were no ethical concerns because all proper confidentiality, privacy, and IRB/ research protocols were ensured.

Summary

This study was a quantitative cross sectional, and secondary analyzed with data from NSRR. I examined the relationship between total cardiovascular exercise participation per week and OSA, and BMI and OSA among overweight adults in the United States. Because the design of this study was cross-sectional, I was able to provide a full description of the target population, the outcome variable, and the risk factors associated with the outcome variable. The detailed results of the analysis were presented in chapter 4.

Chapter 4: Results

Introduction

The purpose of this quantitative study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA as well as BMI and OSA among overweight adults in the United States. This chapter includes: data collection, results, and summary. Below were the research questions and hypotheses that were addressed during analysis.

The research questions and hypotheses associated with the study are as follows:

RQ1: Is there a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0 1$: There is no statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders.

Ha1: There is a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders.

RQ2: Is there a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0 2$: There is no statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

$H_a 2$: There is a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

Data Collection

Data collection for this study began after receiving approval from Walden University Institutional Review Board (IRB) in October 26, 2017 (#10-26-17-0177740). Secondary data from the NSRR were used to conduct this study. The secondary data for this study came from a randomized controlled trials and my interest in using the NSRR secondary data was due to the inclusion of exercise variables in the dataset. The NSRR provided two separate datasets, baseline and follow up. The data used for the analysis of this study were baseline data because they had comprehensive information regarding all the participants. Except reducing the original sample from 318 to 299 after applying case wise deletion, condensing mild and very severe categories into moderate and severe categories of AHI due to insufficient data, and removing normal category in BMI due to insufficient data as well, there were no discrepancies.

Descriptive and Demographic Characteristics of the Sample

Table 3 displays demographic and descriptive statistics for the studied sample. The variables from NSRR secondary data that were pertinent to this study were: race, age, gender, AHI, walking, jogging, running, bicycling, BMI, neck circumference, and employment. Race was categorized as white and non-white. The sample comprised of 240 (80.3%) Whites and 59 (19.7%) non-whites. The age of the participants ranged from 45 and 75 and was coded into three categories (45-54, 55-64, and 65 or older). There were 49 (16.4%) individuals in the 45-54 age group, 128 (42.8%) individuals in the 55-64 age group, and 122 (40.8%) individuals in the group 65 or older. There were 219 (73.2%) males and 80 (26.8%) females. Out of the 299 individuals who enrolled in the exercise participation, 92 (30.8%) of them participated in 0 exercise in a week, 97 (32.4%) participated in moderate exercise (0.1-200 minutes per week) while 110 (36.8%) participated in heavy exercise (>200 minutes per week).

BMI was used to measure adults who were over normal weight and was categorized into overweight, obese, and extremely obese. The categories used were classified in chapter 2. However, normal weight was excluded due to insufficient data. There were 75 (25.1%) individuals who were overweight. The individuals who fell within obese were 191 (63.9%), and 33 (11.0%) accounted for individuals who were extremely obese. Neck circumference was categorized into 3 levels. Of all the measurement of 299 individuals, 92 (30.8%) of them had neck circumference of <40.5 cm, 112 (37.5%) individuals had neck circumference ranging from 40.5-43.5 cm (36.8%) while 95 (31.8%) individuals had neck circumference of >43.5 cm. For employment, 126 (42.1%) were employed and 173 (57.9%) were unemployed.

Table 3

Demographic and Descriptive Characteristics of the Studied Sample (N=299)

Variable	n (%)
Race	
White	240 (80.3)
Non-White	59 (19.7)
Age	
45-54	49 (16.4)
55-64	128 (42.8)
65 or older	122 (40.8)
Gender	
Male	219 (73.2)
Female	80 (26.8)
AHI	
Moderate	212 (70.9)
Severe	87 (29.1)
Cardiovascular Exercise	
0 (no exercise)	92 (30.8)
0.1-200	97 (32.4)
>200	110 (36.8)
Body Mass Index	
Overweight	75 (25.1)
Obese	191 (63.9)
Extremely Obese	33 (11.0)
Neck Circumference	
<40.5	92 (30.8)
40.5-43.5	112 (37.5)
>43.5	95 (31.8)
Employment	
Employed	126 (42.1)
Unemployed	173 (57.9)

In Table 4, AHI was first grouped into four categories as was classified in chapter 2. After descriptive statistics, only 5 (1.6%) participants had mild AHI, 219 (69.3 %) participants had moderate AHI, 91(28.8%) participants had severe AHI, and only 1 (0.3) participant had very severe AHI. As a result of insufficient data, AHI was regrouped into two categories (see table 5).

