ATHABASCA UNIVERSITY

ACCELEROMETER-DETERMINED PHYSICAL ACTIVITY AND SEDENTARY TIME AMONG LUNG CANCER SURVIVORS: ASSOCIATIONS WITH HEALTH-RELATED QUALITY OF LIFE AND FATIGUE

BY

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Abstract

The purpose of this study was to determine associations between objectively assessed physical activity and sedentary time with health-related quality of life and fatigue among lung cancer survivors. We also examined demographic and clinical correlates of physical activity and sedentary time. In total, 127 lung cancer survivors wore an Actigraph® GT3X+ accelerometer on their hip for seven days and completed a mailed questionnaire. Lung cancer survivors were not engaged in meaningful amounts of moderate-to-vigorous intensity physical activity and also engaged in high amounts of sedentary time. Engaging in physical activity was positively associated with better patient-reported outcomes, while negative associations were found with sedentary time. Older and overweight lung cancer survivors with a smoking history who were more than five years post diagnosis were found to be less active and more sedentary. Strategies specifically designed for this population are needed to increase their physical activity levels and decrease sedentary time.

Keywords: health-related quality of life, physical activity, sedentary time, lung cancer survivors, accelerometers

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List of Abbreviations

FACT-L = Functional Assessment of Cancer Therapy-Lung

FS = Fatigue Scale

HRQoL = Health-related Quality of Life

LCS = Lung cancer-specific symptoms

METs = Metabolic equivalents

MVPA = Moderate-to-vigorous physical activity

NSCLC = Non-small cell lung cancer

PROs = Patient reported outcomes

TOI-L = Total Outcome Index-Lung

CHAPTER I — Introduction

The existing literature suggests that physical activity is a safe and feasible way to positively influence health-related quality of life (HRQoL) among cancer survivors. While there is a strong body of literature regarding the benefits of physical activity in individuals with cancer, and several studies examining the relationship in lung cancer patients, limited research exists for lung cancer survivors, particularly using objective measures to measure physical activity and sedentary time. To date, most studies on physical activity and/or sedentary time, and health outcomes in lung cancer patients and survivors have been measured using self-report, which may bias results and lead to incorrect conclusions regarding these behaviors. Objective measurements are believed to increase the accuracy of documenting physical activity and sedentary time. Other tumor groups have successfully eliminated bias of self-report data by objectively measuring physical activity and sedentary behavior with the use of accelerometers. These studies found that accelerometers provide accurate, precise, and reliable objective measurement of physical activity and sedentary time. Studies examining the association between objectively assessed physical activity and sedentary time with HRQoL among lung cancer survivors are currently lacking. This study will be only the second to provide evidence regarding objective measures of physical activity and sedentary time prevalence among lung cancer survivors and the first study to document associations of these behaviors with patient-reported outcomes in this population.

Lung cancer survivors report a lower HRQoL compared to all other cancer survivors. The standard interventions aimed at improving HRQoL are limited by short-term relief and are unable to manage physical symptoms such as fatigue. Achieving

recommended physical activity levels of at least 150 minutes of moderate-to-vigorous physical activity (MVPA) has been shown to improve HRQoL among other cancer groups. Similarly, achieving sufficient levels of physical activity may be important for lung cancer survivors as it may positively influence their HRQoL, and potentially, survival. Time spent in sedentary behavior, which is distinct from physical inactivity, has also been associated with poorer HRQoL in some cancer survivor studies, but not others. Determining the associations of physical activity and sedentary behavior with HRQoL and fatigue among lung cancer survivors may facilitate health promotion efforts and aid in development of future physical activity and sedentary behavior guidelines.

