Physical Activity Levels and Modes of Physical Activity among Canadian Adults with Obstructive Respiratory Disease

by

David C. Jagroop

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Masters of Health Sciences

in

The Faculty of Health Sciences

University of Ontario Institute of Technology

July, 2017

Physical Activity Levels and Modes of Physical Activity among Canadian Adults with Obstructive Respiratory Disease by David Jagroop

CERTIFICATE OF APPROVAL

COPYRIGHT AGREEMENT

ABSTRACT

Purpose: To investigate physical activity levels and modes of physical activity among Canadian adults with obstructive respiratory disease.

Methods: Data from respondents with self-reported asthma, chronic obstructive pulmonary disease (COPD), and a combination of asthma and COPD (CAC) from the Canadian Community Health Survey (2013) were used for analysis. Self-reported physical activity was used to categorize respondents as active or inactive. Self-reported modes of physical activity were grouped into the following categories: walking, endurance activities, recreation activities, conventional exercise, sports, and no physical activity.

Results: Adults with COPD and CAC had the lowest participation in all modes of physical activity, compared to adults without respiratory disease. Physically active adults with CAC were less likely to report hypertension than those who were inactive.

Conclusions: Physical activity levels among adults with COPD and CAC are low; while physical activity preferences in adults with asthma did not differ from the general population.

ACKNOWLEDGEMENTS

First, I would like to thank my supervisor, Dr. Shilpa Dogra, for your endless support and guidance throughout my years at the University of Ontario Institute of Technology. I am truly honoured to have you as a mentor, and I cannot thank you enough for all your efforts in shaping me into the academic I am today.

Thank you to my supervisory committee members, Dr. Mika Nonoyama and Dr. Otto Sanchez for all your guidance in helping to develop my thesis. Your time and feedback throughout my graduate studies is greatly appreciated.

Thank you to my supervisor at the Toronto Rehabilitation Institute, Dr. Susan Marzolini, for your continuous support and mentorship. Thank you so much for your encouragement, and all that you have done in helping me achieve my aspirations.

Thank you to my friends and lab-mates, Carley O'Neill and Joshua Good, for all your motivation and reassurance. You have truly made my graduate experience memorable.

Finally, a special thank you to my family, Mom, Dad, and Alicia, for your continuous support, and believing in me. Thank you for all your encouragement – I could not have done this without you.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

BMI……………Body Mass Index

CAC…………...Combination of Asthma and Chronic Obstructive Pulmonary Disease

CCHS………….Canadian Community Health Survey

CI……………...Confidence Interval

COPD………….Chronic Obstructive Pulmonary Disease

FEV_1…………...Forced Expiratory Volume in One Second

FVC……………Forced Vital Capacity

OR……………..Odds Ratio

GLOSSARY OF TERMS

Asthma	As defined by the International Classification of Diseases (IDC-11), a disease in which there is increased responsiveness of the trachea and bronchi, and reversible airflow limitation consisting of airway inflammation and/or airway constriction [1].
Body Mass Index (BMI)	Calculated as weight (kg) divided by height squared (m^2) [2].
Cardiometabolic Disease	Any chronic condition affecting the cardiovascular system including obesity, diabetes, hypertension, and cardiovascular disease [3].
Chronic Obstructive Pulmonary Disease (COPD)	As defined by the IDC-11, a disease in which there is persistent airflow limitation with partial or no reversibility, combined with chronic inflammation, mucus hypersecretion (chronic bronchitis), narrowing of the small airways, and destruction of the alveolar attachments (emphysema) [1].
Combination of Asthma and Chronic Obstructive Pulmonary Disease (CAC)	Individuals who self-report a diagnosis of both asthma and chronic obstructive pulmonary disease (both diagnosed by a health professional and lasted at least 6 months) [2].
Conventional Exercises	Exercises that are performed isotonically with or without the use of equipment [4]. Such exercises include home-based exercises, aerobic exercise classes, and weight training.
Endurance Activities	Activities that are primarily aerobic in nature such as swimming, running/jogging, cycling, and rollerblading.
Exercise	Physical activity that is planned, structured, and consists of repetitive bodily movements, with the intention of improving or maintaining physical fitness [3].

Hypertension	Individuals with seated blood pressures on two separate occasions that exceeds a systolic reading of 140mmHg or a diastolic reading of 90mmHg [3].
Physical Activity	Any bodily movement produced by skeletal muscles that requires energy expenditure above resting levels, and increases heart rate and breathing [5].
Physical Activity Index	As defined by the Canadian Community Health Survey, the average daily physical activity over the past 3 months, which is derived from daily energy expenditure of 22 activities (kcal/kg/day). The physical activity index consists of 3 classifications: active ($\geq$3.0kcal/kg/day), moderately active (1-5-2.9kcal/kg/day), or inactive ($\leq$1.5kcal/kg/day) [2].
Recreational Activities	Activities that individuals engage in during their free time, enjoy, and recognize as having socially redeeming values [6]. Such activities include gardening, golfing, fishing, bowling, and dance.
Self-perceived Health	As defined by the Canadian Community Health Survey, the perception of one's current health status using the following options: excellent, very good, good, fair, and poor [2].
Sports	Physical activity that is governed by formal or informal rules that involve competition against an opponent or oneself [7]. Such activities that include volleyball, basketball, ice hockey, ice skating, snowboarding/skiing, baseball, tennis, and soccer.

REFERENCES

1. *Eleventh Revision of the International Classification of Diseases* 2017, World Health Organization.
2. *Canadian Community Health Survey, a Guide to Accessing and Interpreting the Data*. 2004 ed. 2006: Health Canada.
3. Medicine, A.C.o.S., *Acsm's Guidelines for Exercise Testing and Prescription*. 2013: Lippincott Williams & Wilkins.
4. Oleksiak, V.G., *A Comparative Study of Conventional Exercise and Weight Training of College Women at Utah State University*. 1974.
5. *Csep-Physical Activity Training for Health (Csep-Path)*. 2013: Canadian Society for Exercise Physiology (CSEP).
6. Hurd, A.R. and D.M. Anderson, *The Park and Recreation Professional's Handbook*. 2010: Human Kinetics.
7. Lumpkin, A., *Physical Education and Sport: A Contemporary Introduction*. 1994: Mosby-Year Book, Inc.

CHAPTER 1: INTRODUCTION

1.1.0 THESIS INTRODUCTION

1.1.1 Prevalence and Burden of Asthma

Asthma is chronic respiratory disease that affects approximately 300 million people globally, and is projected to increase to 400 million by 2025 [1]. In fact, Canada has a high prevalence of asthma, as this disease affects 8.1% of the Canadian population [2]. In a population-based cohort study, authors report this prevalence increased by 55.1% between 1996 and 2005 in Ontario alone [3]; and will continue to increase in the adult population [4].

Asthma symptoms have been shown to create a significant burden in this population [5]. In terms of quality of life, evidence indicates that 32% of Canadians with asthma experience symptoms and use their respiratory medication at least 4 or more days per week, while 40% do not exercise at all due to their asthma [6]. Further, 45% of Canadians have not pursued certain desired activities due to their asthma [6]. In terms of health care, there were approximately 70,000 emergency room visits due to asthma attacks in Canada in 2015 [7]. This in turn, led to $2.1 billion in direct and indirect heath care costs, and this is expected to increase by at least $4 billion per year by 2030 [8].

1.1.2 Pathophysiology and Diagnosis of Asthma

According to the International Classification of Diseases (ICD-11), asthma is characterized by increased responsiveness of the trachea and bronchi, and reversible airflow limitation due to airway inflammation and/or airway constriction [9]. This is caused by direct or indirect stimuli such as exercise or allergens [5]. Once exposed to a stimuli, individuals with asthma will experience episodic flare-ups, also known as exacerbations, that consist of coughing, wheezing, shortness of breath (dyspnea), and/or chest tightness [5].

Individuals with asthma may also experience exercise-induced bronchoconstriction; which is the narrowing of the airways in response of exercise [10]. In fact, exercise-induced bronchoconstriction occurs in 80-90% of individuals with asthma [11]. There are two hypotheses to explain exercise-induced bronchoconstriction: the osmotic and the thermal hypothesis [12]. The osmotic hypothesis suggests that the increase in drying within the airways is a result of the rapid breathing that occurs during exercise [12]. This in turn, leads to the constriction of smooth muscles located in the airways [12]. The thermal hypothesis suggests that the airway begins to cool due to the rapid breathing during exercise; the rapid re-warming of the airway after exercise is thought to trigger exercise-induced bronchoconstriction [12].

The diagnosis of asthma typically requires a positive response to a reversibility test. A positive response is based on pulmonary function, which is used to determine the forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and the ratio of the two measurements. FVC is the maximum volume of air that is forcefully exhaled after full inspiration [5]. Although individuals with asthma can have FVC values that are near normal [13], an FEV_1/FVC ratio less than 80% is characteristic to this population [5]. Further, FEV_1 can be used to determine asthma severity, as individuals with >80% FEV_1 are characterized as mild, while those with 60%-80% are considered moderate, and those with <60% have severe asthma [14].

There are also various asthma phenotypes. Allergic asthma is the most recognized phenotype. It often starts in childhood and is triggered by allergens including pollen, dust, and/or mold [5]. Other phenotypes include early-onset asthma and adult-onset asthma. Early-onset asthma is characterized as developing asthma before the age of 20 [5], and is mainly due to a genetic predisposition, a family history of allergy and asthma, as well as allergic sensitization and tobacco exposure [15]. Research has shown, the abundance of *ORMDL3* at chromosome 17q21 is strongly associated with the development of early-onset asthma; thus suggesting that genetic predisposition is a significant risk factor [16]. Further, evidence shows elevated levels of immunoglobin (Ig)E is associated with allergic rhinitis and atopic dermatitis [17]. Individuals with early-onset asthma typically have higher amounts of immunoglobin (Ig)E compared to those with adult-onset asthma, therefore it is suggested allergy and atopy are also associated with the development of early-onset asthma [17]. Although some studies suggest viral respiratory infections and bacterial colonization contribute to the development of this phenotype, evidence on these potential risk factors remain unclear [15]. In terms of adult-onset asthma, this phenotype is characterized as non-allergic asthma that is developed during adulthood [5], and is due to risk factors such as persistent exposure to environmental pollutants including cigarette smoking, upper airway diseases such as chronic rhinosinusitis, obesity, and high levels of stress [15]. Persistent eosinophilic airway inflammation has also been shown to be a key characteristic of adult-onset asthma [15, 18]. Due to the exposure of noxious stimuli such as environmental pollutants, eosinophil levels increase and interact with inflammatory cells, which results in the production of cytotoxic by-products [18]. It is suggested that these cytotoxic by-products elicit the excess mucus production and bronchial hyperresponsiveness [18].

Asthma control is used to determine the level of treatment required, and is the frequency of asthma symptoms in an individual using the following criteria: 1) daytime symptoms more than twice/week, 2) night waking due to asthma, 3) relief medication needed more than twice/week, and 4) activity limitation due to asthma [5]. Those with well-controlled asthma possess none of these traits, while those with partially-controlled asthma have 1-2 traits, and uncontrolled asthma have 3-4 traits [5]. The goal of asthma treatment is to achieve good symptom control, and to minimize future risk of exacerbations for any severity or any phenotype of asthma.

1.1.3 Prevalence and Burden of COPD

Chronic obstructive pulmonary disease (COPD) affects 11.7% of individuals world-wide [19], and is expected to be the third leading cause of death by 2020 [20]. In Canada, approximately 4% of the population is diagnosed with COPD [21]. Further, COPD is the fourth most common cause of hospitalization among men, and the sixth most common cause of hospitalization among women [22]. In Canada, the annual direct and indirect cost of COPD is approximately $3,000 per patient in 2003 [23]. The burden of COPD is also significant. From a sample of Canadians with COPD, 15% reported that their mental health was fair or poor, and 14% reported being dissatisfied or very dissatisfied with their life [24]. In addition, 21% reported that their breathing problems affected their life quite a bit, or extremely, while 22% reported that they had changed their engagement in the community due to their breathing problems [24].

1.1.4 Pathophysiology and Diagnosis of COPD

According to the IDC-11, COPD is a common preventable and treatable disease, and is characterized by persistent airflow limitation with partial or no reversibility[9]. This is due to significant exposure to noxious particles or gases such as cigarette smoke, which causes chronic inflammation and mucus hypersecretion (chronic bronchitis), narrowing of the small airways, as well as destruction of the alveolar attachments (emphysema) [25]. Adverse symptoms in those with COPD are associated with increased levels of neutrophils, macrophages and their by-products (interleukin 8/IL8), as well as T lymphocytes specifically CD8 in the lungs [26]. With mild adverse symptoms, the airflow obstruction is either unchanged or slightly increased; while in severe cases, pulmonary gas exchange is impaired due to the imbalance between ventilation (hypoxia), perfusion, and respiratory muscle fatigue [26]. As a result of this imbalance, airway inflammation, mucous hypersecretion and bronchoconstriction are exacerbated [26]. Over time, hypoxia in those with COPD may also increase the risk for cardiovascular disease [27]. Hypoxia encourages elevated levels of interleukin 8, which promotes endothelial dysfunction; thus leading to increased plaque formation and the development of cardiovascular disease [27, 28].

Individuals with COPD may be at risk for cor pulmonale and right heart failure [29]. With the progression of COPD, this leads to low concentrations of oxygen in the blood (hypoxemia) and constriction on the pulmonary arteries [29]. This in turn, leads to pulmonary hypertension, which is the increase in pressure in the pulmonary arteries. With prolonged resistance and pressure, there is a greater amount of stress placed on the right ventricle, thus causing it to hypertrophy (cor pulmonale). This eventually progresses to the dilation and failure of the ventricle (right heart failure) [29]. Diagnosis is based on pulmonary function tests combined with risk factors and symptoms (35 years and older, smoking history, phlegm production, exercise-related dyspnea, and frequent colds or respiratory tract infections) [25, 30, 31]. Due to the chronic inflammation and cellular damage associated with COPD, expiratory flow is more impaired than those with asthma [13]. Thus, lower FVC values are associated with COPD, while those with asthma can have values that are near normal [13]. In COPD, FEV_1 values are also lower compared to those with asthma [13]. An FEV_1/FVC ratio less than 70% is typical in COPD [32]. FEV_1 compared to the average FEV_1 of the population, based on age and height, without respiratory disease (FEV_1 %predicted) is also used to determine the severity of COPD [33]. According to the Global Initiative for Chronic Obstructive Lung Disease, the following guidelines are used to characterize COPD with an FEV_1/FVC <70% [32]:

Severity	Lung Function
GOLD 1 (mild)	$FEV_1 \geq 80\%$ predicted
GOLD 2 (moderate)	$50\% \leq FEV_1 < 80\%$ predicted
GOLD 3 (severe)	$30\% \leq FEV_1 < 50\%$ predicted
GOLD 4 (very severe)	$FEV_1 < 30\%$ predicted

1.1.5 Prevalence, Symptoms, and Burden of CAC

Approximately 15-20% of adults with COPD present with a combination of asthma and COPD characteristics [34-36]. These individuals typically have symptoms associated with both asthma and COPD, as well as exhibit persistent, yet reversible, airflow limitation, and exertional dyspnea. [37]. However, studies have used various terms to define this condition. According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD)-Global Initiative for Asthma (GINA) report, such individuals are classified as asthma-COPD overlap syndrome; while studies have used the term asthma-COPD overlap [38, 39]. Based on a recent workshop report by the American Thoracic Society and National Heart, Lung, and Blood Institute [40], this condition does not represent a single discrete disease entity; thus, the term "CAC" for those with a combination of asthma and COPD will be used throughout this thesis.

The pathophysiology of having both diseases is also poorly understood, as there is limited evidence on the condition [37]. Due to the lack of evidence, there are no clear treatment options for this population. Thus, it is not surprising that individuals with CAC typically have more frequent exacerbations (adverse symptoms), and more severe wheezing and dyspnea than those with COPD or asthma alone [34, 36, 41, 42]. Further, this population has the highest rate of hospitalizations when compared to those with only COPD or only asthma [41, 42].

1.1.6 Physical Activity and Obstructive Respiratory Diseases

Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure above resting levels, and increases heart rate and breathing [43]. Exercise is a type of physical activity that is planned, structured, and consists of repetitive bodily movements with the intention to improve or maintain physical fitness [44].

Although exercise is a stimuli for adverse symptoms in both asthma and COPD, by following recommended guidelines, physical activity can lead to both short-term and long-term improvements in respiratory symptoms [45, 46], symptom-free days [47], self-efficacy to exercise [48], and overall quality of life [45, 46, 49]. However, research suggests poor adherence to self-directed exercise among those with asthma [45] and COPD [50, 51]. Poor adherence to physical activity, or low levels of physical activity in general, may lead to the progression of asthma and COPD, and a greater decline in general health [52-54], as well as physical deconditioning, and declines in muscle strength [55]. Given that physical activity is beneficial for adults with asthma and COPD, such interventions need to be further improved to address issues of low adherence. Future research investigating physical activity in these populations is needed to inform the development of effective exercise interventions.

1.2.0 RESEARCH OBJECTIVES AND HYPOTHESES

1.2.1 Objective 1

To determine physical activity levels, and the association between physical activity levels and cardiometabolic disease risk factors in those with asthma, COPD, and those who have CAC.

Hypothesis 1. It was hypothesized that adults with CAC would be the least physically active among those with asthma, COPD and no obstructive respiratory disease. It was further hypothesized that adults with asthma, COPD, and CAC who were inactive would be more likely to have cardiometabolic disease risk factors compared to inactive adults.

1.2.2 Objective 2

To investigate the modes of physical activity in which adults with obstructive respiratory diseases engage. Further, to explore these associations separately in males and females.

Hypothesis 2. It was hypothesized that walking would be the most preferred physical activity among adults with asthma, COPD, and CAC. It was also hypothesized that reported physical activity levels and modes of physical activity would differ in males and females with asthma, COPD, and CAC.

1.3.0 REFERENCES

1. Masoli, M., et al., *The Global Burden of Asthma: Executive Summary of the Gina Dissemination Committee Report.* Allergy, 2004. **59**(5): p. 469-478.
2. *Asthma, 2014*, in *Statistics Canada: Health Fact Sheets* 2015.
3. Gershon, A.S., et al., *Trends in Asthma Prevalence and Incidence in Ontario, Canada, 1996–2005: A Population Study.* American journal of epidemiology, 2010: p. kwq189.
4. Loftus, P.A. and S.K. Wise, *Epidemiology of Asthma.* Current opinion in otolaryngology & head and neck surgery, 2016. **24**(3): p. 245-249.
5. *Global Strategy for Asthma Management and Prevention*. 2017, Global Initiative for Asthma (GINA).
6. *Asthma Control in Canada Survey*. 2016, The Lung Association
7. *Asthma Emergency Department Visits: Volume and Median Length of Stay*. 2015, Canadian Institute for Health Information.
8. *Cost Risk Analysis for Chronic Lung Disease in Canada.* . 2012, Conference Board of Canada.
9. *Eleventh Revision of the International Classification of Diseases* 2017, World Health Organization.
10. Holley, A.B., et al., *Eucapnic Voluntary Hyperventilation Is Superior to Methacholine Challenge Testing for Detecting Airway Hyperreactivity in Nonathletes.* Journal of Asthma, 2012. **49**(6): p. 614-619.
11. Gotshall, R.W., *Exercise-Induced Bronchoconstriction.* Drugs, 2002. **62**(12): p. 1725-1739.
12. Anderson, S.D. and E. Daviskas, *The Mechanism of Exercise-Induced Asthma Is….* Journal of Allergy and Clinical Immunology, 2000. **106**(3): p. 453-459.
13. Yawn, B.P., *Differential Assessment and Management of Asthma Vs Chronic Obstructive Pulmonary Disease.* The Medscape Journal of Medicine, 2009. **11**(1): p. 20.
14. *Asthma Management Handbook* 1998, South Melbourne, Australia National Asthma Campaign.
15. de Nijs, S.B., L.N. Venekamp, and E.H. Bel, *Adult-Onset Asthma: Is It Really Different?* European Respiratory Review, 2013. **22**(127): p. 44-52.
16. Moffatt, M.F., et al., *A Large-Scale, Consortium-Based Genomewide Association Study of Asthma.* New England Journal of Medicine, 2010. **363**(13): p. 1211-1221.
17. Miranda, C., et al., *Distinguishing Severe Asthma Phenotypes: Role of Age at Onset and Eosinophilic Inflammation.* Journal of Allergy and Clinical Immunology, 2004. **113**(1): p. 101-108.
18. de Groot, J.C., A. ten Brinke, and E.H. Bel, *Management of the Patient with Eosinophilic Asthma: A New Era Begins.* ERJ open research, 2015. **1**(1): p. 00024-2015.
19. Adeloye, D., et al., *Global and Regional Estimates of Copd Prevalence: Systematic Review and Meta–Analysis.* Journal of global health, 2015. **5**(2).