Table 4

Frequency Distribution of AHI with Four Categories (N=318)

AHI Category	N (%)
Mild Apnea	5 (1.6)
Moderate Apnea	219 (69.3)
Severe Apnea	91 (28.8)
Very Severe Apnea	1 (0.3)
Total*	316

*The difference between the total and the 318 sample size was due to missing data.

After using case-wise deletion to remove the missing data, the sample was reduced from 318 to 299. Table 5 shows the frequency distribution of the AHI regrouped into 2 categories moderate and severe with 299 individuals. There were 212 (70.9%) individuals with moderate AHI and 87 (29.1%) individuals with severe AHI.

Table 5

Frequency Distribution of AHI with Two Categories (N=299)

AHI Category	N (%)
Moderate	212 (70.9)
Severe	87 (29.1)

Sample Representation of the Population

This study was conducted with a secondary data from the NSRR. The target population of the study were patients between 45 and 75 years of age who were under cardiologist care and who met all inclusion criteria. The sample was representative of the target population who were under the care of cardiologists in Massachusetts, Ohio, and Maryland where the NSRR study was conducted. Going by the inclusion criteria of the study which includes adult patients who had cardiovascular disease or multiple risk factors for cardiovascular disease such as obesity; the sample was representative of the target population based on the above-mentioned points.

Bivariate Logistic Regression Analysis with Moderate and Severe AHI

Table 6 shows the result from bivariate logistic regressions. The bivariate logistic regressions analysis was done to examine whether there was a statistically significant relationship between each of the independent variables and being diagnosed with severe AHI without adjusting for any potential confounders. Gender had no relationship with AHI. Being a male relative to being a female, did not affect the odds of transiting from moderate to severe AHI. Race had relationship with AHI. Being non-white relative to being white increased the odds (UOR= 2.7, CI: 1.3-5.7) of having severe AHI. In terms of age, being in age group of 55-64 relative to being in the age group 45-55, did not increase the odds of having severe AHI. Being in age group 65 or older relative to age 45-55 increased the odds (UOR= 3.3, CI: 1.4-7.7) of having severe AHI.

Cardiovascular exercise participation per week had no statistical relationship with AHI. Among individuals who exercised moderately (0.1-2.0) minutes per a week relative to those who did not exercise, there was no effect on the odds of having severe AHI. Among individuals who exercised more than 200 (>200) minutes per a week relative to no exercise there was no effect on the odds of having severe AHI. Body mass index had no relationship with AHI. Being obese did not affect the odds of having severe AHI relative to the base group (overweight). Relative to being overweight, obese had no effect on the odds of having severe AHI. Neck circumference had no relationship with AHI. Relative to the base group (<40.5), having a neck circumference between 40.5- 43.5 did not have a statistically significant effect on the odds of having severe AHI. Having a neck circumference of over 43.5, did not affect the odds of having severe AHI relative to the base group (<40.5). Employment did not have statistical relationship with AHI. Being employed relative to being unemployed did not affect the odds of having severe AHI.

Table 6

Bivariate Logistic Regression of All Variables with Moderate & Severe AHI Group

	Severe AHI vs Moderate AHI
	Unadjusted OR (95% CI)
Gender	
Male	1.4 (0.8-2.6)
Female	1.00[b]
Race*	
White	1.00[b]
Non White	2.7 (1.3-5.7) *
Age*	
45-54	1.00[b]
55-64	1.6 (0.7-3.9)
65 or older	3.3 (1.4-7.7) *
Cardiovascular Exercise	
0 (no exercise)	1.00[b]
0.1-200	1.3 (0.7-2.5)
>200	1.9 (1.0-3.5)
Body Mass Index	
Overweight	1.00[b]
Obese	0.8 (0.5-1.4)
Extremely Obese	0.5 (0.2-1.4)
Neck Circumference	
<40.5	1.00[b]
40.5-43.5	1.1 (0.6-2.1)
>43.5	1.4 (0.7-2.6)
Employment	
Employed	1.0 (0.6-1.7)
Unemployed	1.00[b]

1.00[b]: reference category *$p<0.05$

Results

Descriptive Statistics of Variables by Moderate & Severe AHI Group

Table 7 shows the descriptive characteristics of all the variables in the sample (n-299) with moderate and severe AHI categories. Column 1 shows the variables, column 2 depicts the number of individuals in the moderate AHI group, and column 2 displays the corresponding confidence interval. Column 4 shows the number of individuals in the severe AHI group while column 5 shows the corresponding confidence interval.