The primary aim of this study was to use objective measures determine the prevalence of physical activity and sedentary time among lung cancer survivors living in Southern Alberta. The secondary aims were to (a) determine associations between objectively assessed physical activity and sedentary time with health outcomes including HRQoL and fatigue and (b) examine demographic and clinical correlates of physical activity and sedentary time in this population. The following terms are operationally defined for the purposes of this study:

a. **Lung cancer survivors:** Individuals diagnosed with lung cancer that continue to live with or without the disease, but are currently not receiving chemotherapy or radiation for their lung cancer, or any other cancer.
b. **Health-related quality of life (HRQoL):** HRQoL is the individual's evaluation of the effect of disease or treatment on functional status, physical symptoms, affective state, and interpersonal relations.

c. **Physical activity:** Any activity bout that lasts longer than 10 minutes duration including light-effort activities (such as easy walking), moderate-effort activities (such as non-exhausting activities like brisk walking or easy bicycling), and strenuous-effort activities (such as activities that cause a rapid heart rate and sweating like jogging or aerobics classes). For accelerometer data processing, commonly accepted activity count cutoffs are used to categorize light-intensity activity (100-1,951 counts/minute) and MVPA (≥1,952) from counts/minute).

d. **Sedentary time:** Sedentary time consists of time spent in activities low in energy expenditure (e.g., watching television, sitting at a computer). Sedentary time may be spent as sitting or reclining in the energy-expenditure range of 1.0 to 1.5 metabolic equivalents (METs). Time spend sedentary is different from physical inactivity (i.e., performing insufficient amounts of moderate-to-vigorous physical activity). For accelerometer data processing, commonly accepted activity count cutoffs were used to categorize sedentary time (<100 counts/minute).

CHAPTER II — Literature Review

Lung Cancer

Lung cancer is the second most commonly diagnosed cancer in men and women accounting for approximately 14% of all cancer diagnoses (American Cancer Society, 2016). In Canada, approximately 26,600 people were expected to be diagnosed with lung cancer in 2015 (Canadian Cancer Society, 2015a). Lung cancer is also the leading cause of cancer deaths for both men and women in Canada (Canadian Cancer Society, 2015a). It is estimated that 73 Canadians are diagnosed with lung cancer every day, while 57 Canadians will die from lung cancer daily (Canadian Cancer Society, 2015a). Non-small cell lung cancer (NSCLC) compromises 85% of lung cancer cases. NSCLC is characterized by slower growth compared to small-cell lung cancer, which represents 15% of cases. Five-year survival rates remain low at 17% (Canadian Cancer Society, 2015a) and survival has not improved significantly despite newer therapies (Wang et al., 2015). Smoking remains the most prominent risk factor for lung cancer, yet approximately 15% of the Canadian population continues to smoke.

Lung cancer survivors are defined as individuals diagnosed with lung cancer who continue to live with or without the disease. Often, cancer survivors are classified as either short-term survivors for those less than five years post diagnosis and long-term survivors for those five or more years post diagnosis. Most lung cancer survivors are diagnosed with early stage disease, for which primary treatment is surgical resection (Molina, Yang, Cassivi, Schild, & Adjei, 2008). Other treatments include chemotherapy and radiation, and both therapies are associated with numerous side effects. Side effects can occur with any type of chemotherapy regimen and some of the most common side

effects include fatigue, pain, nausea and vomiting, diarrhea, loss of appetite, bone marrow suppression, rashes, nervous system and kidney damage, blood clots, hair loss, and depression (Loprinzi et al., 2007; Nicholson, 2005). Neurological complications of chemotherapy include memory loss, cognitive dysfunction, seizures, vision loss, and dementia, amongst others (Csoka & Szyf, 2009; Jackson, 2008). Most side effects are temporary during or shortly post-treatment, but some side effects may continue for long periods of time or become permanent. Most common long-term chemotherapy side effects include chronic fatigue, musculoskeletal complaints, poor sleep, skin changes, poor memory and concentration, and sexual dysfunction (MacCormick, 2006).