20. Murray, C.J. and A.D. Lopez, *Alternative Projections of Mortality and Disability by Cause 1990–2020: Global Burden of Disease Study.* The Lancet, 1997. **349**(9064): p. 1498-1504.
21. Ernst, P., et al., *Underestimation of Copd as a Cause of Death.* Eur Respir J, 2000. **16**(Suppl 31): p. 13S.
22. *Editorial Board for Respiratory Disease in Canada*. 2001, Health Canada: Centre for Chronic Disease Prevention and Control: Ottawa, Canada.
23. Chapman, K., J. Bourbeau, and L. Rance, *The Burden of Copd in Canada: Results from the Confronting Copd Survey.* Respiratory Medicine, 2003. **97**: p. S23-S31.
24. *Fast Facts About Chronic Obstructive Pulmonary Disease (Copd): Data Compiled from the 2011 Survey on Living with Chronic Diseases in Canada*. 2012, Public Health Agency of Canada: Ottawa, Ontario.
25. *Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease*. 2017, Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD).
26. MacNee, W., *Abc of Chronic Obstructive Pulmonary Disease: Pathology, Pathogenesis, and Pathophysiology.* BMJ: British Medical Journal, 2006. **332**(7551): p. 1202.
27. McNicholas, W.T., *Chronic Obstructive Pulmonary Disease and Obstructive Sleep Apnea: Overlaps in Pathophysiology, Systemic Inflammation, and Cardiovascular Disease.* American journal of respiratory and critical care medicine, 2009. **180**(8): p. 692-700.
28. Owens, R.L. and A. Malhotra, *Sleep-Disordered Breathing and Copd: The Overlap Syndrome.* Respiratory care, 2010. **55**(10): p. 1333-1346.
29. Huether, S.E. and K.L. McCance, *Understanding Pathophysiology-E-Book*. 2015: Elsevier Health Sciences.
30. Harris, M., S. Church, and S. Agarwal, *Validity of Spirometry Performed in the Primary Care Setting.* European Respiratory Journal, 2012. **40**(Suppl 56): p. P732.
31. Schneider, A., et al., *Diagnostic Accuracy of Spirometry in Primary Care.* BMC pulmonary medicine, 2009. **9**(1): p. 1.
32. *Global Strategy for the Diagnosis, Management, and Prevention of Copd (Revised 2011)*. 2015, Global Initiative for Chronic Obstructive Lung Disease.
33. Miller, M.R., et al., *Standardisation of Spirometry.* European respiratory journal, 2005. **26**(2): p. 319-338.
34. Barrecheguren, M., C. Esquinas, and M. Miravitlles, *The Asthma–Chronic Obstructive Pulmonary Disease Overlap Syndrome (Acos): Opportunities and Challenges.* Current opinion in pulmonary medicine, 2015. **21**(1): p. 74-79.
35. Bujarski, S., et al., *The Asthma Copd Overlap Syndrome (Acos).* Current allergy and asthma reports, 2015. **15**(3): p. 1-9.
36. Kiljander, T., et al., *Prevalence of Asthma–Copd Overlap Syndrome among Primary Care Asthmatics with a Smoking History: A Cross-Sectional Study.* NPJ primary care respiratory medicine, 2015. **25**: p. 15047.
37. *Diagnosis of Diseases of Chronic Airflow Limitation: Asthma, Copd and Asthma-Copd Overlap Syndrome (Acos)*. 2015, Global Initiative for Asthma & Global Initiative for Chronic Obstructive Lung Disease.

38. Barnes, P.J., *Asthma-Copd Overlap.* CHEST Journal, 2016. **149**(1): p. 7-8.
39. Hardin, M., et al., *The Clinical Features of the Overlap between Copd and Asthma.* Respir Res, 2011. **12**(1): p. 127.
40. Woodruff, P.G., et al., *Ats-Nhlbi Asthma Copd Overlap (Aco) Workshop Report.* Am J Respir Crit Care Med, 2017.
41. Andersén, H., et al., *High Hospital Burden in Overlap Syndrome of Asthma and Copd.* The clinical respiratory journal, 2013. **7**(4): p. 342-346.
42. Menezes, A.M.B., et al., *Increased Risk of Exacerbation and Hospitalization in Subjects with an Overlap Phenotype: Copd-Asthma.* CHEST Journal, 2014. **145**(2): p. 297-304.
43. *Csep-Physical Activity Training for Health (Csep-Path)*. 2013: Canadian Society for Exercise Physiology (CSEP).
44. Medicine, A.C.o.S., *Acsm's Guidelines for Exercise Testing and Prescription*. 2013: Lippincott Williams & Wilkins.
45. Dogra, S., V. Jamnik, and J. Baker, *Self-Directed Exercise Improves Perceived Measures of Health in Adults with Partly Controlled Asthma.* J Asthma, 2010. **47**(9): p. 972-7.
46. Dogra, S., et al., *Exercise Is Associated with Improved Asthma Control in Adults.* European Respiratory Journal, 2011. **37**(2): p. 318-323.
47. Eichenberger, P.A., et al., *Effects of Exercise Training on Airway Hyperreactivity in Asthma: A Systematic Review and Meta-Analysis.* Sports Medicine, 2013. **43**(11): p. 1157-1170.
48. Hartman, J.E., et al., *Self-Efficacy for Physical Activity and Insight into Its Benefits Are Modifiable Factors Associated with Physical Activity in People with Copd: A Mixed-Methods Study.* Journal of Physiotherapy, 2013. **59**(2): p. 117-124.
49. Cambach, W., et al., *The Effects of a Community-Based Pulmonary Rehabilitation Programme on Exercise Tolerance and Quality of Life: A Randomized Controlled Trial.* European Respiratory Journal, 1997. **10**(1): p. 104-113.
50. Heerema-Poelman, A., I. Stuive, and J.B. Wempe, *Adherence to a Maintenance Exercise Program 1 Year after Pulmonary Rehabilitation: What Are the Predictors of Dropout?* Journal of cardiopulmonary rehabilitation and prevention, 2013. **33**(6): p. 419-426.
51. Singh, S.J., et al., *A Short Outpatient Pulmonary Rehabilitation Programme: Immediate and Longer-Term Effects on Exercise Performance and Quality of Life.* Respir Med, 1998. **92**(9): p. 1146-54.
52. Garcia-Aymerich, J., et al., *Physical Activity and Clinical and Functional Status in Copd.* CHEST Journal, 2009. **136**(1): p. 62-70.
53. Lucas, S.R. and T.A. Platts-Mills, *Physical Activity and Exercise in Asthma: Relevance to Etiology and Treatment.* Journal of Allergy and Clinical Immunology, 2005. **115**(5): p. 928-934.
54. Mirabelli, M.C., S.F. Beavers, and A.B. Chatterjee, *Active Asthma and the Prevalence of Physician-Diagnosed Copd.* Lung, 2014. **192**(5): p. 693-700.
55. Gosselink, R., T. Troosters, and M. Decramer, *Peripheral Muscle Weakness Contributes to Exercise Limitation in Copd.* American journal of respiratory and critical care medicine, 1996. **153**(3): p. 976-980.

CHAPTER 2: REVIEW OF THE LITERATURE

2.1.0 LITERATURE REVIEW

The following literature review will provide insight in to the cardiometabolic comorbidities of those with asthma, COPD, and a combination of asthma and COPD (CAC), as well as the benefits and barriers related to physical activity in these populations.

2.2.0 ASTHMA: CARDIOMETABOLIC COMORBIDITIES AND PHYSICAL ACTIVITY

Research shows that individuals with asthma are at greater risk for chronic comorbidities than the general population. In fact, approximately 38% of current adults with asthma are obese [1-4]. This population also tends to report worse asthma control and asthma-related quality of life [1, 5], and not surprisingly, an increased risk of cardiovascular and metabolic diseases [2-4, 6]. It is also suggested that the chronic airway inflammation associated with asthma may contribute to the systemic inflammation and increased risk of cardiovascular disease [7]. Research has shown that adults with asthma typically have higher levels of C-reactive protein, which is an inflammatory marker that induces plaque formation [7, 8]. This in turn, leads to an increased risk of cardiovascular disease[8]. These findings suggest a need for additional intervention in order to reduce the risk of additional comorbidities.

In a retrospective cohort study by Irabarren et al. [9], adults with asthma had a 1.40-fold increased likelihood of coronary heart disease (95% confidence interval (CI): 1.35,1.45), a 1.20-fold likelihood of cerebrovascular disease (95% CI: 1.15, 1.25), and 2.14-fold likelihood of heart failure (95% CI: 2.06, 2.22), compared to those without asthma. However, it was unclear from this study whether sex and the time of diagnosis played a role in the increased risk. Dogra and colleagues [2] investigated the risk of cardiovascular disease in individuals with early-onset and adult-onset asthma using cross-sectional data. Findings showed that those with asthma (early-onset and adult-onset) were 43% and 36% more likely to have heart disease (odds ratio (OR)=1.43, CI=1.19–1.72) and high blood pressure (OR=1.36, CI=1.21–1.53), respectively, compared to those without asthma [2]. Further, males with adult-onset asthma were 63% more likely to have high blood pressure than males with early-onset asthma (OR=1.63, CI=1.05–2.53) [2]. Findings from a cross-sectional study by Lee et al. [7] showed that females with adult-onset asthma were more likely to have cardiovascular disease (OR=2.4, CI=1.20–4.70) and coronary heart disease (OR=2.9, CI=1.40–6.30), respectively, compared to men with adult-onset asthma. Similar results were found in a retrospective cohort study, as females with asthma had a 1.22-fold increased hazard of coronary heart disease (95% CI: 1.14, 1.31) [10].

Evidence on the risk of stroke within this population is mixed. Dogra and colleagues reported there was no correlation between stroke and asthma [2], while other studies present the opposite [11, 12]. For example, Schanen et al. [13] reported those with asthma had a 1.43-fold increased risk of stroke (95% CI, 1.03-1.98). Dogra and colleagues did not investigate whether severity of disease influenced the risk of stroke. Thus, this may serve as a possible explanation for their results, as in a prospective cohort study by Schanen et al. [13], those with more severe respiratory symptoms had a greater risk for stroke. Severity of asthma may also increase the risk of other cardiovascular comorbidities. Using a retrospective cohort, Torén and Lindholm [14] found that females with severe asthma had higher ischemic heart disease related mortality than males with severe asthma (relative risk (RR)=2.5, 95% Cl=1.70-3.30). It is clear from the literature that the severity of disease, sex, and the time of diagnosis of asthma, all influence the risk of developing cardiometabolic comorbidities among adults with asthma.

Research clearly indicates that physical activity leads to chronic adaptations in the cardiovascular system, thus reducing the risk of comorbidities such as heart disease and hypertension [15, 16]; however physical activity levels vary considerably in those with asthma. In a cross-sectional study, Jerning et al. [17] reported no significant difference in the proportion of individuals that were physically active or inactive, when comparing those with and without asthma; while Verlaet et al [18] reported that males with controlled asthma and females with uncontrolled asthma had higher physical activity levels compared to those without asthma. Lastly, Strine et al [19] reported that those with asthma reported lower levels of physical activity compared to individuals without asthma. These mixed findings could be a result of when these studies were conducted. Previous guidelines suggested that those with asthma should take caution when engaging in physical activity [20]; while more recent guidelines encourage this population to be physically active [21]. The season of data collection may also explain these results. Regular physical activity levels may be lower in the summer due to the heat, humidity, and pollen count associated with the season; while in the winter, weather conditions such as snow, can also inhibit the ability to engage in outdoor physical activities [22]. Despite these findings, poor adherence to exercise interventions have been noted in those with asthma. In a quasi-experimental study by Dogra et al. [23], adults with partly controlled asthma participated in 12-week self-directed exercise program. The exercise program consisted of aerobic exercises, strength training, and stretches, and was individualized based on access to equipment, physical activity preferences, as well as short-term and long-term fitness goals [23]. Despite trying to account for possible barriers of physical activity, participants completed only 40% of the weekly prescribed exercises at the end of the intervention [23].

It is evident that physical activity levels and adherence need to be improved in this population in order to prevent cardiometabolic comorbidities. Future research is needed to clarify physical activity levels in this population, as well as to investigate the association between physical activity levels and cardiometabolic risk factors.

2.3.0 COPD: CARDIOMETABOLIC COMORBIDITIES AND PHYSICAL ACTIVITY

Adults with COPD have a high risk of developing comorbidities. In a systematic review by Chen et al. [24], cardiovascular disease diagnosis was higher in patients with COPD compared to healthy controls. In addition, adults with COPD were reported to have 2 to 5 times higher risk of ischemic heart disease (meta-OR=2.28, CI=1.76-2.96, $p<0.0001$), cardiac dysrhythmia (meta-OR=1.19, CI=1.55-2.43, $p<0.0001$), heart failure (OR=2.57, CI=1.90-3.27, $p<0.0001$), diseases of pulmonary circulation (OR=5.14, CI=4.07-6.50, $p<0.0001$). [24]. A possible reason for these findings, is that hallmark risk factors for cardiovascular disease including obesity [25], hypertension, and diabetes are more prevalent in adults with COPD, compared to healthy controls [24, 26]. Smoking history, advancing age, and severity of COPD may be possible reasons for the development of these risk factors.

Smoking history has been shown to be more prevalent in adults with COPD compared to the healthy population [24]. Findings from an observational longitudinal study by Miller et al. [27] reported smokers with COPD (current or ex-smokers with a smoking history of ≥10 pack years) had an increased prevalence of hypertension (p<0.001), osteoporosis (p<0.001), and anxiety (p<0.001) compared to current non-smokers (smoking history of <1 pack year) with COPD. In addition, advancing age may play a role in the development of comorbidities in adults with COPD. In a retrospective cohort study by Curkendall et al. [28], older adults with COPD had a higher prevalence of cardiovascular diseases including stroke, compared to the healthy population. In a cross-sectional, case-control study by de Lucas-Ramos et al. [29], older adults with COPD and a smoking history (65.8 ± 34.8 pack-years) had a significantly higher prevalence of ischemic heart disease (12.5%, p<0.0001), cerebrovascular disease (10%, p<0.0001), and peripheral vascular disease (16.4%, p<0.001) compared to controls without COPD [29]. Thus, it is also possible individuals with COPD possessing both traits (smoking history and increased age), may have a high risk of developing comorbidities.

Interestingly, de Lucas-Ramos and colleagues found COPD was an independent risk factor for ischemic heart disease, after adjusting for other risk factors (hypertension, diabetes, obesity and dyslipidemia) [29]. Mannino et al. [26] reported that increasing severity of lung function impairment was associated with more comorbidities in adults with COPD. In fact, individuals diagnosed with severe to very severe COPD had a higher prevalence of diabetes (OR=1.50, CI=1.10-1.90), hypertension (OR=1.60, CI=1.30-1.90) and cardiovascular disease (OR=2.4, CI=1.9-3.0) compared to healthy controls [26]. The physical deconditioning associated with COPD may explain these findings, as peripheral muscle weakness [30], muscle wasting [31], and diminished physical capacity have been shown to negatively impact physical activity levels among those with COPD [32, 33]. Research shows that adults with COPD have lower levels of physical activity than their healthy peers [34, 35]. In a literature review by Vorrink et al. [34], individuals with COPD had lower levels of physical activity duration and intensity compared to healthy controls. Therefore, it is possible that low physical activity levels contribute to the development of cardiometabolic comorbidities in this population [36].

Overall, physical activity levels need to be improved in those with COPD, in order to prevent cardiometabolic comorbidities. Future research investigating the association between physical activity levels and cardiometabolic risk factors, is needed to inform future guidelines and the development of interventions in this population.

2.4.0 CAC: CARDIOMETABOLIC COMORBIDITIES AND PHYSICAL ACTIVITY

Studies have used various terms to define individuals with both asthma and COPD [37, 38]; however, based on a recent workshop report by the American Thoracic Society and National Heart, Lung, and Blood Institute [39], this condition does not represent a single discrete disease entity. The term “CAC” will be used throughout this thesis to refer to adults who have a diagnosis of asthma and COPD.

Considering that those with asthma and COPD have an increased risk of developing cardiometabolic comorbidities, it is likely that adults with a combination of asthma and COPD also have an increased risk for cardiometabolic comorbidities. Research has shown that those with CAC experience more severe dyspnea, wheezing, and exacerbations (adverse symptoms), compared to those with asthma and COPD alone [40]. With more severe respiratory symptoms, this population may be physically inactive, thus increasing the risk of cardiometabolic comorbidities [41]. In addition, Kauppi et al. [42] reported that having a combination of asthma and COPD was associated with worse quality of life compared to those with asthma and COPD alone.

There is a dearth of research investigating the prevalence of cardiometabolic comorbidities, as well as the association between these comorbidities and physical activity in those with CAC.

2.5.0 BENEFITS OF PHYSICAL ACTIVITY IN ASTHMA

Exercise interventions typically consist of aerobic and strengthening exercises, and have been shown to benefit adults with asthma. In a quasi-experimental study, adults with partially controlled asthma participated in either a 12-week self-directed exercise program (n=12), which consisted of 30 minutes of aerobic exercise, strength training and stretching, 5 days per week, or maintained their current lifestyle habits (n=12). Authors reported improvements in perceived asthma control, as well as frequency and severity of asthma symptoms in the exercise group compared to the control group [23]. Improvements in Asthma Control Questionnaire scores were also observed in a non-randomized control trial with a larger sample size in which adults with partially controlled asthma participated in either the exercise intervention (n=21) or were directed to maintain their current lifestyle (n=15) [43]. The exercise intervention consisted of 12-

week exercise program which incorporated aerobic training, strength training 3 times per week [43]. Finally, in a randomized controlled trial by Turner and colleagues [15], older adults with moderate/severe persistent asthma participated in either a 6-week exercise intervention consisting of walking and endurance activities such as cycling, or a control program where participants continued to receive standard medical care for their asthma. As a result, improvements in asthma symptoms ($p=0.001$), quality of life ($p=0.005$), and cardiorespiratory fitness using the 6-minute walk test ($p<0.01$) were noted among participants of the exercise intervention [15]. When compared to the control group, the exercise intervention group also had significant improvements in health status (Medical Outcomes Study Short-Form 36) ($p=0.04$) [15].

Other randomized control trials consistently show improved asthma control in sedentary adults [44], adults with mild-moderate asthma [45], and adults with moderate-severe asthma and a BMI $\geq 35 kg/m^2$ [46] as a result of aerobic-based exercise interventions. As seen in Turner and colleagues' study, exercise interventions are also associated with improvements in cardiorespiratory fitness [15]. In a combined systematic review and meta-analysis, Eichenberger and colleagues [47] reviewed 67 studies including 2,059 participants, on the effects of exercise training in individuals with asthma. Significant improvements were found for exercise capacity (VO_2) compared to controls ($p<0.001$) [47]. Some studies also revealed improvements in quality of life, number of symptom-free days, and lung function [47].