Table 7

Descriptive Statistics of All Variables by Moderate & Severe AHI Group

	AHI Category			
	Moderate		Severe	
	n (%)	95 % CI	n (%)	95% CI
Characteristics	212 (70.9)	65.8-76.1	87 (29.1)	24.0-34.3
Gender				
Male	151 (68.9)	63.7-74.2	68 (31.1)	25.9-36.4
Female	61 (76.3)	71.5-81.1	19 (23.8)	19.0-28.6
Race				
White	162 (67.5)	62.2-72.2	78 (32.5)	27.2-37.8
Non-White	50 (84.7)	80.6-88. 8	9 (15.3)	11.2-19.4
Cardiovascular Exercise				
0 (no exercise)	71 (77.2)	72.4-82.0	21 (22.8)	18.0-27.6
0.1-200	70 (72.2)	67.1-77.3	27 (27.8)	22.7-32.9
>200	71 (64.5)	59.1-69.9	39 (35.5)	30.1-40.9
Age				
45-54 .99	41 (83.7)	79.5-87.9	8 (16.3)	12.1-20.5
55-64 .99	97 (75.8)	71.0-80.7	31 (24.2)	19.4-29.1
65 or older	74 (60.7)	55.2-66.2	48 (39.3)	33.8-44.8
Body Mass Index				
Overweight	50 (66.7)	61.3-72.0	25 (33.3)	28.0-38.6
Obese	136 (71.2)	66.1-76.3	55 (28.8)	23.7-33.9
Extremely Obese	26 (78.8)	74.2-83.4	7 (21.2)	16.6-25.8
Neck Circumference				
<40.5	68 (73.9)	68.9-78.9	24 (26.1)	21.1-31.1
40.5-43.5	80 (71.4)	66.3-76.5	32 (28.6)	23.5-33.7
>43.5	64 (67.4)	62.1-72.7	31 (32.6)	27.3-37.9
Employment				

Employed	89 (70.6)	65.4-75.8	37 (29.4)	24.2-34.6
Unemployed	123 (71.1)	66.0-76.2	50 (28.9)	23.8-34.0

Statistical Assumptions

Logistic regression is known to be effective in analysis, but a good rule of thumb is to ensure that all assumptions are met. Initially, the proposed statistical test for this study was multinomial logistic regression because the dependent variable (OSA) had more than two categories. After careful consideration of the levels, I implemented cumulative ordinal logistic regression because of the ordered nature of the dependent variable (mild, moderate, severe). While checking for assumptions, all other assumptions were met except the assumption on proportional odd that was violated. As a result of failed assumption (proportional odd), the test for proportional odd was conducted using Brant test in SPSS. The null hypothesis stated that “the location of parameter (slope coefficient) were the same across categories”. For BMI, the test examined whether the effect of BMI was constant across all cumulative response categories of AHI. The data rejected the hypothesis at 1 % significance level (P-value .000). This was an evidence that the effect of BMI across cumulative AHI groups were not constant, and made it questionable to implement cumulative ordinal logistic regression model (estimates using cumulative ordinal logistic regression was invalid).

The Brant test is known for being sensitive to small sample size and having empty cells (some groups having small number of individuals or no observation). For this reason, I investigated in details why the assumption of proportional odds was not met. While investigating the result of the Brant test, I observed that a bivariate ordinal logistic regression where each independent variable was used as a separate repressor of interest was satisfied in all cases. This meant that the number of observations in each AHI group was likely the cause of the failure of the Brant test. There were only 5 individuals who had mild apnea and 1 individual had very severe apnea (see table 4). To overcome this, I regrouped AHI into 2 categories. The 2 categories mild and moderate were combined while severe and very severe were combined as well (see table 5). Because of the aforementioned statement on failure of Brant test and the regrouping of AHI into two, binary logistic regression was then implemented for analysis. With binary logistic regression, assumption of proportional odds is not applicable. When a researcher assumed that a dependent variable followed a logistic distribution with only two ordered categories, it would be equivalent to implementing a binary logistic regression (Bender & Gronvan, 1998).

Study Findings Per Research Question

Table 8 contains the result from the multivariate logistic regression analysis while adjusting for several potential confounders. The variables that were adjusted for included: age, gender, race, BMI, neck circumference, and employment. Cardiovascular exercise participation per week was created using (walking, jogging, running & bicycling) variables from the NSRR secondary data. Information for each of these exercises was reported using 3 variables. For example, walking time was reported as minutes walked per day, hours walked per day, and number of days walked per week. To construct a single cardiovascular exercise variable with each type of cardiovascular exercise (walking, jogging, running & bicycling), I converted hours to minutes (number of hours multiple by 60) and added that to minutes walked per day to obtain total minutes walked per day.