Shortness of breath, dry cough, difficulty swallowing, skin reactions, hair loss, drowsiness, fatigue, confusion, headaches, nausea, vomiting, and fatigue are associated with radiation. As with chemotherapy, side effects from radiation can persist for extended periods of time (i.e., several years) and may cause permanent damage (Canadian Cancer Society, 2015b). Lung cancer survivors also commonly experience comorbid chronic diseases such as chronic obstructive pulmonary disease (Wang et al., 2015). A variety of these chronic comorbid diseases and post-treatment symptoms impair multiple quality of life dimensions in lung cancer survivors (Coups et al., 2009). Gift, Jablonski, Stommel, and Given (2004) found that lung cancer patients with advanced stage disease with more comorbidities and who are treated with chemotherapy are most likely to have multiple symptoms. The more comorbidities and symptoms a lung cancer patient has, the more severe and limiting the symptoms are perceived to be (Gift et al., 2004). The combination of treatment side effects and multiple comorbidities have a major impact on lung cancer survivors' HRQoL (Ostroff et al., 2011; Sigimura & Yang, 2006).

Health-related Quality of Life

Quality of life is defined as a multidimensional construct incorporating the physical, social, emotional, and functional aspects of well-being whereas HRQoL focuses on the impact health status has on quality of life (Rummans, Bostwich, & Clark, 2000). For cancer survivors, Cooley (1998) defined HRQoL as the person's evaluation of the effect of disease or treatment on functional status, physical symptoms, affective state, and interpersonal relations. Lung cancer survivors report significantly poorer HRQoL than survivors of other cancers (Sigimura & Yang, 2006) and even long-term survivors experience HRQoL impairment (approximately 35%) (Ostroff et al., 2011). Ostlund, Wennman-Larsen, Gustavsson, and Wengstrom (2007) found that both emotional and physical functioning were important predictors of HRQoL in lung cancer patients. Therefore, it is essential that both emotional and physical well-being be considered as components of HRQoL in lung cancer survivors.

HRQoL diminishes due to uncertainty and fear of the future, lingering long-term effects of cancer treatments, altered sexuality and self-image, economic problems, and family distress (Mellon, 2002). Montazeri, Milroy, Hole, McEwen, and Gillis (2003) studied HRQoL in newly diagnosed lung cancer patients, majority of whom underwent treatment for their lung cancer. They reported decreased quality of life on all scales, with significant deficits in physical functioning related to mobility and fatigue. Fatigue has been identified as the most distressing symptom that may have the greatest effect on HRQoL in patients with lung cancer (John, 2010). Several other studies have identified fatigue as the most commonly reported symptom associated with lung cancer (Cooley, Short, & Moriarty, 2003; Gift et al., 2004). Fatigue, pain, and insomnia were found to be

the most prevalent and most distressing symptoms in women with primary and recurrent lung cancer (John, 2010). The strategy most frequently used by individuals with lung cancer to manage their fatigue was rest and sleep, but this strategy was found to be ineffective. HRQoL studies amongst other tumor groups reveal similar findings. For instance, Harandy et al. (2010) found that physical problems such as pain and fatigue have the most degree of interference with normal daily activities and HRQoL in breast cancer survivors.

Although some symptoms and HRQoL impairments eventually improve for lung cancer survivors, multiple deficits in psychological well-being and physical functions persist for several years (Sigimura & Yang, 2006). Lung cancer survivors have identified improved HRQoL to be as important as the extent of their survival (Rummans et al., 2000). Further, poor HRQoL has been found to lead to premature death (Rummans et al., 2000). Although the importance of HRQoL as a specific management objective has been identified in other cancer survivors, research on the subject in lung cancer has been relatively limited. In view of the high symptom burden and severe morbidity, understanding what factors may improve HRQoL becomes important in lung cancer survivors (Ediebah et al., 2014).