It is clear from the vast amount of evidence on the benefits of exercise interventions that aerobic training and strengthening exercises are beneficial among adults with asthma. However, there is a dearth of research investigating the preferred modes of physical activity, as well as the adherence to such activities in this population. Previous exercise interventions have shown that some modes of physical activity such as swimming [45, 48], and calisthenics [48] are associated with improved cardiorespiratory fitness and are less likely to elicit exacerbations. Further research is needed to better understand the preferred modes of physical activity in this population.

2.6.0 BENEFITS OF PHYSICAL ACTIVITY IN COPD

Similar to the asthma population, exercise interventions are associated with a plethora of benefits in adults with COPD. Intervention studies report improved dyspnea [49, 50], reduced frequency of adverse symptoms [51], improved exercise capacity and muscular strength [52, 53], and quality of life [54] in adults with COPD. In a systematic review by Puhan and colleagues [55], multiple exercise interventions were shown to improve exercise capacity and cardiorespiratory fitness. More specifically, Troosters et al. [56] conducted a randomized trial with adults diagnosed with severe COPD (n=100). Participants were assigned to either a control group, or a 6-month exercise program that included cycling, walking, and strength training, 3 times a week for 1.5 hours. Following the exercise program, improvements were noted in cardiorespiratory fitness using the 6-minute walk test ($p=0.01$), and quality of life ($p=0.002$), compared to the control group [56]. In addition, improvements in muscular strength (quadriceps force) were noted among the exercise group only; however, these findings were not significant [56]. Ramponi et al. [57] also investigated individuals with severe COPD in an observational prospective trial. Individuals (n=27) participated in a pulmonary rehabilitation program consisting of cycling, and abdominal, upper and lower limb strengthening exercises for 9 weeks. Participants completed a minimum of 21 exercise sessions that were 3 hours each, 3 times per week [57]. Improvements in peak VO_2 ($p<0.05$) as well as leg fatigue ($p<0.05$) were observed [57]. Other cardiovascular parameters such as minute ventilation and tidal volume also improved post-rehabilitation [57]. Thus, Ramponi and colleagues suggested that pulmonary rehabilitation may improve cardiovascular responses to submaximal exercise [57].

Resistance-based exercise programs have been shown to improve musculoskeletal strength in individuals with COPD. Clark et al. [58] investigated the effects of a randomized controlled, 12-week resistance training program in adults with mild COPD. Results of this study reported significant improvements in muscle strength (maximum weight lifted, $p<0.02$), and quadriceps strength ($p<0.001$) compared to healthy controls. Further, improvements in whole body endurance during treadmill walking ($p<0.001$) were noted. Findings from the aforementioned studies are also solidified in a systematic review by Lacasse et al. [59]. Authors of this study conducted a systematic review of 31 randomized controlled trials and found significant improvements in quality of life scores (including dyspnea, fatigue, emotional function and mastery), exercise capacity (6-minute walk distances), as well as improvements in emotional function [59].

Lastly, exercise-based pulmonary rehabilitation programs have also been shown to provide many psychological benefits for individuals with COPD. In a systematic review, pulmonary rehabilitation programs that had an exercise component were significantly more effective in reducing short-term anxiety and depression compared to standard care [60].

Similar to the evidence from the asthma population, there are a plethora of benefits associated with exercise in those with COPD. However, there is a dearth of evidence on the association between physical activity and cardiometabolic risk factors, as well as activities this population engages in. As seen in previous studies, aerobic training and strengthening exercises are predominantly used in exercise interventions, and are associated with different benefits; but it is unclear whether this population enjoys these activities. Further research is warranted to determine the preferred modes of physical activity, and the benefits of such activities in this population.

2.7.0 BENEFITS OF PHYSICAL ACTIVITY IN CAC

Based on previous research, it is evident that physical activity provides many benefits to those with asthma and COPD. However, there is currently no research investigating physical activity in adults with CAC. Therefore, physical activity levels as well as the modes of physical activity engaged in this population require further investigation.

2.8.0 RATIONALE

It is clear that adults with asthma and COPD have a greater risk of developing cardiometabolic comorbidities. Engaging in regular physical activity has been shown to attenuate the risk of cardiometabolic comorbidities; however, evidence on physical activity levels in those with asthma are mixed, and evidence suggests that individuals with COPD are engaging in lower levels of physical activity. Individuals with CAC may also be at risk for cardiometabolic comorbidities; however, there is no research to date investigating the prevalence of cardiometabolic risk factors in this population. Further, it is unclear whether this population is physically active, as there is no evidence on physical activity levels in those with CAC. Thus, research is needed to clarify physical activity levels in those with asthma, COPD, and CAC. In addition, research is needed to better understand the association between physical activity levels and cardiometabolic risk factors in these populations. Poor adherence to physical activity has been observed in both asthma and COPD populations. Therefore, research is needed to better understand preferred modes of physical activity, in order to increase physical activity levels and adherence among those with asthma, COPD, and those with a combination of both diseases.

2.9.0 REFERENCES

1. Baffi, C.W., D.E. Winnica, and F. Holguin, *Asthma and Obesity: Mechanisms and Clinical Implications.* Asthma research and practice, 2015. **1**(1): p. 1.
2. Dogra, S., C.I. Ardern, and J. Baker, *The Relationship between Age of Asthma Onset and Cardiovascular Disease in Canadians.* Journal of Asthma, 2007. **44**(10): p. 849-854.
3. Dogra, S., J. Baker, and C.I. Ardern, *The Role of Physical Activity and Body Mass Index in the Health Care Use of Adults with Asthma.* Ann Allergy Asthma Immunol, 2009. **102**(6): p. 462-8.
4. Guerra, S., et al., *The Relation of Body Mass Index to Asthma, Chronic Bronchitis, and Emphysema.* CHEST Journal, 2002. **122**(4): p. 1256-1263.
5. Beuther, D.A. and E.R. Sutherland, *Overweight, Obesity, and Incident Asthma: A Meta-Analysis of Prospective Epidemiologic Studies.* American journal of respiratory and critical care medicine, 2007. **175**(7): p. 661-666.
6. Christiansen, S.C., et al., *Hypertension and Asthma: A Comorbid Relationship.* J Allergy Clin Immunol Pract, 2016. **4**(1): p. 76-81.
7. Lee, H.M., S.T. Truong, and N.D. Wong, *Association of Adult-Onset Asthma with Specific Cardiovascular Conditions.* Respiratory medicine, 2012. **106**(7): p. 948-953.
8. Ridker, P.M., et al., *C-Reactive Protein and Other Markers of Inflammation in the Prediction of Cardiovascular Disease in Women.* New England Journal of Medicine, 2000. **342**(12): p. 836-843.
9. Iribarren, C., et al., *Adult Asthma and Risk of Coronary Heart Disease, Cerebrovascular Disease, and Heart Failure: A Prospective Study of 2 Matched Cohorts.* American journal of epidemiology, 2012: p. kws181.
10. Iribarren, C., I.V. Tolstykh, and M.D. Eisner, *Are Patients with Asthma at Increased Risk of Coronary Heart Disease?* International journal of epidemiology, 2004. **33**(4): p. 743-748.
11. Schanen, J., et al., *Asthma and Incident Cardiovascular Disease: The Atherosclerosis Risk in Communities Study.* Thorax, 2005. **60**(8): p. 633-638.
12. Onufrak, S., J. Abramson, and V. Vaccarino, *Adult-Onset Asthma Is Associated with Increased Carotid Atherosclerosis among Women in the Atherosclerosis Risk in Communities (Aric) Study.* Atherosclerosis, 2007. **195**(1): p. 129-137.
13. Schanen, J.G., et al., *Asthma and Incident Cardiovascular Disease: The Atherosclerosis Risk in Communities Study.* Thorax, 2005. **60**(8): p. 633-8.
14. Toren, K. and N.B. Lindholm, *Do Patients with Severe Asthma Run an Increased Risk from Ischaemic Heart Disease?* Int J Epidemiol, 1996. **25**(3): p. 617-20.
15. Turner, S., et al., *Improvements in Symptoms and Quality of Life Following Exercise Training in Older Adults with Moderate/Severe Persistent Asthma.* Respiration, 2011. **81**(4): p. 302-310.
16. Cypcar, D. and R.F. Lemanske Jr, *Asthma and Exercise.* Clinics in chest medicine, 1994. **15**(2): p. 351-368.
17. Jerning, C., et al., *Asthma and Physical Activity–a Population Based Study Results from the Swedish Ga 2 Len Survey.* Respiratory medicine, 2013. **107**(11): p. 1651-1658.

18. Verlaet, A., et al., *Physical Activity in Adults with Controlled and Uncontrolled Asthma as Compared to Healthy Adults: A Cross-Sectional Study.* Clinical and translational allergy, 2013. **3**(1): p. 1.
19. Strine, T.W., L.S. Balluz, and E.S. Ford, *The Associations between Smoking, Physical Inactivity, Obesity, and Asthma Severity in the General Us Population.* Journal of Asthma, 2007. **44**(8): p. 651-658.
20. Clark, C.J. and L.M. Cochrane, *Assessment of Work Performance in Asthma for Determination of Cardiorespiratory Fitness and Training Capacity.* Thorax, 1988. **43**(10): p. 745-749.
21. *Global Strategy for Asthma Management and Prevention*. 2017, Global Initiative for Asthma (GINA).
22. Mancuso, C.A., et al., *Barriers and Facilitators to Healthy Physical Activity in Asthma Patients.* Journal of Asthma, 2006. **43**(2): p. 137-143.
23. Dogra, S., V. Jamnik, and J. Baker, *Self-Directed Exercise Improves Perceived Measures of Health in Adults with Partly Controlled Asthma.* J Asthma, 2010. **47**(9): p. 972-7.
24. Chen, W., et al., *Risk of Cardiovascular Comorbidity in Patients with Chronic Obstructive Pulmonary Disease: A Systematic Review and Meta-Analysis.* The Lancet Respiratory medicine, 2015. **3**(8): p. 631-639.
25. Zammit, C., et al., *Obesity and Respiratory Diseases.* Int J Gen Med, 2010. **3**(3): p. 335-343.
26. Mannino, D.M., et al., *Prevalence and Outcomes of Diabetes, Hypertension and Cardiovascular Disease in Copd.* European Respiratory Journal, 2008. **32**(4): p. 962-969.
27. Miller, J., et al., *Comorbidity, Systemic Inflammation and Outcomes in the Eclipse Cohort.* Respir Med, 2013. **107**(9): p. 1376-84.
28. Curkendall, S.M., et al., *Cardiovascular Disease in Patients with Chronic Obstructive Pulmonary Disease, Saskatchewan Canada: Cardiovascular Disease in Copd Patients.* Annals of epidemiology, 2006. **16**(1): p. 63-70.
29. de Lucas-Ramos, P., et al., *Chronic Obstructive Pulmonary Disease as a Cardiovascular Risk Factor. Results of a Case-Control Study (Consiste Study).* Int J Chron Obstruct Pulmon Dis, 2012. **7**: p. 679-686.
30. Franssen, F., et al., *Limb Muscle Dysfunction in Copd: Effects of Muscle Wasting and Exercise Training.* Medicine and science in sports and exercise, 2005. **37**(1): p. 2-9.
31. Debigare, R., C.H. Cote, and F. Maltais, *Peripheral Muscle Wasting in Chronic Obstructive Pulmonary Disease: Clinical Relevance and Mechanisms.* American Journal of Respiratory and Critical Care Medicine, 2001. **164**(9): p. 1712-1717.
32. Cooper, C.B., *The Connection between Chronic Obstructive Pulmonary Disease Symptoms and Hyperinflation and Its Impact on Exercise and Function.* The American journal of medicine, 2006. **119**(10): p. 21-31.
33. Gosselink, R., T. Troosters, and M. Decramer, *Peripheral Muscle Weakness Contributes to Exercise Limitation in Copd.* American journal of respiratory and critical care medicine, 1996. **153**(3): p. 976-980.
34. Vorrink, S.N., et al., *Level of Daily Physical Activity in Individuals with Copd Compared with Healthy Controls.* Respir Res, 2011. **12**(1): p. 33.

35. Pitta, F., et al., *Characteristics of Physical Activities in Daily Life in Chronic Obstructive Pulmonary Disease.* American journal of respiratory and critical care medicine, 2005. **171**(9): p. 972-977.
36. Taylor, R.S., et al., *Exercise-Based Rehabilitation for Patients with Coronary Heart Disease: Systematic Review and Meta-Analysis of Randomized Controlled Trials.* The American journal of medicine, 2004. **116**(10): p. 682-692.
37. Barnes, P.J., *Asthma-Copd Overlap.* CHEST Journal, 2016. **149**(1): p. 7-8.
38. Hardin, M., et al., *The Clinical Features of the Overlap between Copd and Asthma.* Respir Res, 2011. **12**(1): p. 127.
39. Woodruff, P.G., et al., *Ats-Nhlbi Asthma Copd Overlap (Aco) Workshop Report.* Am J Respir Crit Care Med, 2017.
40. Miravitlles, M., et al., *Characterisation of the Overlap Copd–Asthma Phenotype. Focus on Physical Activity and Health Status.* Respiratory medicine, 2013. **107**(7): p. 1053-1060.
41. Fu, J.J., et al., *Systemic Inflammation in Older Adults with Asthma-Copd Overlap Syndrome.* Allergy Asthma Immunol Res, 2014. **6**(4): p. 316-24.
42. Kauppi, P., et al., *Overlap Syndrome of Asthma and Copd Predicts Low Quality of Life.* Journal of Asthma, 2011. **48**(3): p. 279-285.
43. Dogra, S., et al., *Exercise Is Associated with Improved Asthma Control in Adults.* European Respiratory Journal, 2011. **37**(2): p. 318-323.
44. Bacon, S.L., et al., *The Effects of a Multisite Aerobic Exercise Intervention on Asthma Morbidity in Sedentary Adults with Asthma: The Ex-Asthma Study Randomised Controlled Trial Protocol.* BMJ Open, 2013. **3**(6).
45. Boyd, A., et al., *Feasibility of Exercising Adults with Asthma: A Randomized Pilot Study.* Allergy, Asthma & Clinical Immunology, 2012. **8**(1): p. 13.
46. Freitas, P.D., et al., *The Effects of Exercise Training in a Weight Loss Lifestyle Intervention on Asthma Control, Quality of Life and Psychosocial Symptoms in Adult Obese Asthmatics: Protocol of a Randomized Controlled Trial.* BMC pulmonary medicine, 2015. **15**(1): p. 124.
47. Eichenberger, P.A., et al., *Effects of Exercise Training on Airway Hyperreactivity in Asthma: A Systematic Review and Meta-Analysis.* Sports Medicine, 2013. **43**(11): p. 1157-1170.
48. Lucas, S.R. and T.A. Platts-Mills, *Physical Activity and Exercise in Asthma: Relevance to Etiology and Treatment.* Journal of Allergy and Clinical Immunology, 2005. **115**(5): p. 928-934.
49. Corhay, J.L., et al., *[Pulmonary Rehabilitation in Chronic Obstructive Pulmonary Disease]*. Rev Med Liege, 2008. **63**(11): p. 677-83.
50. Arslan, S. and G. Oztunc, *The Effects of a Walking Exercise Program on Fatigue in the Person with Copd.* Rehabil Nurs, 2016. **41**(6): p. 303-312.
51. Kon, S.S., J.L. Canavan, and W.D. Man, *Pulmonary Rehabilitation and Acute Exacerbations of Copd.* Expert Rev Respir Med, 2012. **6**(5): p. 523-31; quiz 531.
52. Gottlieb, V., et al., *Pulmonary Rehabilitation for Moderate Copd (Gold 2)--Does It Have an Effect?* Copd, 2011. **8**(5): p. 380-6.
53. Cameron-Tucker, H.L., et al., *Chronic Disease Self-Management and Exercise in Copd as Pulmonary Rehabilitation: A Randomized Controlled Trial.* Int J Chron Obstruct Pulmon Dis, 2014. **9**: p. 513-23.

54. Moullec, G., et al., *Effects of Pulmonary Rehabilitation on Quality of Life in Chronic Obstructive Pulmonary Disease Patients.* Curr Opin Pulm Med, 2011. **17**(2): p. 62-71.
55. Puhan, M.A., et al., *Respiratory Rehabilitation after Acute Exacerbation of Copd May Reduce Risk for Readmission and Mortality–a Systematic Review.* Respiratory research, 2005. **6**(1): p. 54.
56. Troosters, T., R. Gosselink, and M. Decramer, *Short-and Long-Term Effects of Outpatient Rehabilitation in Patients with Chronic Obstructive Pulmonary Disease: A Randomized Trial.* The American journal of medicine, 2000. **109**(3): p. 207-212.
57. Ramponi, S., et al., *Pulmonary Rehabilitation Improves Cardiovascular Response to Exercise in Copd.* Respiration, 2013. **86**(1): p. 17-24.
58. Clark, C., et al., *Skeletal Muscle Strength and Endurance in Patients with Mild Copd and the Effects of Weight Training.* European Respiratory Journal, 2000. **15**(1): p. 92-97.
59. Lacasse, Y., et al., *Meta-Analysis of Respiratory Rehabilitation in Chronic Obstructive Pulmonary Disease. A Cochrane Systematic Review*. 2007.
60. Coventry, P.A. and D. Hind, *Comprehensive Pulmonary Rehabilitation for Anxiety and Depression in Adults with Chronic Obstructive Pulmonary Disease: Systematic Review and Meta-Analysis.* Journal of psychosomatic research, 2007. **63**(5): p. 551-565.

CHAPTER 3: MANUSCRIPT 1

TITLE: PHYSICAL ACTIVITY AND CARDIOMETABOLIC RISK FACTORS AMONG ADULTS WITH OBSTRUCTIVE RESPIRATORY DISEASES

3.1.0 ABSTRACT

Purpose: To investigate the association between physical activity and three types of obstructive respiratory disease in adults.

Methods: Data from respondents with self-reported asthma (n=4,293), chronic obstructive pulmonary disease (COPD, n=3,118), a combination of asthma and COPD (CAC) (n=1,569), and those without an obstructive respiratory disease (n=64,175) from the Canadian Community Health Survey (2013) were used for analysis. Self-reported physical activity was used to categorize respondents as active or inactive. Self-perceived health, body mass index and physician-diagnosed hypertension were also used as outcomes.

Results: Adults with COPD and CAC were less likely to be physically active than those without a respiratory disease (COPD: OR = 0.69; CI = 0.62-0.78; CAC: OR = 0.59, CI = 0.50-0.71). Physically active adults with CAC had higher odds of good self-perceived health (OR = 2.66, CI = 1.71-4.16), and were 40% less likely to report hypertension (OR = 0.60, CI = 0.43-0.86) than those who were inactive. The odds of hypertension were the lowest among those who were active and had asthma (OR = 0.77, CI = 0.63-0.94)

Conclusions: Physical activity levels among adults with COPD and CAC are low. This may further increase their risk of cardiometabolic comorbidities.

3.2.0 INTRODUCTION

Recent research indicates that approximately 15-20% of adults with chronic obstructive pulmonary disease (COPD) present with a combination of asthma and COPD characteristics [1-3]. Studies have used various terms to define individuals with both asthma and COPD [4, 5]; however, based on a recent workshop report by the American Thoracic Society and National Heart, Lung, and Blood Institute [6], this condition does not represent a single discrete disease entity. The term "CAC" will be used throughout this thesis to refer to adults who have a diagnosis of asthma and COPD. Asthma is characterized by chronic airway inflammation and reversible airway obstruction, while those with COPD display persistent airflow limitation with partial or no reversibility [7].