I then multiplied total minutes walked per day with number of days walked per week to obtain total minutes walked per week. I repeated the same procedure for each cardiovascular exercise variables used for this study. The resulting 4 variables (the total of walking, jogging, running, & bicycling in minutes per week) were then used to construct a single cardiovascular exercise (total cardiovascular exercise participation per week) variable by adding all four variables (walking, jogging, running, & bicycling in minutes per week). See more step-by-step explanation.

Step **1**: calculate total jogging in minutes per week as follows:

$$\text{jogging } \mathit{in\ minutes\ per\ week} = [(\text{jogging } \mathit{in\ hours\ per\ day} * 60) + \text{jogging } \mathit{in\ minutes\ per\ day}] * \mathit{number\ of\ days} \text{ jogged } \mathit{per\ week}$$

Step 2: calculate total walking in minutes per week as follows:

$$\mathit{Walking\ in\ minutes\ per\ week} = [(\mathit{walking\ in\ hours\ per\ day} * 60) + \mathit{walking\ in\ minutes\ per\ day}] * \mathit{number\ of\ days\ walked\ per\ week}$$

Step 3: calculate total running in minutes per week as follows:

$$\mathit{running\ in\ minutes\ per\ week} = [(\text{running } \mathit{in\ hours\ per\ day} * 60) + \text{running } \mathit{in\ minutes\ per\ day}] * \mathit{number\ of\ days} \text{ ran } \mathit{per\ week}$$

Step 4: calculate total bicycling in minutes per week as follows:

$$\text{bicycling } \mathit{in\ minutes\ per\ week} = [(\text{bicycling } \mathit{in\ hours\ per\ day} * 60) + \text{bicycling } \mathit{in\ minutes\ per\ day}] * \mathit{number\ of\ days} \text{ cycled } \mathit{per\ week}$$

Step 5: calculate cardiovascular exercise per week in minutes as follows:

$$Total\ cardiovascular\ exercise\ per\ week\ in\ munutes \\ = \text{jogging}\ in\ minutes\ per\ week + Walking\ in\ minutes\ per\ week \\ + running\ in\ minutes\ per\ week + \text{bicycling}\ in\ minutes\ per\ week$$

Cardiovascular exercise was then categorized into 3 levels: 0 (no exercise), 0.1-200 minutes per week (moderate exercise), and >200 minutes per week (heavy exercise).

RQ1

RQ1: Is there a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0 1$: There is no statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders.

$H_a 1$: There is a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United

States while controlling for potential confounders.

The findings of the RQ1 analysis were two-fold: exercising between 0.1 and 200 minutes per week was not statistically significant with AHI relative to individuals who did not exercise. Another indication from the multivariate logistic regression analysis was that exercising more than 200 minutes per week was statistically significant (AOR=2.1, CI:1.0-4.1) with AHI relative to individuals who did not exercise. From this result, doing moderate cardiovascular exercise participation per week (0.1 and 200 minutes per week) had no relationship with OSA while heavy cardiovascular exercise participation per week

(200 minutes per week) had relationship with OSA by increasing the odds of having severe AHI.

RQ2

RQ2: Is there a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders?

$H_0$2: There is no statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

H_a2: There is a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders.

Table 8 contains result from multivariate logistic regression in RQ2, and the following confounders were controlled for: age, gender, race, cardiovascular exercise, neck circumference and employment. Results from the multivariate analysis indicated that being obese relative to being overweight was not statistically significant with AHI. Being extremely obese was not statistically significant with AHI relative to being overweight.

Table 8

Multivariate Logistic Regressions of All Variables with Moderate & Severe AHI Group

	Severe AHI vs Moderate AHI
	Adjusted OR (95% CI)
Gender	
Male	0.8 (0.4-1.8)

Female	1.00[b]
Race*	
White	1.00[b]
Non-White	0.4 (0.2-0.9) *
Age*	
45-54 .99	1.00[b]
55-64 .99	1.8 (0.7-4.4)
65 or older	3.7 (1.5-9.3) *
Cardiovascular Exercise	
0 (no exercise)	1.00[b]
0.1-200	1.5 (0.7-3.0)
>200	2.1 (1.0-4.1) *
Body Mass Index	
Overweight	1.00[b]
Obese	0.8 (0.4-1.5)
Extremely Obese	0.5 (0.2-2.2)
Neck Circumference	
<40.5	1.00[b]
40.5-43.5	0.5 (0.2-1.4)
>43.5	0.6 (0.3-1.1)
Employment	
Employed	1.3 (0.7-2.2)
Unemployed	1.00[b]

1.00[b]: reference category *p<0.05

Supplementary Analysis

After the main analysis where variables walking, jogging, running, and bicycling were used to construct cardiovascular exercise participation per week, a supplementary multivariate logistic regression analysis was done to examine the relationship between each of the exercise variables separately and AHI. Multivariate logistic regression analysis results indicated no statistically significant relationship between any (individually) of the four cardiovascular exercise participation per week and AHI (see tables A1, A2, A3, & A4). The result of the supplementary analysis may not be a definite conclusion because the number of participants in each type of the exercise was small.