HRQoL Interventions

Several interventions have been associated with psychosocial adjustment and improved HRQoL, however the impact of these interventions is limited. Rueda, Sola, Pascual, and Subirana Casacuberta (2011) conducted a review of thirteen trials exploring non-invasive interventions for improving HRQoL in patients with lung cancer. Four trials assessed structured nursing programs. One trial found positive effects on delay in clinical

deterioration, dependency and symptom distress, and improvements in emotional functioning and satisfaction with care. Three trials of nursing interventions to manage breathlessness showed benefit in symptom experience, performance status, and emotional functioning. Three trials assessed the effect of different psychotherapeutic, psychosocial, and educational interventions. One trial showed counselling may benefit some emotional components of the illness, but the findings were not conclusive. One trial found that although pain coaching increases the amount of pain data communicated by lung cancer patients, the magnitude of the effect is small and does not lead to improved efficacy of analgesics prescribed for each patient's pain level. One trial found that patients in telephone-based sessions of either caregiver-assisted coping skills training or education/support involving the caregiver showed improvements in pain, depression, quality of life, and self-efficacy. One nutritional trial intervention found positive effects for increasing energy intake, but no improvement in HRQoL.

In conclusion, structured nursing programs, psychotherapeutic, psychosocial, spiritual, educational, and nutritional interventions may play a role in improving HRQoL in lung cancer survivors. These interventions mainly improve emotional symptom management, often with only short-term beneficial effects, without the ability to manage the physical symptoms such as pain and fatigue associated with long-term treatment side effects. Similar conclusions have been made from a meta-analysis of 62 trials by Meyer and Mark (1995) who found that psychological interventions have positive effects on emotional and functional adjustment linked to disease and treatment-related symptoms in adult cancer patients. However, Meyer and Mark (1995) add that most of these intervention studies do not have enough statistical power to detect interaction effect in

small sample sizes. These authors also state the aforementioned interventions may have some psychosocial benefit, but have little or no impact on the physical or functional aspects of recovery. With the limited evidence supporting psychosocial, educational, and other interventions aimed at improving HRQoL among lung cancer survivors, physical activity is one mode of rehabilitation that is emerging and that may play a valuable role in improving HRQoL and psychosocial, physical, and functional outcomes among lung cancer survivors (Schmitz et al., 2010).

Physical Activity and Sedentary Behavior

The American College of Sports Medicine recently established an expert panel and examined the evidence of the impact of physical activity on cancer survivors and concluded that physical activity is safe for cancer survivors both during and after treatment (American College of Sports Medicine, 2010). The panel recommended a minimum of 150 minutes of MVPA a week (defined as ≥3.0 METs). MVPA includes brisk walking, jogging, biking, or dancing. Achieving recommended levels of physical activity has been found to positively influence HRQoL and survival among lung cancer survivors (Granger et al., 2014). Overall, lung cancer survivors who are more active report higher HRQoL scores (Coups et al., 2009; Lin et al., 2013, Solberg et al., 2012).

Sedentary behaviors are activities low in energy expenditure. They have been conceptualized as sitting or reclining and are in the energy-expenditure range of 1.0 to 1.5 METs (Owen, 2012). Examples of time spent in sedentary behaviors include watching television or sitting at a computer station. Although some standing activities (standing quietly) require low energy expenditure (<1.5 METs), they are not considered sedentary behaviors as the individual is not in a seated posture. Moreover, sedentary behavior does

not include sleep, which has important restorative functions. Sedentary behaviors are not to be confused with physical inactivity (i.e., performing insufficient amounts of MVPA) (Sedentary Behavior Research Network, 2012).

Sedentary behavior has harmful health consequences that are distinct from the negative effects of physical inactivity (Owen, Sparling, Healy, Dunstan, & Matthews, 2010). Sedentary behavior has been linked to oxidative stress, insulin response, and disruptions of metabolic activity in muscle cells (Reich, Chen, Thompson, Hoffman, & Clarkson, 2010). According to Rezende, Lopes, Rey-Lopez, Matsudo, and Luiz (2014) sedentary behavior is an important determinant of health outcomes, independent of physical activity, and a growing body of evidence suggests that time spent in sedentary behaviors is positively associated with mortality (Chau et al., 2015; Katzmarzyk, Church, Craig, & Bouchard, 2009; Matthews et al., 2012).