COPD is the fourth most common cause of hospitalization among men, and the sixth most common cause of hospitalization among women [8]; while there were approximately 70,000 emergency room visits due to asthma attacks in Canada in 2015 [9]. However, individuals with CAC have even higher rates of hospitalizations, a greater decline in health-related quality of life, more frequent exacerbations (adverse symptoms), wheezing, and dyspnea compared to those with COPD or asthma alone [1, 3, 10, 11]. Individuals with COPD have been shown to have a higher risk of cardiometabolic conditions such as heart disease and obesity [12-14]. Similarly, individuals with asthma are more likely to have a high body mass index (BMI), and have a higher risk of cardiovascular and metabolic diseases [15-17]. Thus, those with CAC may be more likely to develop cardiometabolic disease risk factors such as hypertension or obesity [18].

Physical activity is consists of any bodily movement that is produced by skeletal muscles, requires energy expenditure above resting levels, and increases heart rate and breathing [19]. Exercise is a type of physical activity that is planned, structured, and consists of repetitive bodily movements with the intention to improve or maintain physical fitness [20]. Previous research indicates that physical activity is beneficial for those with asthma and COPD [21-23]. Among those with COPD, exercise leads to improvements in ventilatory function, respiratory discomfort, dyspnea, and hyperinflation [21, 22]. Among those with asthma, exercise leads to improvements in lung function, dyspnea, intensity of wheeze, and overall quality of life [23-25]. In addition, moderate to vigorous intensity physical activity leads to chronic adaptations in the cardiovascular system, thus reducing the risk of cardiometabolic diseases such as heart disease and hypertension [21-23, 26, 27]. However, there is a dearth of data exploring the benefits of physical activity among those with CAC.

Evidence suggests that individuals with either asthma or COPD have poor health outcomes compared to their healthy peers [28, 29]; while those with CAC have even worse health outcomes than those with asthma or COPD only [1, 7, 11]. Regular physical activity may be important for disease management and the prevention of cardiometabolic comorbidities. To our knowledge, no research to date has addressed the association between physical activity and health in this sub-group of individuals with multiple chronic obstructive respiratory diseases. Therefore, the primary purpose of this study was to investigate physical activity levels in those with asthma, COPD, and CAC, compared to those without an obstructive respiratory disease. We also sought to determine the association between physical activity levels and cardiometabolic disease risk factors in this population.

3.3.0 METHODS AND DESIGN

3.3.1 Data Source and Sample

The Canadian Community Health Survey (CCHS) is a cross sectional survey that collects information pertaining to the health determinants, health care utilization, and health status of Canadians [30]. The CCHS spans across all provinces and territories, covering an estimated 98% of the total Canadian population aged 12 years and older. It excludes individuals that were full-time members of the Canadian Forces, or those living in the Territories, on First Nation Reserves or Crown Lands, in prisons or care facilities, or in some remote areas [30]. Data for the CCHS is collected on an annual basis [30]. Respondents provided consent and participated in a telephone interview [30].

The CCHS 2011-2012 (version 1.0, 2013) was used for the present analysis (n=124 929). Only those aged 45 years and older (n=73 434), and those who responded either “yes” or “no” to the asthma and COPD questions (n= 73 155) were included. This age was chosen because COPD diagnosis is less likely to occur before 45 years [31].

The CCHS does not contain any identifiable information; thus, according to the Tri-Council Policy Statement (TCPS 2), secondary analysis of such data does not require research ethics board review.

3.3.2 Main Variables

Respiratory Disease Variables. Respondents were asked whether a healthcare professional ever told them that they have asthma. A similar question was asked regarding COPD. Respondents were instructed to consider long term diseases that had lasted for 6 months or more. Those who responded "yes" to the asthma question, and "no" to the COPD question were classified as having *asthma* (n= 4 293). Those who responded "yes" to the COPD question, and "no" to the asthma question were classified as having *COPD* (n=3 118). Those who responded "yes" to both questions were classified as having *CAC* (n= 1 569). Finally, those who responded with "no" to both questions were classified as having *no obstructive respiratory disease* (n= 64 175).

Physical Activity. The physical activity index variable, derived from daily energy expenditure levels (kcal/kg/day), was used for analysis [32]. Respondents were first asked a series of questions regarding leisure time and physical activity during the past three months [32]. A total of 22 activities were presented, varying from sports, recreational, and household activities. Respondents selected all that applied, and indicated the frequency and duration they engaged in these activities [32]. Using these responses, as well as the corresponding metabolic equivalent values, an estimated energy expenditure level was calculated (kcal/kg/day) [32]. The estimated energy expenditure levels for all activities were then summed to create the daily energy expenditure variable (kcal/kg/day) [32]. Respondents were then classified as active, moderately active and inactive based on the following cut points: $\geq$3.0 kcal/kg/day, 1.5-2.9 kcal/kg/day and < than 1.5 kcal/kg/day, respectively [32]. For the purpose of this study, these categories were recoded into *active* (active and moderately active) and *inactive*. Such self-reported physical activity recall has been shown to be valid and reliable in both a healthy population, and those with a chronic condition [33-35].

Self-perceived Health. For self-perceived health, respondents were asked “in general, how would you say your health is now?”. Response options were “excellent”, “very good”, “good”, “fair”, and “poor”. These variables were then dichotomized into *good* (excellent, very good, and good) or *poor* (fair and poor).

Hypertension. Respondents were asked whether they had high blood pressure that was diagnosed by a healthcare professional and if it was expected to last, or had already lasted for 6 or more months. Those who responded “yes” were considered to have *hypertension.*

Body Mass Index (BMI). Self-reported weight and height data were used to calculate BMI, by dividing weight in kilograms by height in metres squared [36]. BMI data were then classified as underweight (<18.5 kg/m^2), normal weight (18.5 to 24.9 kg/m^2), overweight (25 to 29.9 kg/m^2), or obese (≥ 30 kg/m^2) [36]. When used as an outcome, these categories were dichotomized into two groups: *normal* (normal weight) and *high* (overweight and obese). Self-reported weight and height has been shown to be a valid measure for estimating BMI in population based studies [37].

3.3.3 Covariates

Age, sex, and smoking history were used to describe the sample and were used as covariates in adjusted models. Age was reported in 5 year categories; these were subsequently collapsed to: middle aged adults (45 to 64 years) and older adults (65 years and older). Respondents were categorized as either daily smokers, occasional smokers or non-smokers based on self-reported current smoking.

3.3.4 Statistical Analysis

Descriptive statistics were used to calculate the frequencies of outcomes (physical activity level, self-perceived health, hypertension, and BMI) within the asthma, COPD, CAC, and no obstructive respiratory disease groups. Cross-tabulations were used to describe the groups (age and sex). Pearson Chi-squares were used to determine whether there was a relationship between type of respiratory disease and socio-demographic characteristic (age, sex, BMI, smoking history, physical activity levels and self-perceived health. Adjusted residual cut points of +1.96 to -1.96 were used to detect differences between groups; values outside this range indicated that there were significant differences ($p<0.05$) between adjacent cells.

Logistic regressions were used in to investigate the association between categorical outcomes and categorical predictors. Logistic regression analyses were conducted with physical activity, self-perceived health, hypertension, and BMI as outcomes; type of respiratory disease was the main covariate. Models were adjusted for age, sex, BMI and smoking history. Logistic regressions were also conducted using self-perceived health, hypertension, and BMI as outcomes and physical activity as the main covariate for those with asthma, COPD, and CAC. Those with no obstructive respiratory disease were used as the referent group. Models were adjusted for age, sex, BMI, and smoking history. BMI was not included in the model when BMI was used as the outcome. Individuals aged 45 years and older were included in all logistic regression analyses.

All analyses were performed using IBM SPSS Statistics V24. Population weights were rescaled, standardized and reapplied to ensure accurate measures of variance, and to eliminate the possibility of groups being over or under represented. A p-value <0.05 was considered significant.

3.4.0 RESULTS

Table 1 presents the sample characteristics of all groups. Among those with CAC, 66% were female and 68.6% were either overweight or obese. Further, in the CAC group, 69.2% were categorized as inactive compared to 64.2% and 52.2% of those with COPD and asthma, respectively.

The associations between health outcomes and obstructive respiratory disease type are presented in Table 2. Those with CAC were 41% less likely to be physically active (OR = 0.59, CI = 0.50-0.71); while those with COPD were 31% less likely to be physically active (OR = 0.69; CI = 0.62-0.78), compared to those with no obstructive respiratory disease. Those with CAC were 64% (OR = 1.64, CI = 1.38-1.94) and 86% (OR = 1.86, CI = 1.55-2.22) more likely to have hypertension and a BMI $\geq$25 kg/m^2, respectively compared to those with no obstructive respiratory disease.

The association between physical activity and health outcomes are presented in Table 3. Among those with CAC, the odds of reporting good self-perceived health were 2.7 times higher among those who were active compared to those who were inactive (OR = 2.66, CI = 1.71-4.16). The odds of hypertension were the lowest among those who were active and had asthma (OR = 0.77, CI = 0.63-0.94). Among those with COPD, and CAC, the BMI category seemed to be an important correlate for self-perceived health, and hypertension, but was not significant when used as an outcome.

3.5.0 DISCUSSION

Using data from the CCHS (2011-2012), we sought to determine associations of physical activity and type of obstructive respiratory disease. The primary finding of this study is that individuals with obstructive respiratory disease are less likely to be physically active than those who do not have an obstructive respiratory disease. More importantly, our secondary finding is that individuals with obstructive respiratory disease who were active were more likely to report better cardiometabolic outcomes than those who were inactive. To our knowledge, these findings are the first to describe health outcomes in the context of physical activity levels in those with CAC. In addition, our results may have implications for pulmonary rehabilitation programs that include physical activity, and future research related to adults with asthma-COPD overlap syndrome.

In our sample, the group with the highest proportion of inactive adults was the CAC group. This group was also 41% less likely to be active than those without an obstructive respiratory disease. Those with COPD also had lower odds of being physically active, but this trend was not noted among adults with asthma. These findings are in line with previous research. Adults with COPD have been shown to be less physically active than their healthy peers [38-41]; however, the evidence for asthma is mixed [42, 43]. A potential reason for lower physical activity levels among those with asthma, COPD and CAC is that exercise induces symptoms such as dyspnea, coughing, wheezing and fatigue [44]. This in turn affects maintenance of regular exercise. In fact, poor adherence rates have been observed in pulmonary rehabilitation programs for both asthma and COPD populations [45, 46]. Unfortunately, research indicates that physical inactivity may lead to further progression of asthma and COPD, as well as a decrease in general health [38, 47, 48]. This is in line with our findings that physically active adults with any of the three respiratory diseases had better health outcomes.

Physical activity is associated with multiple physical and psychosocial benefits that likely improve perceived and measured health [23, 49-52]. Our results show that those with CAC who were physically active had higher odds of reporting good self-perceived health compared to those who were inactive. The association observed between self-perceived health and physical activity in those with CAC has been demonstrated in other respiratory populations. In a study by Dogra and Baker [49], adults with asthma who were physically active had significantly higher self-perceived health compared to those who were inactive. Arne and colleagues [53] found that higher levels of physical activity were associated with higher ratings of self-perceived health in adults with COPD. Similarly, de Miguel Diez et al., [54] found that physical inactivity was associated with poor self-perceived health and higher health services use. Perceived health is an important indicator of quality of life [55, 56].

Physical activity has been shown to be effective for management of hypertension [57]; thus our finding that odds of hypertension were the lowest among those who were active and had asthma is not surprising This is likely due to the increase in cardiorespiratory fitness. Liu and colleagues [58] found that higher cardiorespiratory fitness was associated with better blood pressure management, and that it may delay the development of hypertension in healthy men. Studies have also shown that pulmonary rehabilitation with an exercise component leads to significant improvements in cardiorespiratory fitness [26, 59]. Thus pulmonary rehabilitation has the potential to effectively manage hypertension, and other cardiometabolic risk factors, in addition to improving pulmonary outcomes.

We also found that those with CAC were more likely to have a higher BMI compared to those with no obstructive respiratory disease. This is in line with previous research in adults with asthma and COPD [60, 61]. Somewhat surprisingly, no significant differences were observed for BMI between active and inactive adults with COPD. Nonetheless, evidence on BMI and COPD severity is inconsistent. One study reported that BMI was not statistically different across different severities of COPD [62]; while another reported those with severe COPD had a high prevalence of obesity [63]. Mitra and colleagues [61] reported an inverse relationship between severity of disease and BMI in adults with COPD; therefore, it is possible that the severity or length of time since diagnosis may impact the association between physical activity levels and BMI. Unfortunately, the CCHS does not provide information on disease severity. Thus, future research is needed to further elucidate the association between BMI and physical activity among those with CAC, as it may be an indicator of disease severity in some, and an indicator of cardiometabolic risk in others.

There are many noteworthy strengths of this study. Our findings were based on a large sample covering adults aged 45 years and older, across all provinces and territories in Canada. Population weights were modified and reapplied to correct variance estimates, and to eliminate the risk of groups being over or under represented. Further, variables such as physical activity were recoded into binary variables (*active* and *inactive)* to simplify interpretation of findings.

The main limitation of this study is that the CCHS is cross-sectional, thus, the direction of the association cannot be determined. Nevertheless, it is likely that physical activity is leading to the decreased risk of hypertension and good perceived health based on previous research using longitudinal data [64]. Secondly, since the CCHS only contains self-reported data, all variables, including physical activity levels, are subject to misclassification and recall bias. However our main variable, self-reported physical activity, has been shown to be a valid and reliable measure [34, 35, 65]. While self-reported chronic conditions may have been misclassified, the CCHS specifically asks for conditions that were diagnosed by a health professional and were expected to last, or have lasted 6 months or more, thus reducing misclassification bias. Thirdly, although the CCHS accounts for 98% of the Canadian population, the CCHS does not include individuals that were full-time members of the Canadian Forces, or those living in the Territories, on First Nation Reserves or Crown Lands, in prisons or care facilities, or in some remote areas. Therefore, such populations could not be accounted for in our analyses. Finally, the CCHS does not provide information on asthma or COPD severity, age of diagnosis, types of medications, the season of data collection, or other management variables, thus they could not be accounted for in our analyses.

In conclusion, adults with an obstructive respiratory disease are less active than those without an obstructive respiratory disease. Active adults with CAC and COPD are more likely to have better perceived health, compared to those who are inactive, and active adults with asthma had the lowest odds of hypertension and a high BMI compared to those who were inactive. These findings emphasize the continued need for pulmonary rehabilitation programs that include an exercise component for disease management and prevention of cardiometabolic comorbidities. These results also have implications for future research related to adults with asthma-COPD overlap syndrome and exercise.

3.6.0 REFERENCES

1. Barrecheguren, M., C. Esquinas, and M. Miravitlles, *The Asthma–Chronic Obstructive Pulmonary Disease Overlap Syndrome (Acos): Opportunities and Challenges.* Current opinion in pulmonary medicine, 2015. **21**(1): p. 74-79.
2. Bujarski, S., et al., *The Asthma Copd Overlap Syndrome (Acos).* Current allergy and asthma reports, 2015. **15**(3): p. 1-9.
3. Kiljander, T., et al., *Prevalence of Asthma–Copd Overlap Syndrome among Primary Care Asthmatics with a Smoking History: A Cross-Sectional Study.* NPJ primary care respiratory medicine, 2015. **25**: p. 15047.
4. Barnes, P.J., *Asthma-Copd Overlap.* CHEST Journal, 2016. **149**(1): p. 7-8.
5. Hardin, M., et al., *The Clinical Features of the Overlap between Copd and Asthma.* Respir Res, 2011. **12**(1): p. 127.
6. Woodruff, P.G., et al., *Ats-Nhlbi Asthma Copd Overlap (Aco) Workshop Report.* Am J Respir Crit Care Med, 2017.
7. Mannino, D.M., *Coexisting Asthma and Copd: Confused Clinicians or Poor Prognosticator?* CHEST Journal, 2008. **134**(1): p. 1-2.
8. *Editorial Board for Respiratory Disease in Canada*. 2001, Health Canada: Centre for Chronic Disease Prevention and Control: Ottawa, Canada.
9. *Asthma Emergency Department Visits: Volume and Median Length of Stay*. 2015, Canadian Institute for Health Information.
10. Andersén, H., et al., *High Hospital Burden in Overlap Syndrome of Asthma and Copd.* The clinical respiratory journal, 2013. **7**(4): p. 342-346.
11. Menezes, A.M.B., et al., *Increased Risk of Exacerbation and Hospitalization in Subjects with an Overlap Phenotype: Copd-Asthma.* CHEST Journal, 2014. **145**(2): p. 297-304.
12. Zammit, C., et al., *Obesity and Respiratory Diseases.* Int J Gen Med, 2010. **3**(3): p. 335-343.
13. Fabbri, L., et al., *Complex Chronic Comorbidities of Copd.* European Respiratory Journal, 2008. **31**(1): p. 204.
14. Sin, D.D. and S.P. Man, *Why Are Patients with Chronic Obstructive Pulmonary Disease at Increased Risk of Cardiovascular Diseases? The Potential Role of Systemic Inflammation in Chronic Obstructive Pulmonary Disease.* Circulation, 2003. **107**(11): p. 1514-1519.
15. Dogra, S., C.I. Ardern, and J. Baker, *The Relationship between Age of Asthma Onset and Cardiovascular Disease in Canadians.* Journal of Asthma, 2007. **44**(10): p. 849-854.
16. Dogra, S., J. Baker, and C.I. Ardern, *The Role of Physical Activity and Body Mass Index in the Health Care Use of Adults with Asthma.* Ann Allergy Asthma Immunol, 2009. **102**(6): p. 462-8.
17. Guerra, S., et al., *The Relation of Body Mass Index to Asthma, Chronic Bronchitis, and Emphysema.* CHEST Journal, 2002. **122**(4): p. 1256-1263.
18. Pleasants, R.A., et al., *Chronic Obstructive Pulmonary Disease and Asthma–Patient Characteristics and Health Impairment.* COPD: Journal of Chronic Obstructive Pulmonary Disease, 2014. **11**(3): p. 256-266.

19. *Csep-Physical Activity Training for Health (Csep-Path)*. 2013: Canadian Society for Exercise Physiology (CSEP).
20. Medicine, A.C.o.S., *Acsm's Guidelines for Exercise Testing and Prescription*. 2013: Lippincott Williams & Wilkins.
21. Cambach, W., et al., *The Effects of a Community-Based Pulmonary Rehabilitation Programme on Exercise Tolerance and Quality of Life: A Randomized Controlled Trial.* European Respiratory Journal, 1997. **10**(1): p. 104-113.
22. Troosters, T., R. Gosselink, and M. Decramer, *Short-and Long-Term Effects of Outpatient Rehabilitation in Patients with Chronic Obstructive Pulmonary Disease: A Randomized Trial.* The American journal of medicine, 2000. **109**(3): p. 207-212.
23. Turner, S., et al., *Improvements in Symptoms and Quality of Life Following Exercise Training in Older Adults with Moderate/Severe Persistent Asthma.* Respiration, 2011. **81**(4): p. 302-310.
24. Dogra, S., V. Jamnik, and J. Baker, *Self-Directed Exercise Improves Perceived Measures of Health in Adults with Partly Controlled Asthma.* J Asthma, 2010. **47**(9): p. 972-7.
25. Dogra, S., et al., *Exercise Is Associated with Improved Asthma Control in Adults.* European Respiratory Journal, 2011. **37**(2): p. 318-323.
26. Ramponi, S., et al., *Pulmonary Rehabilitation Improves Cardiovascular Response to Exercise in Copd.* Respiration, 2013. **86**(1): p. 17-24.
27. Cypcar, D. and R.F. Lemanske Jr, *Asthma and Exercise.* Clinics in chest medicine, 1994. **15**(2): p. 351-368.
28. Iribarren, C., et al., *Adult Asthma and Risk of Coronary Heart Disease, Cerebrovascular Disease, and Heart Failure: A Prospective Study of 2 Matched Cohorts.* American journal of epidemiology, 2012: p. kws181.
29. Mannino, D.M., et al., *Prevalence and Outcomes of Diabetes, Hypertension and Cardiovascular Disease in Copd.* European Respiratory Journal, 2008. **32**(4): p. 962-969.
30. *Canadian Community Health Survey (Cchs) Annual Component Public Use Microdata File, 2012*. 2013, Statistics Canada: Ottawa, ON.
31. *Global Strategy for the Diagnosis, Management, and Prevention of Copd (Revised 2011)*. 2015, Global Initiative for Chronic Obstructive Lung Disease.
32. *Canadian Community Health Survey, a Guide to Accessing and Interpreting the Data*. 2004 ed. 2006: Health Canada.
33. Jacobs, D.R., et al., *Validity and Reliability of Short Physical Activity History: Cardia and the Minnesota Heart Health Program.* Journal of Cardiopulmonary Rehabilitation and Prevention, 1989. **9**(11): p. 448-459.
34. Ainsworth, B.E., et al., *Accuracy of the College Alumnus Physical Activity Questionnaire.* Journal of clinical epidemiology, 1993. **46**(12): p. 1403-1411.
35. Simpson, K., *Validity and Reliability of the Paffenbarger Physical Activity Questionnaire among Healthy Adults.* University of Connecticut, 2011.
36. *Canadian Guidelines for Body Weight Classification in Adults*. 2003, Health Canada: Minister of Public Works and Government Services Canada.
37. Spencer, E.A., et al., *Validity of Self-Reported Height and Weight in 4808 Epic–Oxford Participants.* Public health nutrition, 2002. **5**(04): p. 561-565.