Table A1

Multivariate Logistic Regressions of All Variables with Moderate & Severe AHI Group on Walking

	Severe AHI vs Moderate AHI
	Adjusted OR (95% CI)
Gender	
Male	0.7 (0.4- 1.9)
Female	1.00[b]
Race*	
White	1.00[b]
Non White	0.1 (0.2-1.0)*
Age*	
45-54 .99	1.00[b]
55-64 .99	0.2 (0.7- 4.5)
65 or older	0.01 (1.5-9.2)*
Cardiovascular Exercise	
No walking	1.00[b]
Walking	0.1 (0.9-2.8)
Body Mass Index	
Overweight	1.00[b]
Obese	0.4 (0.4-1.5)
Extremely Obese	0.4 (0.2-2.0)
Neck Circumference	
<40.5	1.00[b]
40.5-43.5	0.9 (0.5-2.3)
>43.5	0.2 (0.7-4.5)
Employment	
Employed	0.5 (0.7-2.1)
Unemployed	1.00[b]

1.00[b]: reference category*p<0.05

Table A2

Multivariate Logistic Regressions of All Variables with Moderate & Severe AHI Group on Jogging

	Severe AHI vs Moderate AHI
	Adjusted OR (95% CI)
Gender	
Male	0.8 (0.4-2.0)
Female	1.00[b]
Race*	
White	1.00[b]
Non White	0.04 (0.2-0.9)*
Age*	
45-54 .99	1.00[b]

55-64 .99	0.3 (0.7-4.0)
65 or older	0.01 (1.4-8.6)*
Cardiovascular Exercise	
No jogging	1.00[b]
Jogging	0.3 (0.6-6.1)
Body Mass Index	
Overweight	1.00[b]
Obese	0.6 (0.4-1.6)
Extremely Obese	0.5 (0.2-2.1)
Neck Circumference	
<40.5	1.00[b]
40.5-43.5	1.0 (0.5-2.2)
>43.5	0.3 (0.7-4.1)
Employment	
Employed	0.471 (0.7-2.1)
Unemployed	1.00[b]

1.00[b]: reference category*p<0.05

Table A3

Multivariate Logistic Regressions of All Variables with Moderate & Severe AHI Group on Running

	Severe AHI vs Moderate AHI
	Adjusted OR (95% CI)
Gender	
Male	0.9 (0.5-2.1)
Female	1.00[b]
Race*	
White	1.00[b]
Non White	0.1 (0.2-1.0)*
Age*	
45-54 .99	1.00[b]
55-64 .99	0.3 (0.7-4.1)
65 or older	0.01 (1.4-8.2)*
Cardiovascular Exercise	
No running	1.00[b]
Running	0.4 (0.04-3.326)
Body Mass Index	
Overweight	1.00[b]
Obese	0.6 (0.4-1.6)
Extremely Obese	0.4 (0.2-1.9)
Neck Circumference	
<40.5	1.00[b]
40.5-43.5	1.0 (0.5-2.2)

>43.5	0.3 (0.7-3.9)
Employment	
Employed	0.4 (0.7-2.1)
Unemployed	1.00[b]

1.00[b]: reference category*p<0.05

Table A4

Multivariate Logistic Regressions of All Variables with Moderate & Severe AHI Group on Bicycling

	Severe AHI vs Moderate AHI
	Adjusted OR (95% CI)
Gender	
Male	1.0 (0.5-2.1)
Female	1.00[b]
Race*	
White	1.00[b]
Non White	0.1 (0.2-1.0)*
Age*	
45-54 .99	1.00[b]
55-64 .99	0.3 (0.7-4.0)
65 or older	0.01 (1.4-8.7)*
Cardiovascular Exercise	
No bicycling	1.00[b]
Bicycling	0.2 (0.7-3.6)
Body Mass Index	
Overweight	1.00[b]
Obese	0.6 (0.4-1.7)
Extremely Obese	0.5 (0.2-2.1)
Neck Circumference	
<40.5	1.00[b]
40.5-43.5	1.0 (0.5-2.2)
>43.5	0.3 (0.7-4.0)
Employment	
Employed	0.4 (0.7-2.2)
Unemployed	1.00[b]

1.00[b]: reference category*p<0.05

Summary

In this chapter, I presented the results of the analysis of the secondary data received from the NSRR. This quantitative cross sectional study was conducted by using logistic regression to analyze the research questions. Through the bivariate logistic regression analysis in RQ1, I was able to establish through analysis that cardiovascular exercise participation per week had no statistical relationship with AHI. Subsequent findings from multivariate logistic regression indicted that relative to individuals who did not participate in any cardiovascular exercise per week, exercising moderately did not affect the odds of having severe AHI while exercising heavily increased the odds of having severe AHI. In RQ2, both sets of results from the bivariate and multivariate logistic regression established that BMI did not have a statistically significant relationship with AHI.