38. Lucas, S.R. and T.A. Platts-Mills, *Physical Activity and Exercise in Asthma: Relevance to Etiology and Treatment.* Journal of Allergy and Clinical Immunology, 2005. **115**(5): p. 928-934.
39. Ford, E.S., et al., *Leisure-Time Physical Activity Patterns among Us Adults with Asthma.* CHEST Journal, 2003. **124**(2): p. 432-437.
40. Vorrink, S.N., et al., *Level of Daily Physical Activity in Individuals with Copd Compared with Healthy Controls.* Respir Res, 2011. **12**(1): p. 33.
41. Pitta, F., et al., *Characteristics of Physical Activities in Daily Life in Chronic Obstructive Pulmonary Disease.* American journal of respiratory and critical care medicine, 2005. **171**(9): p. 972-977.
42. Jerning, C., et al., *Asthma and Physical Activity–a Population Based Study Results from the Swedish Ga 2 Len Survey.* Respiratory medicine, 2013. **107**(11): p. 1651-1658.
43. Verlaet, A., et al., *Physical Activity in Adults with Controlled and Uncontrolled Asthma as Compared to Healthy Adults: A Cross-Sectional Study.* Clinical and translational allergy, 2013. **3**(1): p. 1.
44. Troosters, T., et al., *Improving Physical Activity in Copd: Towards a New Paradigm.* Respir Res, 2013. **14**(1): p. 115.
45. Harris, D., M. Hayter, and S. Allender, *Improving the Uptake of Pulmonary Rehabilitation in Patients with Copd.* Br J Gen Pract, 2008. **58**(555): p. 703-710.
46. Weinstein, A.G., *Asthma Adherence Management for the Clinician.* The Journal of Allergy and Clinical Immunology: In Practice, 2013. **1**(2): p. 123-128.
47. Garcia-Aymerich, J., et al., *Physical Activity and Clinical and Functional Status in Copd.* CHEST Journal, 2009. **136**(1): p. 62-70.
48. Mirabelli, M.C., S.F. Beavers, and A.B. Chatterjee, *Active Asthma and the Prevalence of Physician-Diagnosed Copd.* Lung, 2014. **192**(5): p. 693-700.
49. Dogra, S. and J. Baker, *Physical Activity and Health in Canadian Asthmatics.* Journal of Asthma, 2006. **43**(10): p. 795-799.
50. Eichenberger, P.A., et al., *Effects of Exercise Training on Airway Hyperreactivity in Asthma: A Systematic Review and Meta-Analysis.* Sports Medicine, 2013. **43**(11): p. 1157-1170.
51. Moullec, G., et al., *Effects of Pulmonary Rehabilitation on Quality of Life in Chronic Obstructive Pulmonary Disease Patients.* Curr Opin Pulm Med, 2011. **17**(2): p. 62-71.
52. Puhan, M.A., et al., *Respiratory Rehabilitation after Acute Exacerbation of Copd May Reduce Risk for Readmission and Mortality–a Systematic Review.* Respiratory research, 2005. **6**(1): p. 54.
53. Arne, M., et al., *Factors Associated with Good Self-Rated Health and Quality of Life in Subjects with Self-Reported Copd.* International Journal of COPD, 2011. **6**: p. 511-519.
54. de Miguel Díez, J., et al., *Trends in Self-Rated Health Status and Health Services Use in Copd Patients (2006–2012). A Spanish Population-Based Survey.* Lung, 2015. **193**(1): p. 53-62.
55. Ghorbani Saeedian, R., et al., *Self-Rated Health Mediates the Association between Functional Status and Health-Related Quality of Life in Parkinson's Disease.* Journal of clinical nursing, 2014. **23**(13-14): p. 1970-1977.

56. Bonomi, A.E., et al., *Validation of the United States' Version of the World Health Organization Quality of Life (Whoqol) Instrument.* Journal of clinical epidemiology, 2000. **53**(1): p. 1-12.
57. Whelton, S.P., et al., *Effect of Aerobic Exercise on Blood Pressure: A Meta-Analysis of Randomized, Controlled Trials.* Annals of internal medicine, 2002. **136**(7): p. 493-503.
58. Liu, J., et al., *Effects of Cardiorespiratory Fitness on Blood Pressure Trajectory with Aging in a Cohort of Healthy Men.* Journal of the American College of Cardiology, 2014. **64**(12): p. 1245-1253.
59. Trevor, J.L., et al., *Benefits of Completing Pulmonary Rehabilitation in Patients with Asthma.* Journal of Asthma, 2015. **52**(9): p. 969-973.
60. Beuther, D.A. and E.R. Sutherland, *Overweight, Obesity, and Incident Asthma: A Meta-Analysis of Prospective Epidemiologic Studies.* American journal of respiratory and critical care medicine, 2007. **175**(7): p. 661-666.
61. Mitra, M., et al., *A Study of Correlation between Body Mass Index and Gold Staging of Chronic Obstructive Pulmonary Disease Patients.* The Journal of Association of Chest Physicians, 2013. **1**(2): p. 58.
62. Ischaki, E., et al., *Body Mass and Fat-Free Mass Indices in Copd: Relation with Variables Expressing Disease Severity.* CHEST Journal, 2007. **132**(1): p. 164-169.
63. Eriksson, B., et al., *Only Severe Copd Is Associated with Being Underweight: Results from a Population Survey.* ERJ open research, 2016. **2**(3): p. 00051-2015.
64. Shuval, K., et al. *Sedentary Behavior, Cardiorespiratory Fitness, Physical Activity, and Cardiometabolic Risk in Men: The Cooper Center Longitudinal Study*. in *Mayo Clinic Proceedings*. 2014. Elsevier.
65. Albanes, D., et al., *Validation and Comparison of Eight Physical Activity Questionnaires.* Epidemiology, 1990: p. 65-71.

Table 1: Socio-Demographic Characteristics of Adults with Asthma, COPD, CAC, and No Obstructive Respiratory Disease.

	Asthma	**COPD**	**CAC**	**No Obstructive Respiratory Disease**
	(n=4293)	**(n=3118)**	**(n= 1569)**	**(n=64175)**
Sex (%)				
Male	33.7*	42.6*	34.0*	46.2
Female	66.3*	57.4*	66.0*	53.8
Age Group (%)				
Middle-aged Adults	66.6*	41.9*	47.9*	62.5
Older Adults	33.4*	58.1*	52.1*	37.5
BMI Category (%)				
Underweight	1.3*	4.0*	3.3*	1.5
Normal Weight	32.5*	35.9*	28.1*	39.2
Overweight	35.4*	35.0*	31.5*	38.1
Obese	30.8*	25.1*	37.1*	21.2
Self-perceived Health (%)				
Good	39.6*	22.5*	14.9*	52.5
Poor	60.4*	77.5*	85.3*	47.5
Physical Activity Level (%)				
Active	47.8	35.8*	30.8*	48.7
Inactive	52.2	64.2*	69.2*	51.3
Smoking History (%)				
Daily	12.8*	29.4*	29.0*	14.9
Occasional	2.3*	3.2*	2.9*	2.8
Not at all	84.9*	67.4*	68.2*	82.3

COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; BMI: body mass index.
*$p<0.05$, based on adjusted residual cut points of +1.96 to -1.96.

Table 2: Associations of Obstructive Respiratory Disease with Physical Activity, Perceived Health, Hypertension and Body Mass Index.

	Physically Active†		**Good Self-Perceived Health†**		**Hypertension†**		**Body Mass Index ≥25 kg/m^2‡**	
	OR	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**
Asthma (crude)	0.96	0.88-1.05	0.59*	0.54-0.65	1.20*	1.09-1.31	1.35*	1.22-1.48
Asthma (adjusted)	1.02	0.93-1.12	0.61*	0.55-0.67	1.15*	1.04-1.27	1.44*	1.30-1.57
COPD (crude)	0.59*	0.52-0.66	0.26*	0.23-0.30	1.54*	1.38-1.71	1.11	0.98-1.25
COPD (adjusted)	0.69*	0.62-0.78	0.32*	0.28-0.36	1.23*	1.08-1.39	1.23*	1.09-1.39
CAC (crude)	0.47*	0.40-0.55	0.16*	0.13-0.20	2.12*	1.83-2.50	1.62*	1.36-1.93
CAC (adjusted)	0.59*	0.50-0.71	0.21*	0.17-0.26	1.64*	1.38-1.94	1.86*	1.55-2.22
No Obstructive Respiratory Disease	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent

COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; OR: odds ratio; CI: confidence interval.

*$p<0.05$

†Models are adjusted for age, sex, BMI, and smoking history.

‡Models are adjusted for age, sex, and smoking history.

Table 3: Associations of Obstructive Respiratory Diseases by Physical Activity Levels with Perceived Health, Hypertension, and Body Mass Index.

		Good Self-Perceived Health†		**Hypertension†**		**Body Mass Index ≥25 kg/m²‡**	
		OR	**CI**	**OR**	**CI**	**OR**	**CI**
Asthma	Active (Crude)	2.48*	2.07-2.97	0.61*	0.51-0.73	0.67*	0.55-0.81
	Inactive	1.00	Referent	1.00	Referent	1.00	Referent
	Active (Adjusted)	2.14*	1.77-2.59	0.77*	0.63-0.94	0.63*	0.52-0.76
	Inactive	1.00	Referent	1.00	Referent	1.00	Referent
COPD	Active (Crude)	2.11*	1.63-2.74	0.77*	0.61-0.97	0.90	0.71-1.15
	Inactive	1.00	Referent	1.00	Referent	1.00	Referent
	Active (Adjusted)	2.08*	1.58-2.74	0.93	0.72-1.19	0.80	0.62-1.03
	Inactive	1.00	Referent	1.00	Referent	1.00	Referent
CAC	Active (Crude)	2.67*	1.74-4.11	0.59*	0.42-0.82	0.76	0.53-1.10
	Inactive	1.00	Referent	1.00	Referent	1.00	Referent
	Active (Adjusted)	2.66*	1.71-4.16	0.60*	0.43-0.86	0.71	0.49-1.04
	Inactive	1.00	Referent	1.00	Referent	1.00	Referent

COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; OR: odds ratio; CI: confidence interval.

*$p<0.05$

†Models are adjusted for age, sex, BMI and smoking history.

‡Models are adjusted for age, sex, and smoking history.

CHAPTER 4: MANUSCRIPT 2

TITLE: REPORTED MODES OF PHYSICAL ACTIVITY AMONG ADULTS WITH OBSTRUCTIVE RESPIRATORY DISEASES

4.1.0 ABSTRACT

Purpose: To investigate the different modes of physical activity in which adults with obstructive respiratory disease engage, and the associations between modes of physical activity and type of obstructive respiratory disease separately in males and females.

Methods: Data from respondents with self-reported asthma (n=4,293; males: n=1,418, females: n=2,875), chronic obstructive pulmonary disease (COPD) (n=3,118; males: n=1,317, females: n=1,801), a combination of asthma and COPD (CAC) (n=1,569; males: n=543, females: n=1,026), and those without an obstructive respiratory disease (n=64,175; males: n=28,410, females: n=35,765) from the Canadian Community Health Survey (2013) were used for analysis. Self-reported modes of physical activity were grouped into the following categories: walking, endurance activities, recreation activities, conventional exercise, sports, and no physical activity. Logistic regression analyses were conducted using modes of physical activity as outcomes, and type of respiratory disease as the main covariate.

Results: Adults with COPD and CAC had the lowest participation in all modes of physical activity, and the highest odds of reporting no physical activity compared to adults without respiratory disease (COPD: OR=1.65, CI=1.43-1.92; CAC: OR=2.16, CI=1.78-2.61). Adults with asthma had similar physical activity levels and preferences compared adults with no obstructive respiratory disease. Females with CAC were less likely to participate in walking (OR=0.58, CI=0.48-0.71) and recreational activities (OR=0.50, CI=0.41-0.60) compared to females without respiratory disease.

Conclusions: Adults with COPD and CAC were more likely to engage in common activities such as walking; while physical activity preferences in adults with asthma did

not differ from the general population. These findings provide insight into the physical activity behavior of adults with obstructive respiratory diseases, and have important implications for guidelines and future exercise interventions.

4.2.0 INTRODUCTION

It is estimated that only 5% of Canadian adults are achieving the minimum recommended 150 minutes of moderate-to-vigorous intensity physical activity per week [1, 2]. Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure above resting levels, and increases heart rate and breathing [2]. Physical activity levels are particularly low among those with respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma, and among those with a combination of both asthma and COPD (herein referred to as CAC). Research indicates that adults with COPD and CAC are 31% and 41% less likely to be physically active than those without a respiratory disease, respectively [3]. Among those diagnosed with asthma, physical activity levels vary, with some studies indicating higher physical activity levels than the general population [4, 5], while others show similar levels [6], or lower levels [7-9]. Individuals with respiratory diseases often experience tightening of the airways, dyspnea, and wheezing during or after exercise. This may act as a unique barrier for adoption and maintenance of regular physical activity [10, 11]. It should be noted that at least among those with asthma, such symptoms can be prevented with an appropriate warm-up and medication use [12]. However, medication adherence among those with respiratory disease is low, particularly when used to prevent exercise-induced symptoms [13] .

Among those with asthma, walking and endurance activities such as swimming have been shown to improve cardiorespiratory fitness and are less likely to elicit exacerbations [14-16]; while activities that are resistance-based, such as weight training, are less likely to trigger breathlessness, and are recommended for those with COPD [17, 18]. However, only 0.4% of all Canadians with COPD, and 0.8% of those with moderate to severe COPD, have access to pulmonary rehabilitation [19]. In addition, according to a study, only 26%% of those with COPD completed the required walking-based exercise prescription for a frequency of 4 days per week [20]. Low adherence levels have also been observed in adults with asthma. Participants in a 12-week self-directed exercise program completed only 40% of prescribed weekly exercise [21]. Studies have shown that incorporating physical activities that are similar to hobbies, or activities that are sport-like, or those that create a social outlet with family and/or friends are critical for adherence to physical activity [11, 22]. In fact, enjoyment of physical activity has been shown to be a key enabler to physical activity adherence among those with COPD [11, 23]. Thus, it appears that physical activity programs targeting those with obstructive respiratory diseases should incorporate a social component to create a sense of camaraderie, and should include activities that this population enjoys, in order to promote long-term adherence. Unfortunately, most community-based programs use conventional activities such as walking, and strength training while neglecting to include modes of activities that individuals enjoy, or already participate in. Allowing individuals to choose the modes of physical activity they engage in, for example joining a walking group or engaging in recreational activities such as dancing, has been shown to be a crucial factor for enjoyment [23].

Based on previous research [24-27], it is clear that engaging in regular physical activity has the potential to improve respiratory symptoms, overall quality of life, and risk of cardiometabolic comorbidities among those with asthma, COPD and CAC. In order to inform the development of effective physical activity programs for this population, it is important to better understand their physical activity preferences. Thus, the primary purpose of this study was to explore the different modes of physical activity in which adults with obstructive respiratory disease engage. Physical activity preferences tend to be different between males and females [28, 29]. In fact, research has shown that healthy males are more physically active than females [30], and tend to engage in a greater variety of activities, including sports [31, 32]. Longitudinal data also indicates that as females age, they consider physical activity to be less important [33].Therefore, we investigated these associations separately for males and females.

4.3.0 METHODS AND DESIGN

4.3.1 Data source and sample

The Canadian Community Health Survey (CCHS) is a cross sectional survey covering an estimated 98% of the total Canadian population, aged 12 years and older [34]. However, the CCHS does not include individuals that were full-time members of the Canadian Forces, or those living in the Territories, on First Nation Reserves or Crown Lands, in prisons or care facilities, or in some remote areas [34]. The CCHS collects information pertaining to health determinants, health care utilization, and health status, and is conducted on an annual basis [34]. All respondents to the CCHS provided consent and participated in a telephone interview [34].

The CCHS 2011-2012 (version 1.0, 2013) was used for the present analysis (n=124 929). Only those aged 45 years and older (n=73 434) with valid responses to the asthma and COPD questions (n= 73 155) were included. This age was chosen because COPD diagnosis is less likely to occur before 45 years [35].

The CCHS does not contain any identifiable information; thus, according to the Tri-Council Policy Statement (TCPS 2), secondary analysis of such data does not require research ethics board review.

4.3.2 Main Variables

Respiratory Disease Variables. Respondents were asked whether they have ever been told by a healthcare professional that they have asthma. A similar question was asked regarding COPD. Respondents were instructed to consider long-term conditions that had lasted for 6 months or more. Those who responded “yes” to the asthma question, and “no” to the COPD question were classified as having *asthma* (n=4 293; males: n=1 418, females: n=2 875). Those who responded “yes” to the COPD question, and “no” to the asthma question were classified as having *COPD* (n=3 118; males: n=1 317, females: n=1 801). Those who responded “yes” to both questions were classified as having *CAC* (n=1 569; males: n=543, females: n=1 026). Those who responded with “no” to both questions were classified as having *no obstructive respiratory disease* (n=64 175; males: n=28 410, females: n=35 765).

Modes of Physical Activity. Respondents were asked whether they participated in various modes of physical activities in the past 3 months. The modes of physical activity were then grouped into the following categories: walking, endurance activities (swimming, running/jogging, cycling, and rollerblading), recreation activities (gardening, golfing, fishing, bowling, and dance), conventional exercise (home based exercise, aerobic exercise classes, and weight training), sports (volleyball, basketball, ice hockey, ice skating, snowboarding/skiing, baseball, tennis, and soccer), and no physical activity.

Walking was considered a separate category, as it is a common activity among middle-aged and older adults [36, 37].

Although the CCHS provides intensity values for each mode of physical activity, studies have shown that adults tend to either underestimate or overestimate physical activity intensity [38, 39]; thus self-reported physical activity intensity was not included in our analyses.

4.3.3 Covariates and Demographic Variables

Age, sex, and smoking history were used to describe the sample and were used as covariates in adjusted models. Age was reported in 5 year categories; these were subsequently collapsed to: middle aged adults (45 to 64 years) and older adults (65 years and older). Self-reported weight in kilograms and height in meters were used to calculate body mass index (BMI) [40]. Respondents were then classified as either underweight (<18.5 kg/m^2), normal weight (18.5 to 24.9 kg/m^2), overweight (25 to 29.9 kg/m^2), or obese ($\geq$30 kg/m^2) [40]. For physical activity, respondents were classified as active, moderately active and inactive based on the following cut offs: $\geq$3.0 kcal/kg/day, 1.5-2.9 kcal/kg/day and < than 1.5 kcal/kg/day, respectively [41]. For smoking history, respondents were categorized as either daily smokers, occasional smokers or non-smokers, based on their current self-reported smoking habit.