In Chapter 5, I discuss the interpretation of the results by comparing the study findings with existing literature and incorporating the theoretical framework of the study. Additional discussion was on limitation of the study, recommendations, and social change implications of the study.

Chapter 5: Discussion, Conclusion, and Recommendation

Introduction

The purpose of this quantitative study was to assess the relationship between cardiovascular exercise participation and OSA by examining the relationship between total cardiovascular exercise participation per week and OSA as well as the relationship between BMI and OSA among adults over normal weight in the United States. Secondary data on the Heart Biomarker Evaluation in Apnea Treatment (HeartBEAT) from the NSRR were used for analysis in this study. Bivariate logistic regression analysis was done to find relationships between variables and moderate to severe AHI while multivariate logistic regression analysis was done to answer the research questions.

About 29.5 million people above the age of 30 suffer from mild to severe OSA, and about 13 million adults above the age of 30 years are living with OSA in the United States (Knuaert et al., 2015). The prevalence of OSA ranges up to 17% among the adult population in general and 49% in older adults (Senaratna et al., 2018). Ansarin et al. (2013) asserted that in comparison to developing countries, there were 26% more incidence of OSA syndrome in the United States. The health impact of OSA impairs a person's ability to effectively perform daily living activities, and older adults are disproportionately affected (Strohl, 2017).

In summary, bivariate logistic regression analysis indicted no relationship between total cardiovascular exercise participation per week and AHI while multivariate logistic regression analysis indicated that moderate cardiovascular exercise participation per week did not have relationship with AHI, but heavy cardiovascular exercise participation per week had relationship with AHI. Additional result was that bivariate logistic regression analysis had no relationship between BMI and AHI, and multivariate logistic regression analysis also indicated no relationship between BMI and AHI.

Interpretation of Findings

Secondary data from the NSRR was used to examine the relationship between total cardiovascular exercise participation per week and OSA, and the relationship between BMI and OSA among adults over normal weight in the United States. Bivariate regression analysis was done to examine whether there was a statistically significant relationship between each of the independent variables and being diagnosed with severe AHI without adjusting for potential confounders. Cardiovascular exercise participation per week had no relationship with AHI on the bivariate regression analysis, and BMI had no relationship with AHI. Multivariate logistic regression analysis was done to answer the research questions while controlling for potential confounders. It is paramount to note that AHI was used to measure the level of severity in OSA. Any result showing no relationship or relationship with AHI means no relationship or relationship with OSA.

RQ1: Is there a statistically significant relationship between total cardiovascular exercise participation per week and OSA among adults over normal weight in the United States while controlling for potential confounders?

Multivariate logistic regression analysis result showed that total cardiovascular exercise participation per week had no relationship with AHI when exercising between 0.1 and 200 minutes per week, but there was a relationship between total cardiovascular exercise per week with AHI when exercising more than (>200) minutes per a week with increased odds (AOR=2.1, CI:1.05-4.1) of having severe AHI.

Therefore, heavy cardiovascular exercise participation per week increased the odds of having severe AHI after controlling for confounders. In other words, indulging in moderate cardiovascular exercise participation neither increased nor reduced the severity of AHI. However, heavy cardiovascular exercise participation per week increased the severity of AHI.

While interpreting the results of this study and comparing it with the existing literature, RQ1 result contradicted the studies where the researchers postulated that exercise reduced the severity of OSA. This study contradicted a previous study by Kline et al. (2011) who examined the efficacy of a 12-week exercise training program to reduce the severity of OSA, improve sleep quality, and assess the mechanisms through which exercise might reduce OSA severity. Kline et al. (2011) ascertained that there was reduction in AHI and ODI without decrease in body weight. OSA should not be a hindrance to cardiovascular exercise participation because exercising can help in improving quality of life, and minimizing the risk of chronic diseases (Butner et al., 2013). Although researchers reported that exercise training could reduce the severity of OSA, Iftikhar et al. (2014) asserted that the mechanism through which exercise training enhanced OSA was still unknown.

RQ2: Is there a statistically significant relationship between BMI and OSA among adults over normal weight in the United States while controlling for potential confounders?