4.3.4 Statistical Analysis

The frequencies of categorical variables (BMI, smoking history, physical activity, and modes of physical activity) were determined within the asthma, COPD, CAC, and no obstructive respiratory disease groups. Cross-tabulations were used to describe the groups (age and sex).Pearson Chi-squares were used to determine whether there was a relationship between type of respiratory disease and demographic characteristic (age, sex, BMI, smoking history, physical activity index and modes of physical activity. Adjusted residual cut points of +1.96 to -1.96 were used to detect differences between groups; values outside this range indicated that there were significant differences ($p<0.05$) between adjacent cells.

Logistic regressions and odds ratios were used in order to investigate the association between categorical outcomes and categorical predictors. Logistic regression analyses were conducted using modes of physical activity as outcomes, and type of respiratory disease as the main covariate. Models were adjusted for age, sex, and smoking history. Models were then run separately for males and females based on previous research [42, 43], and the Canadian Institutes for Health Research Sex and Gender Based Analysis recommendations [44] Those with no obstructive respiratory disease were used as the referent group for both logistic regression analyses. Individuals aged 45 years and older were included in all logistic regression analyses.

All analyses were performed using IBM SPSS Statistics V24. Population weights were rescaled, standardized and reapplied to ensure accurate measures of variance, and to eliminate the possibility of groups being over or under represented. A p-value <0.05 was considered significant.

4.4.0 RESULTS

Sample characteristics of all groups are presented in Table 1. Among those with CAC, 66% were female, and 69.2% were categorized as physically inactive. Those with COPD had the highest prevalence of current daily smokers (29.4%), followed by those with CAC (29.0%). Figure 1 displays the modes of physical activity, expressed in percentages. Among those with asthma, 73.7% and 57.2% participated in walking and recreation activities in the past 3 months, respectively. Less than 1% of those with COPD and CAC participated in conventional exercise.

The associations between modes of physical activity and obstructive respiratory disease type in the combined sample of males and females are presented in Table 2a. Those with CAC were 35% less likely to report walking compared to those with no obstructive respiratory disease (OR=0.65, CI=0.55-0.76). Those with COPD were 30% less likely to report participation in endurance activities (OR=0.70, CI=0.60-0.81). The odds for reporting “no physical activity” was 2.16 times higher among those with CAC compared to those with no obstructive respiratory disease (OR=2.16, CI=1.78-2.61). Among those with asthma, significant differences were only noted for recreational activities (OR=0.88, CI=0.81-0.97) when compared to those with no obstructive respiratory disease.

The associations between modes of physical activity and obstructive respiratory diseases are presented separately for males and females in Tables 2b and 2c. Odds of reporting no physical activity were 2.29 times higher (OR=2.29, CI=1.83-2.87) among females with CAC, and 1.93 times higher among males with CAC (OR=1.93, CI=1.35-

2.75) compared to those without respiratory disease. Females with CAC were also 42% (OR=0.58, CI=0.48-0.71) and 50% (OR=0.50, CI=0.41-0.60) less likely to report participating in walking and recreational activities compared to females with no obstructive respiratory disease. Males with CAC and COPD were 73% (OR=0.27, CI=0.13-0.58) and 44% (OR=0.56, CI=0.39-0.80) less likely to report participating in sports, and less likely to report participating in endurance activities (CAC: OR=0.48, CI=0.33-0.70; COPD: OR=0.78, CI=0.62-0.96) compared to males with no obstructive respiratory disease, respectively. Among females with asthma, participation in recreational activities was significantly lower than those without respiratory disease.

4.5.0 DISCUSSION

Using data from the CCHS (2011-2012), we explored engagement in different modes of physical activity of adults with obstructive respiratory diseases. Our findings indicate that: 1) adults with COPD and CAC are more likely to report engaging in “no physical activity”, and less likely to engage in all modes of physical activity when compared to those without respiratory disease, 2) individuals with COPD or CAC (as a whole or according to sex) had different magnitudes of participation in different activities, and 3) adults with asthma had similar levels of physical inactivity and similar participation levels in different modes of physical activity when compared to those without respiratory disease. These findings provide insight in to physical activity preferences of adults with obstructive respiratory disease. Our findings could also be used to inform the development of physical activity programs and interventions, in order to improve adherence in this population.

Our finding that those with COPD and CAC had the lowest participation in all modes of physical activity, and the highest odds of reporting no physical activity, are consistent with previous literature. Respiratory-related symptoms including reduced expiratory flow, and low skeletal muscle performance combined with physical deconditioning, have all been shown to negatively impact physical activity levels [45, 46]. A possible explanation for our finding is that certain modes may be too strenuous for these groups. Specifically, conventional exercises such as weight training exercises, sports, and endurance activities including running, require a greater demand on the cardiorespiratory and musculoskeletal system. Such demands are known to increase dyspnea, and therefore, make the activity more difficult [47]. In addition, research has shown that COPD is associated with peripheral muscle weakness [48] and wasting [49], which in turn, can also limit the ability to engage in such activities [46]. Other possible reasons for the lack of participation in sports can include the cold, dry environments that are associated with ice hockey, skating and skiing; which may elicit airway constriction (airway hyperresponsiveness) [50]. In terms of recreational activities, most of these activities are carried out in community centres; thus, travelling to these centres may be a challenge for those with severe dyspnea and those who are physically deconditioned [11, 51]. In addition, environmental factors can elicit respiratory symptoms in this population as well. Current guidelines also caution those with COPD regarding urban air pollution, which has been deemed harmful for those with lung disease [52]. Thus, it is likely that outdoor recreational activities such as gardening, golfing, and fishing, are avoided to help prevent adverse symptoms. Swimming may be avoided due to the use of chlorine and its derivatives, which could be an irritant to the airways [50].

It is evident that many modes of physical activity are avoided in this population either due to low physical and musculoskeletal capacity [46, 48], or due to a variety of environmental factors [50, 52]. However, research has shown that many of these activities provide much needed benefit to those with COPD and CAC [17, 18, 53]. In fact, conventional exercises are recommended for those with COPD [17, 18]; while recreational exercises have been shown to improve muscular strength and endurance, as well as cardiorespiratory fitness among healthy older adults [54]. Sports including gymnastics and tai-chi have also shown to improve peak expiratory flow among those with COPD [53]. Overall, different modes of physical activity should not be avoided by this population, and can be safely performed while adhering to medication and when outdoor conditions are suitable (days with low pollen count and in areas with low urban pollution). In order to increase physical activity levels, guidelines and interventions need to inform the educational needs of this population on how to safely engage in a variety of physical activities.

The magnitude of the association between participation in different activities and respiratory disease differed by sex. Healthy females have been shown to have lower levels of physical activity, and to participate in limited types of activities when compared to males [30, 55]. Our finding that females with CAC have high odds of reporting no physical activity compared to sex-matched individuals without respiratory disease is concerning. One study showed that females who participated in a cardiac rehabilitation program, perceived more barriers to exercise than males [56]. The burden of their disease was found to be the most influential barrier on physical activity participation [56]. This finding is similar to those with respiratory diseases, as symptoms such as dyspnea have been shown to be a barrier to exercise in individuals with COPD [11].

We also found that both males and females with CAC and COPD were less likely to participate in recreational activities while females with CAC had the lowest odds of reporting walking. Recreational activities provide a social outlet and may improve exercise self-efficacy; therefore, such activities should be carried out in local community centres. Thus, it remains evident, physical activity guidelines and exercise interventions need to inform the educational needs in these populations, in order to improve physical activity levels and adherence.

We found that both females and males with CAC and COPD were less likely to participate in sports and endurance activities, compared to sex-matched individuals without a respiratory disease. However, previous research has shown that healthy males typically engage in a variety of physical activities [32], including sports [31]. A possible reason for our findings may be that sports and endurance activities such as running are too strenuous for this population, and as a result, are avoided to prevent adverse symptoms. Outdoor sports may be avoided by these populations due to the risk of urban air pollution and allergens [52], while indoor sports such as ice hockey may be avoided due to cold dry environments [50]; both environments have the potential to aggravate respiratory symptoms. Nonetheless, sports should not be neglected in these populations, as regular participation is associated with higher psychological well-being, and is inversely associated with both stress and distress [57]. Sports and endurance activities are also an enjoyable way to engage in moderate-vigorous intensity physical activity, and therefore may affect long-term adherence. Exercise interventions should incorporate sports; however, interventions should be at an appropriate intensity to prevent injury, and should be conducted indoors to avoid the risk of adverse symptoms. Further, in order to improve adherence, exercise interventions should strive to incorporate sports that males and females with COPD and CAC currently enjoy and participate in.

In our sample, adults with asthma had similar physical activity levels, and similar participation in the various modes of physical activity compared to those without respiratory disease. These findings are not surprising, as Jerning et al. [6] reported no significant difference in the proportion of individuals that were physically active or inactive, when comparing those with and without asthma. It is possible that current guidelines encouraging adults with asthma to be more physically active are effective [58], and that improved asthma care is reducing barriers to physical activity. Those with well-controlled or mild to moderate asthma [4], or those who are able to appropriately manage environmental triggers [59], may be able to achieve or engage in physical activity similar to their healthy peers.

It is also possible that the intermittent and/or reversible nature of asthma plays a role in physical activity engagement. With optimized care, those with asthma are less likely to experience exercise-induced symptoms [60] and therefore have fewer barriers to engagement in physical activity. Lastly, our sample of adults with asthma had a similar age profile as the comparison group of adults without respiratory disease. This may help to further explain the similarities as physical activity levels are known to differ between middle-aged adults and older adults [61], and the frequency and intensity of physical activity also differs between middle-aged and older adults [62].

Significant differences were only noted for recreational activities between adults with asthma and those without respiratory disease. Further, participation in recreational activities was significantly lower in females with asthma, than those without respiratory disease. It is important to note, the activities included in our category of recreational activities were primarily outdoor activities (e.g. gardening, golfing, and fishing). Therefore, these activities may be avoided due to outdoor allergens inducing respiratory symptoms, especially in those with allergy-induced asthma [63]. However, recreational activities also provide a social outlet for adults which may alleviate depression symptoms and behavior, as well as improve self-efficacy to exercise [64]. Thus, it is evident that future respiratory guidelines should not only to promote physical activity, but also continue to encourage adults with asthma to participate in a variety of physical activities in order to prevent cardiometabolic comorbidities [3] and improve overall psychosocial wellbeing.

There are many strengths in this study that are worth highlighting. To our knowledge, these findings are the first to describe physical activity preferences among those with asthma, COPD and CAC. Our findings were based on analysis of a large representative sample of Canadian adults aged 45 years and older. Lastly, modes of physical activities were grouped into categories (*walking, endurance activities, recreation activities, conventional exercises, and sports*) to simplify the interpretation of our findings.

Findings from this study should also be interpreted in light of the following limitations. First, the CCHS is cross-sectional, thus, the direction of the association cannot be determined. Studies show that in chronic conditions such as cardiovascular disease, low levels of physical activity lead to the progression of disease [65]. However, in the case of respiratory diseases such as asthma and COPD, longitudinal studies have shown that the disease itself, combined with risk factors including smoking history, lead to a decrease in exercise capacity and low levels of physical activity [66, 67]. Secondly, the CCHS is comprised of self-reported data; thus, all variables, including the modes of physical activity examined, are subject to misclassification and recall bias. Although devices are available to objectively measure volume of physical activity, self-report is necessary to understand physical activity preferences [68]. While self-reported chronic conditions may have been misclassified, the CCHS specifically asks for conditions that were diagnosed by a health professional and were expected to last, or have lasted 6 months or more, thus reducing misclassification bias. Thirdly, although the CCHS accounts for 98% of the Canadian population, the CCHS does not include individuals that were full-time members of the Canadian Forces, or those living in the Territories, on First Nation Reserves or Crown Lands, in prisons or care facilities, or in some remote areas. Therefore, these populations could not be accounted for in our analyses. Finally, the CCHS does not provide information on asthma or COPD severity, age of diagnosis, types of medications, the season of data collection, or other management variables, therefore these variables could not be accounted for in our analyses. Future research should investigate whether severity of disease, age of diagnosis, and medication use, influence the participation in certain modes of physical activity in this population.

In conclusion, adults with COPD and CAC were more likely to report no physical activity, and less likely to participate in common activities such as walking. It appears that adults with asthma do not differ from the general population in terms of activity preferences. Further, the magnitude of the association between participation in different activities and respiratory disease differed by sex. Future research is needed to better understand the influence of incorporating preferred modes of activity into pulmonary rehabilitation and community exercise programs to increase adherence.

4.6.0 REFERENCE

1. Colley, R.C., et al., *Physical Activity of Canadian Adults: Accelerometer Results from the 2007 to 2009 Canadian Health Measures Survey.* Health reports, 2011. **22**(1): p. 7.
2. *Csep-Physical Activity Training for Health (Csep-Path).* 2013: Canadian Society for Exercise Physiology (CSEP).
3. Jagroop, D., J. Good, and S. Dogra, *Physical Activity and Cardiometabolic Risk Factors among Adults with Obstructive Respiratory Diseases.* 2017.
4. Verlaet, A., et al., *Physical Activity in Adults with Controlled and Uncontrolled Asthma as Compared to Healthy Adults: A Cross-Sectional Study.* Clinical and translational allergy, 2013. **3**(1): p. 1.
5. Lövström, L., et al., *High Levels of Physical Activity Are Associated with Poorer Asthma Control in Young Females but Not in Males.* Respirology, 2016. **21**(1): p. 79-87.
6. Jerning, C., et al., *Asthma and Physical Activity–a Population Based Study Results from the Swedish Ga 2 Len Survey.* Respiratory medicine, 2013. **107**(11): p. 1651-1658.
7. Yawn, B.P., et al., *Obesity, Low Levels of Physical Activity and Smoking Present Opportunities for Primary Care Asthma Interventions: An Analysis of Baseline Data from the Asthma Tools Study.* NPJ primary care respiratory medicine, 2015. **25**: p. 15058.
8. Strine, T.W., L.S. Balluz, and E.S. Ford, *The Associations between Smoking, Physical Inactivity, Obesity, and Asthma Severity in the General Us Population.* Journal of Asthma, 2007. **44**(8): p. 651-658.
9. Ford, E.S., et al., *Leisure-Time Physical Activity Patterns among Us Adults with Asthma.* CHEST Journal, 2003. **124**(2): p. 432-437.
10. Randolph, C., *An Update on Exercise-Induced Bronchoconstriction with and without Asthma.* Current allergy and asthma reports, 2009. **9**(6): p. 433-438.
11. Thorpe, O., S. Kumar, and K. Johnston, *Barriers to and Enablers of Physical Activity in Patients with Copd Following a Hospital Admission: A Qualitative Study.* Int J Chron Obstruct Pulmon Dis, 2014. **9**(1): p. 115-128.
12. Dryden, D.M., et al., *Exercise-Induced Bronchoconstriction and Asthma.* 2010.
13. Bidwal, M., et al., *Evaluation of Asthma Medication Adherence Rates and Strategies to Improve Adherence in the Underserved Population at a Federally Qualified Health Center.* Research in Social and Administrative Pharmacy, 2016.
14. Lucas, S.R. and T.A. Platts-Mills, *Physical Activity and Exercise in Asthma: Relevance to Etiology and Treatment.* Journal of Allergy and Clinical Immunology, 2005. **115**(5): p. 928-934.
15. Boyd, A., et al., *Feasibility of Exercising Adults with Asthma: A Randomized Pilot Study.* Allergy, Asthma & Clinical Immunology, 2012. **8**(1): p. 13.
16. Emtner, M., M. Finne, and G. Stålenheim, *A 3-Year Follow-up of Asthmatic Patients Participating in a 10-Week Rehabilitation Program with Emphasis on Physical Training.* Archives of physical medicine and rehabilitation, 1998. **79**(5): p. 539-544.

17. Probst, V., et al., *Cardiopulmonary Stress During Exercise Training in Patients with Copd.* European Respiratory Journal, 2006. **27**(6): p. 1110-1118.
18. Spruit, M.A., et al., *Copd and Exercise: Does It Make a Difference?* Breathe, 2016. **12**(2): p. e38.
19. Camp, P.G., et al., *Pulmonary Rehabilitation in Canada: A Report from the Canadian Thoracic Society Copd Clinical Assembly.* Canadian respiratory journal, 2015. **22**(3): p. 147-152.
20. Donesky-Cuenco, D., et al., *Adherence to a Home-Walking Prescription in Patients with Chronic Obstructive Pulmonary Disease.* Heart & Lung: The Journal of Acute and Critical Care, 2007. **36**(5): p. 348-363.
21. Dogra, S., V. Jamnik, and J. Baker, *Self-Directed Exercise Improves Perceived Measures of Health in Adults with Partly Controlled Asthma.* J Asthma, 2010. **47**(9): p. 972-7.
22. Harris, D., M. Hayter, and S. Allender, *Improving the Uptake of Pulmonary Rehabilitation in Patients with Copd.* Br J Gen Pract, 2008. **58**(555): p. 703-710.
23. Hartman, J.E., et al., *Self-Efficacy for Physical Activity and Insight into Its Benefits Are Modifiable Factors Associated with Physical Activity in People with Copd: A Mixed-Methods Study.* Journal of Physiotherapy, 2013. **59**(2): p. 117-124.
24. Cambach, W., et al., *The Effects of a Community-Based Pulmonary Rehabilitation Programme on Exercise Tolerance and Quality of Life: A Randomized Controlled Trial.* European Respiratory Journal, 1997. **10**(1): p. 104-113.
25. Dogra, S., et al., *Exercise Is Associated with Improved Asthma Control in Adults.* European Respiratory Journal, 2011. **37**(2): p. 318-323.
26. Ramponi, S., et al., *Pulmonary Rehabilitation Improves Cardiovascular Response to Exercise in Copd.* Respiration, 2013. **86**(1): p. 17-24.
27. Troosters, T., R. Gosselink, and M. Decramer, *Short-and Long-Term Effects of Outpatient Rehabilitation in Patients with Chronic Obstructive Pulmonary Disease: A Randomized Trial.* The American journal of medicine, 2000. **109**(3): p. 207-212.
28. Fuchs, R., et al., *Patterns of Physical Activity among German Adolescents: The Berlin—Bremen Study.* Preventive Medicine, 1988. **17**(6): p. 746-763.
29. Vilhjalmsson, R. and G. Kristjansdottir, *Gender Differences in Physical Activity in Older Children and Adolescents: The Central Role of Organized Sport.* Social science & medicine, 2003. **56**(2): p. 363-374.
30. *Prevalence of Health-Care Providers Asking Older Adults About Their Physical Activity Levels--United States, 1998.* MMWR Morb Mortal Wkly Rep, 2002. **51**(19): p. 412-4.
31. *Sport Participation 2010*. 2013, Canadian Heritage: Ottawa, Ontario.
32. Lee, Y.S., *Gender Differences in Physical Activity and Walking among Older Adults.* J Women Aging, 2005. **17**(1-2): p. 55-70.
33. Päivi, M., H. Mirja, and P. Terttu, *Changes in Physical Activity Involvement and Attitude to Physical Activity in a 16-Year Follow-up Study among the Elderly.* Journal of aging research, 2010. **2010**.
34. *Canadian Community Health Survey (Cchs) Annual Component Public Use Microdata File, 2012*. 2013, Statistics Canada: Ottawa, ON.

35. *Global Strategy for the Diagnosis, Management, and Prevention of Copd (Revised 2011)*. 2015, Global Initiative for Chronic Obstructive Lung Disease.
36. Siegel, P.Z., R.M. Brackbill, and G.W. Heath, *The Epidemiology of Walking for Exercise: Implications for Promoting Activity among Sedentary Groups.* American journal of public health, 1995. **85**(5): p. 706-710.
37. Stephens, T., D.R. Jacobs Jr, and C.C. White, *A Descriptive Epidemiology of Leisure-Time Physical Activity.* Public health reports, 1985. **100**(2): p. 147.
38. Tzetzis, G., et al., *Differences in Self-Reported Perceived and Objective Measures of Duration and Intensity of Physical Activity for Adults in Skiing.* European journal of epidemiology, 2001. **17**(3): p. 217-222.
39. Prince, S.A., et al., *A Comparison of Direct Versus Self-Report Measures for Assessing Physical Activity in Adults: A Systematic Review.* International Journal of Behavioral Nutrition and Physical Activity, 2008. **5**(1): p. 56.
40. *Canadian Guidelines for Body Weight Classification in Adults*. 2003, Health Canada: Minister of Public Works and Government Services Canada.
41. *Canadian Community Health Survey, a Guide to Accessing and Interpreting the Data*. 2004 ed. 2006: Health Canada.
42. JaKa, M.M., et al., *Describing the Relationship between Occupational and Non-Occupational Physical Activity Using Objective Measurement.* Preventive medicine reports, 2015. **2**: p. 213-217.
43. Pitanga, F.J.G. and I. Lessa, *Relationship between Leisure-Time Physical Activity and Blood Pressure in Adults.* Arquivos brasileiros de cardiologia, 2010. **95**(4): p. 480-485.
44. Heidari, S., et al., *Sex and Gender Equity in Research: Rationale for the Sager Guidelines and Recommended Use.* Research Integrity and Peer Review, 2016. **1**(1): p. 2.
45. Cooper, C.B., *The Connection between Chronic Obstructive Pulmonary Disease Symptoms and Hyperinflation and Its Impact on Exercise and Function.* The American journal of medicine, 2006. **119**(10): p. 21-31.
46. Gosselink, R., T. Troosters, and M. Decramer, *Peripheral Muscle Weakness Contributes to Exercise Limitation in Copd.* American journal of respiratory and critical care medicine, 1996. **153**(3): p. 976-980.
47. Grazzini, M., et al., *Pathophysiology of Exercise Dyspnea in Healthy Subjects and in Patients with Chronic Obstructive Pulmonary Disease (Copd).* Respiratory medicine, 2005. **99**(11): p. 1403-1412.
48. Franssen, F., et al., *Limb Muscle Dysfunction in Copd: Effects of Muscle Wasting and Exercise Training.* Medicine and science in sports and exercise, 2005. **37**(1): p. 2-9.
49. Debigare, R., C.H. Cote, and F. Maltais, *Peripheral Muscle Wasting in Chronic Obstructive Pulmonary Disease: Clinical Relevance and Mechanisms.* American Journal of Respiratory and Critical Care Medicine, 2001. **164**(9): p. 1712-1717.
50. Langdeau, J.-B. and L.-P. Boulet, *Prevalence and Mechanisms of Development of Asthma and Airway Hyperresponsiveness in Athletes.* Sports Medicine, 2001. **31**(8): p. 601-616.
51. Keating, A., A.L. Lee, and A.E. Holland, *Lack of Perceived Benefit and Inadequate Transport Influence Uptake and Completion of Pulmonary*

Rehabilitation in People with Chronic Obstructive Pulmonary Disease: A Qualitative Study. J Physiother, 2011. **57**(3): p. 183-90.

52. *Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease*. 2017, Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD).
53. Jungblut, S., et al., *Peak Expiratory Flow as a Predictor for the Effectiveness of Sport for Patients with Copd.* European journal of medical research, 2006. **11**(1): p. 33.
54. Keogh, J.W., et al., *Physical Benefits of Dancing for Healthy Older Adults: A Review.* Journal of aging and physical activity, 2009. **17**(4): p. 479-500.
55. *Healthy People 2010: Understanding and Improving Health. Us Government Printing Office*. 2000, US Department of Health Human Services: Washington, DC.
56. Lieberman, L., M. Meana, and D. Stewart, *Cardiac Rehabilitation: Gender Differences in Factors Influencing Participation.* Journal of women's health, 1998. **7**(6): p. 717-723.
57. Eime, R.M., et al., *A Systematic Review of the Psychological and Social Benefits of Participation in Sport for Adults: Informing Development of a Conceptual Model of Health through Sport.* International Journal of Behavioral Nutrition and Physical Activity, 2013. **10**(1): p. 135.
58. Bateman, E., et al., *Global Strategy for Asthma Management and Prevention: Gina Executive Summary*. European Respiratory Journal, 2008. **31**(1): p. 143-178.
59. Bacon, S.L., et al., *Association between Patterns of Leisure Time Physical Activity and Asthma Control in Adult Patients.* BMJ open respiratory research, 2015. **2**(1): p. e000083.
60. Axelsson, M., L. Ekerljung, and B. Lundbäck, *The Significance of Asthma Follow-up Consultations for Adherence to Asthma Medication, Asthma Medication Beliefs, and Asthma Control.* Nursing research and practice, 2015. **2015**.
61. Troiano, R.P., et al., *Physical Activity in the United States Measured by Accelerometer.* Medicine and science in sports and exercise, 2008. **40**(1): p. 181.
62. Frisard, M.I., et al., *Physical Activity Level and Physical Functionality in Nonagenarians Compared to Individuals Aged 60-74 Years.* J Gerontol A Biol Sci Med Sci, 2007. **62**(7): p. 783-8.
63. *Global Strategy for Asthma Management and Prevention*. 2017, Global Initiative for Asthma (GINA).
64. Mazzeo, R.S., et al., *Exercise and Physical Activity for Older Adults.* Medicine and science in sports and exercise, 1998. **30**(6): p. 992-1008.
65. Taylor, R.S., et al., *Exercise-Based Rehabilitation for Patients with Coronary Heart Disease: Systematic Review and Meta-Analysis of Randomized Controlled Trials.* The American journal of medicine, 2004. **116**(10): p. 682-692.
66. Oga, T., et al., *Exercise Capacity Deterioration in Patients with Copd: Longitudinal Evaluation over 5 Years.* CHEST Journal, 2005. **128**(1): p. 62-69.
67. Bestall, J., et al., *Longitudinal Trends in Exercise Capacity and Health Status after Pulmonary Rehabilitation in Patients with Copd.* Respiratory medicine, 2003. **97**(2): p. 173-180.

68. Jakicic, J.M., et al., *The Accuracy of the Tritrac-R3d Accelerometer to Estimate Energy Expenditure.* Medicine and science in sports and exercise, 1999. **31**(5): p. 747-754.

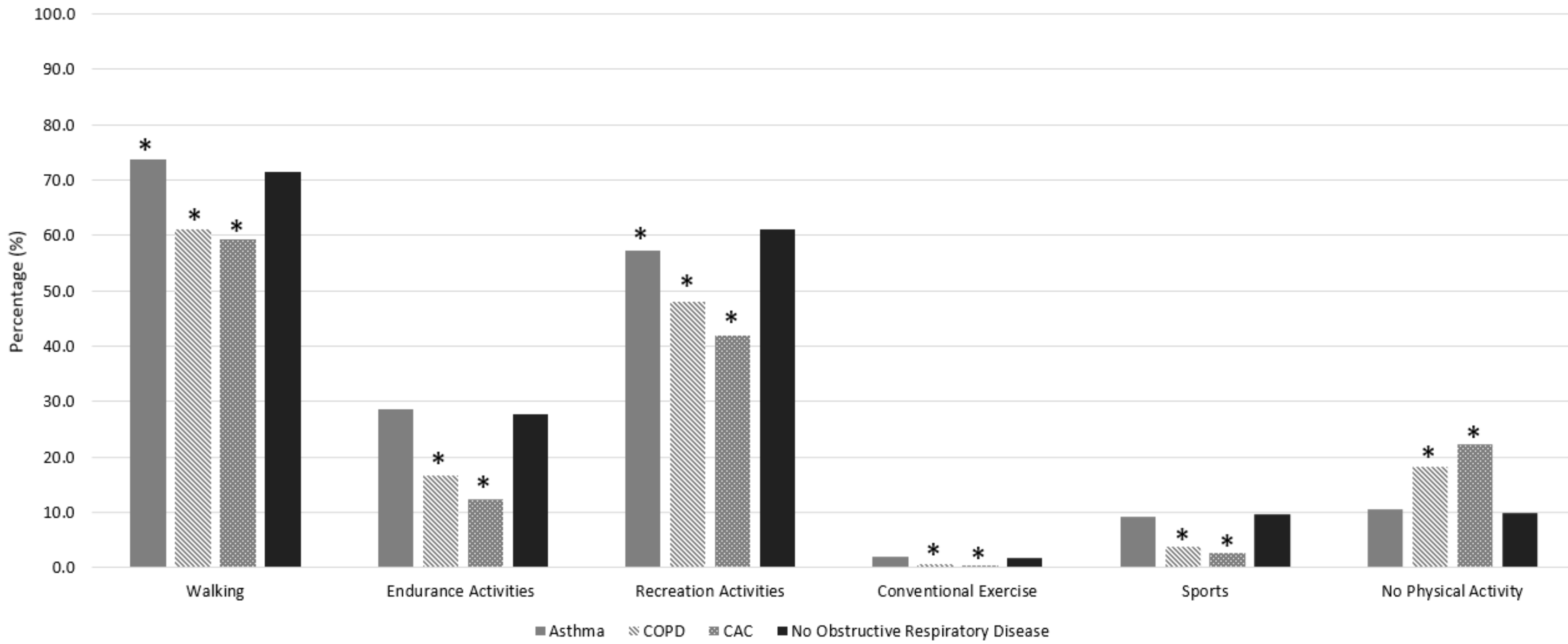
Table 1: Demographic Characteristics of Adults with Asthma, COPD, CAC, and No Obstructive Respiratory Disease.

		Asthma	COPD	CAC	No Obstructive Respiratory Disease
		n= 4293	**n= 3118**	**n= 1569**	**n= 64175**
Age	**Middle Aged**	66.6*	41.9*	47.9*	62.5
	Older Adult	33.4*	58.1*	52.1*	37.5
Sex	**Male**	33.7*	42.6*	34.0*	46.2
	Female	66.3*	57.4*	66.0*	53.8
BMI	**Underweight**	1.3*	4.0*	3.3*	1.5
	Normal	32.5*	35.9*	28.1*	39.2
	Overweight	35.4*	35.0*	31.5*	38.1
	Obese	30.8*	25.1*	37.0*	21.2
Smoking History	**Daily**	12.8*	29.4*	29.0*	14.9
	Occasional	2.3*	3.2*	2.9*	2.8
	Not at all	84.9*	67.4*	68.2*	82.3
PA Index	**Active**	22.4	15.5*	13.6*	22.8
	Moderately Active	25.4	20.3*	17.2*	26.0
	Inactive	52.2	64.2*	69.2*	51.3
PA Mode	**Walking**	73.7*	61.1*	59.4*	71.5
	Endurance Activities	28.7	16.6*	12.3*	27.7
	Recreation Activities	57.2*	48.0*	42.0*	61.1
	Conventional Exercise	1.9	0.7*	0.5*	1.7
	Sports	9.2	3.8*	2.6*	9.6
	No PA	10.5	18.2*	22.2*	9.8

COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; BMI: body mass index; PA: physical activity; PA Index: Physical Activity Index; Active: $\geq$3.0kcal/kg/day; Moderately Active: 1.5-2.9kcal/kg/day; Inactive: $\leq$1.5kcal/kg/day; Endurance Activities: swimming, running/jogging, cycling, and rollerblading; Recreation Activities: gardening, golfing, fishing, bowling, and dance; Conventional Exercise: home-based exercise, aerobic classes, weight training; Sports: volleyball, basketball, ice hockey, ice skating, snowboarding/skiing, baseball, tennis, and soccer.

*p<0.05 based on adjusted residual cut points of +1.96 to -1.96.

Figure 1: Modes of Physical Activity among Adults with and without Obstructive Respiratory Diseases.



COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; Endurance Activities: swimming, running/jogging, cycling, and rollerblading; Recreation Activities: gardening, golfing, fishing, bowling, and dance; Conventional Exercise: home-based exercise, aerobic classes, weight training; Sports: volleyball, basketball, ice hockey, ice skating, snowboarding/skiing, baseball, tennis, and soccer.

*$p<0.05$ based on adjusted residual cut points of +1.96 to -1.96.

Table 2a: Associations of Obstructive Respiratory Disease with Modes of Physical Activity.

	Walking		**Endurance Activities**		**Recreation Activities**		**Conventional Exercise**		**Sports**		**No Physical Activity**	
	OR	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**
Asthma (crude)	1.12*	1.01-1.24	1.05	0.95-1.16	0.85*	0.78-0.93	1.11	0.80-1.54	0.95	0.82-1.11	1.08	0.93-1.25
Asthma (adjusted)	1.04	0.94-1.16	1.04	0.94-1.15	0.88*	0.81-0.97	0.95	0.68-1.31	1.04	0.88-1.22	1.10	0.95-1.27
COPD (crude)	0.63*	0.56-0.71	0.52*	0.45-0.60	0.59*	0.53-0.66	0.40*	0.21-0.77	0.38*	0.28-0.50	2.05*	1.77-2.37
COPD (adjusted)	0.72*	0.64-0.81	0.70*	0.60-0.81	0.66*	0.59-0.74	0.58	0.30-1.13	0.55*	0.41-0.74	1.65*	1.43-1.92
CAC (crude)	0.59*	0.50-0.68	0.37*	0.29-0.46	0.46*	0.40-0.54	0.25*	0.08-0.79	0.25*	0.16-0.41	2.62*	2.17-3.16
CAC (adjusted)	0.65*	0.55-0.76	0.47*	0.37-0.60	0.52*	0.44-0.61	0.33	0.11-1.02	0.38*	0.23-0.62	2.16*	1.78-2.61
No Obstructive Respiratory Diseases	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent

COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; OR: odds ratio; CI: confidence interval.
*$p<0.05$.
Models were adjusted for age, sex, smoking history, and BMI.

Table 2b: Associations of Obstructive Respiratory Diseases with Modes of Physical Activity in Males.

	Walking		**Endurance Activities**		**Recreation Activities**		**Conventional Exercise**		**Sports**		**No Physical Activity**	
	OR	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**
Asthma (crude)	0.97	0.82-1.14	1.13	0.96-1.33	0.90	0.77-1.06	0.65	0.26-1.61	1.08	0.88-1.34	1.16	0.90-1.50
Asthma (adjusted)	0.94	0.80-1.11	1.08	0.92-1.30	0.90	0.76-1.05	0.61	0.25-1.54	1.03	0.83-1.28	1.20	0.93-1.56
COPD (crude)	0.80*	0.67-0.96	0.59*	0.47-0.72	0.69*	0.58-0.82	0.13	0.01-1.26	0.39*	0.27-0.55	1.72*	1.34-2.21
COPD (adjusted)	0.87	0.73-1.05	0.78*	0.62-0.96	0.74*	0.62-0.89	0.18	0.02-1.77	0.56*	0.39-0.80	1.50*	1.17-1.93
CAC (crude)	0.70*	0.54-0.92	0.37*	0.25-0.54	0.52*	0.40-0.69	0.57	0.10-3.13	0.19*	0.91-0.41	2.21*	1.55-3.14
CAC (adjusted)	0.78	0.59-1.03	0.48*	0.33-0.70	0.56*	0.43-0.73	0.83	0.15-4.59	0.27*	0.13-0.58	1.93*	1.35-2.75
No Obstructive Respiratory Diseases	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent

COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; OR: odds ratio; CI: confidence interval.
*$p<0.05$.
Models were adjusted for age, sex, smoking history, and BMI.

Table 2c: Associations of Obstructive Respiratory Diseases with Modes of Physical Activity in Females.

	Walking		**Endurance Activities**		**Recreation Activities**		**Conventional Exercise**		**Sports**		**No Physical Activity**	
	OR	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**
Asthma (crude)	1.14*	1.00-1.30	1.07	0.95-1.22	0.90	0.80-1.00	1.10	0.78-1.57	1.11	0.88-1.41	1.01	0.84-1.20
Asthma (adjusted)	1.10	0.96-1.26	1.02	0.90-1.16	0.87*	0.78-0.98	1.03	0.72-1.46	1.05	0.83-1.33	1.06	0.89-1.27
COPD (crude)	0.51*	0.44-0.60	0.48*	0.39-0.59	0.54*	0.47-0.63	0.47*	0.24-0.93	0.39*	0.24-0.64	2.23*	1.86-2.67
COPD (adjusted)	0.62*	0.53-0.72	0.61*	0.50-0.76	0.59*	0.51-0.69	0.73	0.37-1.45	0.54*	0.33-0.88	1.79*	1.48-2.15
CAC (crude)	0.50*	0.41-0.60	0.39*	0.29-0.52	0.47*	0.38-0.57	0.16*	0.03-0.73	0.41*	0.22-0.76	2.71*	2.17-3.38
CAC (adjusted)	0.58*	0.48-0.71	0.46*	0.34-0.63	0.50*	0.41-0.60	0.22	0.05-1.02	0.51*	0.27-0.96	2.29*	1.83-2.87
No Obstructive Respiratory Diseases	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent

COPD: chronic obstructive pulmonary disease; CAC: combination of asthma and COPD; OR: odds ratio; CI: confidence interval.
*p<0.05.
Models were adjusted for age, sex, smoking history, and BMI.

CHAPTER 5: GENERAL DISCUSSION

5.1.0 THESIS SUMMARY AND INSIGHTS

Objective 1. The primary objective of this thesis was to determine physical activity levels, and the association between physical activity levels and cardiometabolic disease risk factors in those with asthma, COPD, and those who have a combination of both asthma and COPD (CAC).

Hypothesis 1. It was hypothesized that adults with CAC would be the least physically active among those with asthma, COPD and no obstructive respiratory disease. It was further hypothesized that adults with asthma, COPD, and CAC who were inactive would be more likely to have cardiometabolic disease risk factors compared to inactive adults.

Our findings show that: 1) the majority of adults with COPD or CAC were inactive, and had higher odds of engaging in no physical activity when compared to adults without respiratory disease, 2) adults with CAC or COPD who were active were more likely to report better cardiometabolic outcomes than those who were inactive, and 3) those active with asthma had the lowest odds of hypertension, and were less likely to have a BMI $\geq 25 kg/m^2$. Therefore, based on our findings, our first hypothesis was supported.

Objective 2. The second objective of this thesis was to investigate the modes of physical activity in which adults with obstructive respiratory diseases engage, and to explore these associations separately in males and females.

Hypothesis 2. It was hypothesized that walking would be the most preferred physical activity among adults with asthma, COPD, and CAC. It was also hypothesized that reported physical activity levels and modes of physical activity would differ in males and females with asthma, COPD, and CAC.

Our findings show that: 1) walking was the most reported mode of physical activity among all groups, and 2) males and females with asthma, COPD, and CAC had different magnitudes of participation in different activities. Both males and females with CAC and COPD had high odds of engaging in no physical activity; while females with CAC and COPD were less likely to participate in walking and recreational activities compared to females without respiratory disease. Significant differences were only noted for recreational activities in females with asthma. Males with CAC and COPD also were less likely to participate in sports and endurance activities; for males with asthma, there were no significant differences in the modes of activities. Thus, our second hypothesis was supported based on our findings.

Research has shown that disease burden [1, 2], as well as age and sex differences [3, 4]**,** tend to influence physical activity levels; thus, these factors may help explain some of our findings. For example, individuals with asthma are less likely to engage in physical activity due to the possibility of eliciting respiratory symptoms, such as coughing, wheezing, dyspnea, and/or chest tightness [1]. Therefore, the burden of respiratory-related symptoms can be a barrier for adoption and maintenance of regular physical activity among those with obstructive respiratory diseases.