Both the bivariate and multivariate logistic regression analyses result showed that there was no relationship between BMI and AHI in this study. This result contradicted previous finding by Wall, Smith, and Hubbard (2012). Wall et al. (2012) assessed the relationship between BMI and OSA among adults 50 years and over in the United Kingdom, and reported that there was a relationship between BMI and OSA among people with BMI of 40+. However, the result of this study aligns with the findings by Ciavarella et al. (2018). Ciavarella et al. (2018) evaluated the relationship between BMI, AHI, mean arterial oxygen saturation, and Nadir among 75 adults, and ascertained that BMI had no relationship with AHI. Although the result of this study did not indicate relationship between BMI and AHI, a complicating relationship still exists between obesity and OSA. Bonsignore et al. (2012) asserted that researchers have been having difficulties in evaluating the roles between OSA and obesity.

Findings in Relation to the SEM

McLeroy et al. (1988) emphasized on health behavior when they proposed their version of SEM. In this study, the SEM theoretical framework was used for health behavioral change, and it helped in understanding the factors that affected the sampled population through the five factors. The expected behavioral change in this study was indulging in a structured exercise programs as well as losing weight. The findings of this study were that total cardiovascular exercise participation per week had no relationship with AHI when done moderately, but total cardiovascular exercise participation per week had relationship with AHI by increasing the severity of OSA when done in a high capacity, and that BMI had no relationship with AHI. Based on the findings of this study, the encouragement and support gained by target population on interpersonal factor of the SEM can motivate them to indulge in moderate cardiovascular exercise which will not increase the severity of OSA or discourage them from performing high levels of cardiovascular exercise because of the odds of increasing the severity of OSA.

Through this framework, the factors of SEM (intrapersonal, interpersonal, institution, community & policy) were independently assessed. Adults over normal weight understood the dangers of OSA and the need for self-empowerment in order to exercise independently, weekly, and moderately. The characteristics associated with intrapersonal factor could aid adults to see the need for behavioral change by indulging in moderate exercise programs for other health benefits. The participants of the study were adults mainly in the age range from 45 to75. With trust on any person they are working with, they will see the need to check their BMI and not worry about being judged or marginalized.

Although the finding of RQ2 showed no relationship between BMI and OSA, applying multilevel approach associated with SEM was essential to the target adults for the purpose of losing or maintaining acceptable weight. Institutional factor played integral role in peoples' lives through recognition of social norms, social identity, and values where target population can come out and mangle with friends. McElroy et al. (1988) argued that organizational influences had positive impact on health and health related behaviors. In other words, elements in institutional factors such as rules and regulations of parks, recreational centers, and work-out places can influence participants in such a way that they will maintain normal weight.

Any adult living with OSA who lacks the ability to engage in physical activities, exercise programs, or choose to maintain sedentary lifestyle can be overweight, obese, or extremely obese; therefore, being aware of the multilevel factors of SEM framework can help such adults in making informed decision. A community is a neighborhood where one resides which should be free of crimes. Adults are fragile and any threat from their social environment will definitely generate fear and hinder the motivation of taking a walk or a jog. In caring for the health of the public, public health is known for the use of policies, regulations, and procedures. Most policies are those that can control risk behaviors, promote health, or guide the allocation of resources (McElroy et al., 1988). Implementing policy/s that will bring awareness and routine check on OSA, will be integral to diagnosis. The treatment of OSA will be more successful if approached through multi-level dimensions.

Limitations of the Study

In any epidemiological study, there is always room for limitations and the same applies to this study. The major limitation associated with this study that might have affected the study result was treating continuous variables as categorical. Treating continuous variables as categorical could constitute loss of information because of cutoff issues (Ranganathan, Pramesh, & Aggarwal, 2017). Moreover, the secondary data used was not originally collected for this study. Most of the variables contained self-reported information which might have contained some errors that could have affected the validity of the findings. The questionnaires used to get data contained self-reported information, and such information might have introduced information bias.

The comparison of AHI group in this study was based on two levels (moderate and severe) of AHI which might have affected the validity of the result since all AHI groups were not compared. The sample did not contain information on normal weight, and analysis was based on three categories (overweight, obese, and extremely obese). The type of exercise used in this study might have affected the findings. This study did not seek causation, and an examination of internal validity was not evaluated. The result of this study was generalized on the target population in three states in the United States. The above mentioned limitations might have had major impact on the general outcome of the study.