5.1.1 Respiratory Disease Burden & Physical Activity

Individuals with CAC may have a greater disease burden than those with asthma or COPD alone. Previous research has reported that those with CAC have more frequent and more severe exacerbations (adverse symptoms), and respiratory symptoms such as wheezing and dyspnea compared to individuals with COPD or asthma [5, 6]. This may explain why a large percentage of this population remains inactive, and are more likely to report "no physical activity". Exercise has been shown to induce respiratory symptoms among those with COPD [7], and as a result, individuals with obstructive respiratory disease tend to avoid physical activity for fear of triggering symptoms[8]. This population may also be more physically deconditioned and experience a greater decline in musculoskeletal strength [2]. In fact, COPD is associated with peripheral muscle weakness [9] and wasting [10], and as a result, can limit the ability to engage in such activities [2]. Thus, certain modes of physical activity may be avoided, as endurance activities and sports could be too strenuous for this population.

In addition, with greater disease severity, these individuals could be more sensitive to allergens and pollutants. Therefore, recreational activities and outdoor sports, may be avoided due to airway irritants such as allergens, urban air pollution, and chlorine from swimming pools [11]. Disease burden and severity of respiratory symptoms can be reduced with regular use of medication [12]. However, research has shown that adherence to respiratory medication is low among individuals with obstructive respiratory disease [13]. Thus, interventions and guidelines should stress the importance of medication adherence in order to lessen the burden of respiratory disease and to improve physical activity levels. It is also evident that the current methods of promoting physical activity among those with obstructive respiratory diseases are not effective. In Canada, only 0.4% of all Canadians with COPD have access to pulmonary rehabilitation that includes supervised physical activity programs [14]. This is important as it may affect participation among those with severe disease. Exercise interventions and community-based programs should strive to incorporate various modes of physical activity into their programming to ensure long-term adherence to guidelines

5.1.2 Age Differences & Physical Activity

In our sample, a large proportion of those with asthma were middle-aged and had similar physical activity levels and preferences to those without respiratory disease. On the other hand, the majority of those with COPD and CAC were older adults, were less physically active, and engaged in fewer modes of physical activity. Thus, it is possible that age differences account for some of the differences observed between groups.

As adults age, they typically begin to transition from being physically active to adopting a more sedentary lifestyle [15]. There are clear differences in physical activity between middle-aged and older adults. In terms of the duration of physical activity, Troiano and colleagues [16] showed that middle-aged adults obtained less than 2 minutes of vigorous-intensity activity per day, while older adults (aged 60 years and older) had engaged in none. Evidence also shows a sharp decline in frequency and intensity of physical activity after age 75 [17]. A possible explanation for the age difference seen in physical activity could be due to barriers such as poor health, reduced strength and endurance, diminished pulmonary function, and functional limitations, which may hinder their ability to perform exercise [18]. However, physical activity has been shown to counteract these barriers. In fact, physical activity slows the decline of functional fitness and muscular strength associated with aging, and prevents the development of risk factors for cardiovascular disease [19].

With respect to the mode of physical activity, participating in endurance activities (swimming and cycling), sports (cross-country skiing), and recreational activities (dancing and gardening), are typically lower in older adults [15, 20]. However, engaging in walking, home-based exercises, and supervised exercise classes at a center, are common among this population [15, 20]. Walking and conventional exercises are noted to be convenient, and are easily carried out in familiar environments such as at home, or a recreational center [15].

In order to develop effective physical activity interventions for adults with CAC and COPD, it is important to take into consideration the differences in physical activity characteristics that exist among middle-aged and older adults. Older adults with CAC and COPD experience functional declines and reduced pulmonary function to a greater extent [5, 6, 21]. Therefore reintroducing endurance, sports, and recreational activities among these subgroups may require longer supervised periods, but, such programming has the potential to increase adherence to physical activity, and therefore, should not be ignored.

5.1.3 Sex Differences & Physical Activity

We treated sex as an effect modifier in our analysis based on previous research [22, 23], and the Canadian Institutes for Health Research Sex and Gender Based Analysis recommendations [24]. Therefore, males and females are discussed separately below.

Males & Physical Activity. Research has shown that healthy males are typically more physically active than females [3]. In terms of physical activity preferences, males tend to engage in more activities, including sports [25, 26]. However, our findings show that males with CAC and COPD were less likely to participate in sports and endurance activities than adults without respiratory disease. In addition to the disease state itself, age might explain sport and endurance activity participation in this sample. Evidence indicates an inverse relationship between sport participation and age, in healthy males [25]. In addition, environmental factors may influence outdoor sport and endurance activity participation. Current guidelines advise those with COPD to avoid areas with high urban air pollution, as it is deemed harmful to their respiratory health [11]. Lastly, sports and endurance activities may also be too strenuous for those with respiratory diseases [27]. Therefore, age, intensity of activity, and the environment may serve as an explanation for low sport and endurance activity participation in males with COPD and CAC.

Females & Physical Activity. Healthy females tend to be less physically active, and engage in fewer modes of physical activity compared to males [3, 4]. In a longitudinal study, Päivi and colleagues [15] showed that as females aged there was a significant decline in the amount of individuals that considered physical activity to be very important. In addition, research showed that females who participated in a cardiac rehabilitation program perceived more barriers to exercise than males; their illness being the most influential barrier on physical activity participation [28]. These findings may also be applicable to females with obstructive respiratory diseases, as symptoms such as dyspnea have been shown to be a barrier to exercise in individuals with COPD [29].

However, this population has much to benefit from physical activity. In fact, various modes of physical activity have been shown to benefit females, especially in those that are older. In a randomized controlled trial, strengthening activities have been shown to improve bone mineral density and strength in females aged 50 to 70 years [30]. This is particularly relevant to those with COPD given their physical deconditioning. Endurance training has also been shown to improve exercise capacity, and reduce the risk of cancer and osteoporosis in post-menopausal women [31]; while participation in sports and other moderate leisure time physical activity are inversely related to all-cause mortality in females [32].

Research has shown that females with asthma have worse asthma-related quality of life, higher perception of dyspnea, and more physical limitations than males with asthma [33-35]. Similarly, females with COPD have more severe dyspnea, lower health-related quality of life, and have a greater risk of developing osteoporosis [36-38]. Given that the prevalence of asthma, COPD, and CAC is higher in females, there is clearly a need for sex-specific treatment strategies among those with obstructive respiratory diseases.

5.2.0 STUDY IMPLICATIONS

Results from this study provide novel insight into the physical activity behavior of adults with obstructive respiratory diseases, and have important implications for guidelines and future exercise interventions. Firstly, guidelines should continue to encourage this population to be physically active, while stressing the importance of reducing risk factors for comorbidities. Future guidelines should also strongly encourage this population to pursue various modes of physical activities. Although walking and conventional exercises provide great physiological benefit to this population, these activities lack the intensity, and the high level of social engagement and enjoyment associated with recreational and sport activities. This in turn, increases the likelihood of adhering to physical activity long term. Secondly, exercise interventions lack diversity in physical activities, and fail to incorporate activities this population enjoys and currently engage in. Including recreational activities into exercise interventions allows individuals to engage in activities that are similar to their hobbies, creates a social outlet, and improves physical activity enjoyment. Third, exercise interventions such as pulmonary rehabilitation also need to address the age and sex differences that occur in physical activity behaviour. In terms of age differences, exercise interventions need to be tailored to accommodate the different barriers, physical activity levels, and preferences of middle-aged and older adults. There is also a need for sex-specific exercise interventions to address the gaps seen between males and females in order to improve long term adherence to physical activity. It is evident that both males and females have lower physical activity levels; while females engage in fewer types of activities compared to males. Therefore, exercise interventions that are specific to females with obstructive respiratory diseases, would provide more effective opportunities to increase physical activity and disease management in this population.

Overall, findings from this study have important implications for improving current exercise interventions. These findings may also aid in the development of exercise guidelines and exercise prescription for adults with obstructive respiratory diseases.

5.3.0 FUTURE RESEARCH

Our study was the first to investigate the characteristics of physical activity and its association with health among adults with obstructive respiratory diseases. Thus, our findings set the stage for several future investigations among this population.

Our findings show those with COPD and CAC had the lowest participation in all modes of physical activity examined, and the highest odds of physical inactivity; while adults with asthma do not differ from the general population. A solution may be to incorporate physical activities that this population enjoys and currently engage in. Future research is needed to better understand the influence of incorporating preferred modes of physical activity into pulmonary rehabilitation and community exercise programs to increase adherence.

In our study, we had analyzed the association between modes of physical activity and obstructive respiratory disease. Both males and females with COPD and CAC were more likely to engage in “no physical activity”, and had lower odds of participating in various modes of physical activity. Our study sets the stage for future research that focuses on creating sex-specific exercise interventions.

Evidence suggests that individuals with CAC, or an overlap of the two diseases (asthma-COPD overlap syndrome) are difficult to treat and have worse health outcomes than those with asthma or COPD only [5, 6]. Although our study investigated adults with CAC, our findings may have implications for exercise guidelines and prescription in those with asthma-COPD overlap syndrome. Thus, future research is needed to investigate the association between physical activity levels and cardiometabolic disease risk factors in those with asthma-COPD overlap syndrome, as well as to explore preferred modes of physical activity in this population.

5.4.0 STRENGTHS

There are many noteworthy strengths in this study. Firstly, the CCHS consists of data from respondents living in all provinces and territories, and accounts for approximately 98% of the Canadian population [39]; thus, our findings were based on a large representative sample of Canadian adults aged 45 years and older. Secondly, population weights were modified and reapplied to correct variance estimates, and to eliminate the risk of groups being over or under represented. Third, variables such as physical activity were recoded into binary variables (*active* and *inactive)*, and modes of physical activity were grouped into categories (*walking, endurance activities, recreation activities, conventional exercises, and sports*), in order to simplify interpretation of findings.

5.5.0 LIMITATIONS

There are also some limitations in this study that are worth highlighting. The primary limitation of this study is that the CCHS is cross-sectional, thus, reverse-causality cannot be ruled out. Studies show that in chronic conditions such as cardiovascular disease, low levels of physical activity lead to the progression of disease [40]. However, in the case of respiratory diseases such as asthma and COPD, longitudinal studies have shown that the disease itself combined with risk factors including smoking history, lead to the deterioration of exercise capacity and low levels of physical activity

[41, 42]. Another longitudinal study had shown that physical activity leads to the decreased risk of hypertension and good perceived health [43]. The CCHS only contains self-reported data; thus all variables, including physical activity levels, and modes of physical activity, are subject to misclassification and response bias. However, self-reported physical activity has been shown to be valid and reliable [44-46]. Lastly, the CCHS does not provide information on respiratory disease severity, age of diagnosis, types of medications, or other management variables, thus, they could not be accounted for in our analyses.

5.6.0 SIGNIFICANCE OF THE STUDY

To our knowledge, this study was the first to investigate physical activity levels and modes of physical activity among Canadian adults with obstructive respiratory disease. Our findings provide a greater understanding of physical activity preferences, and propose methods of increasing physical activity levels among this population. Our study also sets the stage for future work investigating age and sex differences in physical activity among those with obstructive respiratory diseases. Lastly, our findings have important implications for guidelines and future exercise interventions, in order to successfully improve physical activity adherence among this population

5.7.0 REFERENCES

1. Mancuso, C.A., et al., *Barriers and Facilitators to Healthy Physical Activity in Asthma Patients.* Journal of Asthma, 2006. **43**(2): p. 137-143.
2. Gosselink, R., T. Troosters, and M. Decramer, *Peripheral Muscle Weakness Contributes to Exercise Limitation in Copd.* American journal of respiratory and critical care medicine, 1996. **153**(3): p. 976-980.
3. *Prevalence of Health-Care Providers Asking Older Adults About Their Physical Activity Levels--United States, 1998.* MMWR Morb Mortal Wkly Rep, 2002. **51**(19): p. 412-4.
4. *Healthy People 2010: Understanding and Improving Health. Us Government Printing Office*. 2000, US Department of Health Human Services: Washington, DC.
5. Barrecheguren, M., C. Esquinas, and M. Miravitlles, *The Asthma–Chronic Obstructive Pulmonary Disease Overlap Syndrome (Acos): Opportunities and Challenges.* Current opinion in pulmonary medicine, 2015. **21**(1): p. 74-79.
6. Menezes, A.M.B., et al., *Increased Risk of Exacerbation and Hospitalization in Subjects with an Overlap Phenotype: Copd-Asthma.* CHEST Journal, 2014. **145**(2): p. 297-304.
7. Troosters, T., et al., *Improving Physical Activity in Copd: Towards a New Paradigm.* Respir Res, 2013. **14**(1): p. 115.
8. Amorim, P.B., et al., *Barriers Associated with Reduced Physical Activity in Copd Patients.* Jornal Brasileiro de Pneumologia, 2014. **40**(5): p. 504-512.
9. Franssen, F., et al., *Limb Muscle Dysfunction in Copd: Effects of Muscle Wasting and Exercise Training.* Medicine and science in sports and exercise, 2005. **37**(1): p. 2-9.
10. Debigare, R., C.H. Cote, and F. Maltais, *Peripheral Muscle Wasting in Chronic Obstructive Pulmonary Disease: Clinical Relevance and Mechanisms.* American Journal of Respiratory and Critical Care Medicine, 2001. **164**(9): p. 1712-1717.
11. *Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease*. 2017, Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD).
12. Dryden, D.M., et al., *Exercise-Induced Bronchoconstriction and Asthma.* 2010.
13. Bidwal, M., et al., *Evaluation of Asthma Medication Adherence Rates and Strategies to Improve Adherence in the Underserved Population at a Federally Qualified Health Center.* Research in Social and Administrative Pharmacy, 2016.
14. Camp, P.G., et al., *Pulmonary Rehabilitation in Canada: A Report from the Canadian Thoracic Society Copd Clinical Assembly.* Canadian respiratory journal, 2015. **22**(3): p. 147-152.
15. Päivi, M., H. Mirja, and P. Terttu, *Changes in Physical Activity Involvement and Attitude to Physical Activity in a 16-Year Follow-up Study among the Elderly.* Journal of aging research, 2010. **2010**.
16. Troiano, R.P., et al., *Physical Activity in the United States Measured by Accelerometer.* Medicine and science in sports and exercise, 2008. **40**(1): p. 181.

17. Frisard, M.I., et al., *Physical Activity Level and Physical Functionality in Nonagenarians Compared to Individuals Aged 60-74 Years.* J Gerontol A Biol Sci Med Sci, 2007. **62**(7): p. 783-8.
18. Rasinaho, M., et al., *Motives for and Barriers to Physical Activity among Older Adults with Mobility Limitations.* J Aging Phys Act, 2007. **15**(1): p. 90-102.
19. Sattelmair, J.R., J.H. Pertman, and D.E. Forman, *Effects of Physical Activity on Cardiovascular and Noncardiovascular Outcomes in Older Adults.* Clinics in geriatric medicine, 2009. **25**(4): p. 677-702.
20. Armstrong, G.K. and K. Morgan, *Stability and Change in Levels of Habitual Physical Activity in Later Life.* Age and Ageing, 1998. **27**(suppl 3): p. 17-23.
21. Andersén, H., et al., *High Hospital Burden in Overlap Syndrome of Asthma and Copd.* The clinical respiratory journal, 2013. **7**(4): p. 342-346.
22. JaKa, M.M., et al., *Describing the Relationship between Occupational and Non-Occupational Physical Activity Using Objective Measurement.* Preventive medicine reports, 2015. **2**: p. 213-217.
23. Pitanga, F.J.G. and I. Lessa, *Relationship between Leisure-Time Physical Activity and Blood Pressure in Adults.* Arquivos brasileiros de cardiologia, 2010. **95**(4): p. 480-485.
24. Heidari, S., et al., *Sex and Gender Equity in Research: Rationale for the Sager Guidelines and Recommended Use.* Research Integrity and Peer Review, 2016. **1**(1): p. 2.
25. *Sport Participation 2010*. 2013, Canadian Heritage: Ottawa, Ontario.
26. Lee, Y.S., *Gender Differences in Physical Activity and Walking among Older Adults.* J Women Aging, 2005. **17**(1-2): p. 55-70.
27. Watz, H., et al., *Physical Activity in Patients with Copd.* European Respiratory Journal, 2009. **33**(2): p. 262-272.
28. Lieberman, L., M. Meana, and D. Stewart, *Cardiac Rehabilitation: Gender Differences in Factors Influencing Participation.* Journal of women's health, 1998. **7**(6): p. 717-723.
29. Thorpe, O., S. Kumar, and K. Johnston, *Barriers to and Enablers of Physical Activity in Patients with Copd Following a Hospital Admission: A Qualitative Study.* Int J Chron Obstruct Pulmon Dis, 2014. **9**(1): p. 115-128.
30. Nelson, M.E., et al., *Effects of High-Intensity Strength Training on Multiple Risk Factors for Osteoporotic Fractures. A Randomized Controlled Trial.* Jama, 1994. **272**(24): p. 1909-14.
31. Wang, C.-H., et al., *Effects of Endurance Exercise Training on Risk Components for Metabolic Syndrome, Interleukin-6, and the Exercise Capacity of Postmenopausal Women.* Geriatric Nursing, 2014. **35**(3): p. 212-218.
32. Andersen, L.B., et al., *All-Cause Mortality Associated with Physical Activity During Leisure Time, Work, Sports, and Cycling to Work.* Archives of internal medicine, 2000. **160**(11): p. 1621-1628.
33. McCallister, J.W., et al., *Sex Differences in Asthma Symptom Profiles and Control in the American Lung Association Asthma Clinical Research Centers.* Respir Med, 2013. **107**(10): p. 1491-500.

34. Chhabra, S.K. and P. Chhabra, *Gender Differences in Perception of Dyspnea, Assessment of Control, and Quality of Life in Asthma.* Journal of Asthma, 2011. **48**(6): p. 609-615.
35. Sinclair, A.H. and D.D. Tolsma, *Gender Differences in Asthma Experience and Disease Care in a Managed Care Organization.* J Asthma, 2006. **43**(5): p. 363-7.
36. de Torres, J.P., et al., *Gender and Copd in Patients Attending a Pulmonary Clinic.* Chest Journal, 2005. **128**(4): p. 2012-2016.
37. Aryal, S., E. Diaz-Guzman, and D.M. Mannino, *Copd and Gender Differences: An Update.* Translational Research, 2013. **162**(4): p. 208-218.
38. Agusti, A., et al., *Characterisation of Copd Heterogeneity in the Eclipse Cohort.* Respiratory research, 2010. **11**(1): p. 122.
39. *Canadian Community Health Survey, a Guide to Accessing and Interpreting the Data*. 2004 ed. 2006: Health Canada.
40. Taylor, R.S., et al., *Exercise-Based Rehabilitation for Patients with Coronary Heart Disease: Systematic Review and Meta-Analysis of Randomized Controlled Trials.* The American journal of medicine, 2004. **116**(10): p. 682-692.
41. Oga, T., et al., *Exercise Capacity Deterioration in Patients with Copd: Longitudinal Evaluation over 5 Years.* CHEST Journal, 2005. **128**(1): p. 62-69.
42. Bestall, J., et al., *Longitudinal Trends in Exercise Capacity and Health Status after Pulmonary Rehabilitation in Patients with Copd.* Respiratory medicine, 2003. **97**(2): p. 173-180.
43. Shuval, K., et al. *Sedentary Behavior, Cardiorespiratory Fitness, Physical Activity, and Cardiometabolic Risk in Men: The Cooper Center Longitudinal Study*. in *Mayo Clinic Proceedings*. 2014. Elsevier.
44. Ainsworth, B.E., et al., *Accuracy of the College Alumnus Physical Activity Questionnaire.* Journal of clinical epidemiology, 1993. **46**(12): p. 1403-1411.
45. Albanes, D., et al., *Validation and Comparison of Eight Physical Activity Questionnaires.* Epidemiology, 1990: p. 65-71.
46. Simpson, K., *Validity and Reliability of the Paffenbarger Physical Activity Questionnaire among Healthy Adults.* University of Connecticut, 2011.