Recommendations

This study was a quantitative cross-sectional where secondary data were used to examine the relationship between total cardiovascular exercise participations per week and OSA as well as between BMI and OSA among adults over normal weight in the U.S. The findings of the study indicated that total cardiovascular exercise participations per week on moderate exercise had no relationship on the severity of OSA, but heavy cardiovascular exercise per week increased the severity of OSA. Also BMI had no relationship with OSA. Based on the results, I recommend that all adults engage in physical active as stipulated on the national guidelines for adults or indulge in moderate routine exercise because cardiovascular exercise participation per week can be beneficial to their health. Since OSA is a public health concern, public health officials should propose health programs that will incorporate awareness and management of OSA.

As researchers continue to investigate the relationship between exercise and the severity of OSA, more focus should be on the type of exercises that will affect upper airway patency. They should also make known to the public the type of exercise that can attenuate the severity of OSA and the mechanisms. On the same note, more studies are needed to uncover the areas of upper airway that high BMI aggravates and the mechanisms as well. There are muscles responsible for the upper airway collapse in OSA patients. The airway patency necessitates a synchronized action of the upper airway and thoracic respiratory muscles, and researchers are yet to show the relationship between these muscles and cardiovascular exercises (Andrade & Pedrosa, 2016).

Pham and Schwartz (2015) postulated that any type of intervention that included the restoration of the airway patency, would serve as a treatment to OSA. Therefore, as researchers continue to emphasize and recommend exercise as being beneficial to OSA patients, they should also focus more on evaluating cardiovascular exercise participation that can influence the upper airway muscles, and define a mechanism through which cardiovascular exercise participation reduces AHI. Through the framework of this study (SEM), public health can bring awareness of OSA through multilevel approach. Understanding the multifactorial nature of OSA through the five levels of social ecological influences is pertinent to prevention and treatment regimen. Curbing misconceptions will encourage proper evaluation of OSA in future (Shaw et al., 2012).

Implication for Social Change

Through the analysis and findings of this study, clear evidence showed that the selected cardiovascular exercise participations did not have any effect on AHI with moderate cardiovascular exercise participation per week while with heavy cardiovascular exercise participation per week, it increased the odds of having severe AHI. The analysis also showed that BMI did not have relationship with AHI. The recognition of the relationships that existed through SEM (intrapersonal, interpersonal, institution, community & policy) among OSA adult patients over normal weight might have aided them in seeking a behavioral change that constituted a positive social change. After reviewing this study, OSA patients who had doubts whether cardiovascular exercise participation per week could alleviate or elevate their condition would now be well informed. Through the findings of this study, the target population may have to engage in a moderate cardiovascular exercise programs per week and avoid heavy exercise programs per week now they have better understanding of the relationship between cardiovascular exercise participation and OSA.

Behavioral change was one of the reasons for implementing SEM framework on this study, and the findings of this study could encourage behavioral change among adults over normal weight living with OSA. One of the lessons learned from the outcome of this study was the eradication of curiosity that existed prior to the study whether being overweight, obese, or extremely obese might increase the severity of OSA or whether cardiovascular exercise participation could reduce the severity of OSA. This study has eradicated such doubts or conclusions. Through this study, the health, societal, economical, and morbidity and mortality impacts of OSA were addressed, and these points can serve as guidelines for public health officials in terms of health promotion, intervention, or policy purposes for OSA awareness and education. Understanding the multifactorial nature of OSA is pertinent to prevention and treatment regimen. Curbing misconceptions of etiology and complications of OSA will encourage proper evaluation of OSA in future (Shaw et al., 2012).

Conclusion

The purpose of this study was to assess the relationship between cardiovascular exercise participation and OSA by examining total cardiovascular participation per week as well as the relationship between BMI and OSA among adults over normal weight in the U.S. Conducting this study was necessary because of the unclear views on the effect of exercise participation on OSA. The prevalence of OSA is increasing rapidly in the United States, and the impacts in various areas of peoples' lives are disturbing. One of the findings of this study confirmed that participation of moderate cardiovascular exercise per week did not increase or decrease the chances of having severe OSA; however, it showed that heavy cardiovascular exercise participation per week increased the odds of having severe OSA. Further finding also showed that BMI had no relationship with OSA among the target population. For a while, researchers have shown evidence that obesity was the major risk factor of OSA. Emerging studies are proving otherwise, and one of the outcomes of this study is an exemplary.

The disparities associated with sleep health can be remedied if adults living with OSA indulge in a behavioral change by seeking healthy sleep behaviors. Using exercise to reduce the severity of OSA is not suggested in this study based on the findings. While moderate exercise participation per week had no beneficial or harmful effects on the severity of OSA, heavy exercise participative per week increased the odds of severe AHI.

Adults over normal weight living with OSA in the United States can indulge in moderate cardiovascular exercise participations for other benefits, and not for treatment or to reduce the severity of OSA. Seeking proper treatment is highly recommended for adults over normal weight living with OSA in the United States.

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