Sedentary time has also been found to be an important correlate of HRQoL in cancer survivors such that HRQoL decreases with prolonged sedentary time (George et al., 2013, George et al., 2014; Phillips et al., 2015a; Phillips, Stampfer, Chan, Giovannucci, & Kenfield, 2015b). Given the infancy of this area of inquiry, it is important to note that it may be too early to make conclusions given some studies have reported no associations between sedentary time and psychosocial and HRQoL outcomes in cancer survivors (Vallance et al., 2014; 2015).

Physical Activity and Sedentary Time in Lung cancer

According to results from Coups et al. (2009), approximately two-thirds of lung cancer survivors do not meet national physical activity guidelines. Compared with less active lung cancer survivors, those who met physical activity guidelines reported better

HRQoL in multiple domains such a physical functioning, general heath, vitality, fatigue, and depression symptoms (Coups et al., 2009). Lin et al. (2013) reported similar findings indicating only 25% of lung cancer survivors achieve recommended guidelines. Lung cancer survivors who achieved recommended guidelines had significantly higher HRQoL scores compared to sedentary participants. Solberg et al. (2012) also found that lung cancer survivors tend to have a sedentary lifestyle at diagnosis and even several years post diagnosis. Individuals who decreased physical activity since diagnosis reported a decrease in overall HRQoL. In contrast, patients reporting increased physical activity since diagnosis reported an increase in HRQoL and symptom control. Granger et al. (2014) objectively assessed physical activity in 50 lung cancer survivors and found that these individuals engage in significantly less physical activity than similarly-aged healthy individuals. The proportion of lung cancer survivors meeting physical guidelines at diagnosis was 40% compared to 71% for healthy participants.

To date, only one study has examined sedentary time among lung cancer survivors. Cavalheri, Jenkins, Cecins, Phillips, Sanders, and Hill (2016) compared objectively measured sedentary time and physical activity between 20 NSCLC patients following curative intent treatment and 20 healthy controls. Compared to healthy controls, NSCLC survivors took fewer steps each day (8,863 vs. 11,856; p=.009). NSCLC survivors also accumulated more time in prolonged, uninterrupted sedentary time in bouts of 30 minutes (49% vs. 42%; p=.048), but there was no difference in total time spent in sedentary behavior. They also spent less time during waking hours in light-intensity physical activity (defined as 1.6 to <3 METs or 100-1951 counts per min; 21% vs. 26%; p=.040) and accumulated a lower percentage of time in this activity level in

uninterrupted bouts of 10 minutes (13% vs. 19%; p=.025). Time spent in MVPA was not different between groups (p= .920).

Associations between Physical Activity and Sedentary Time with HRQoL

A relatively small number of studies have examined physical activity and HRQoL in lung cancer survivors. Coups et al. (2009) studied the association between self-reported physical activity and HRQoL among 175 lung cancer survivors. Compared with less active lung cancer survivors, those who met the physical activity guidelines reported better HRQoL in multiple domains such a physical functioning, general heath, vitality, less dyspnea, fatigue, and fewer depression symptoms. Solberg et al. (2012) also used self-report measures to study the association between physical and HRQoL, but in a larger sample of 1937 long-term lung cancer survivors. Individuals who reported decreased physical activity since diagnosis also reported a decrease in mental, physical, emotional, social, spiritual well-being, as well as in overall HRQoL. In contrast, those who reported increased physical activity since diagnosis also reported an increase in their mental, physical, emotional, social, and spiritual, and overall HRQoL. Likewise, increased physical activity since diagnosis was associated with increased symptom control. A study by Lin et al. (2013) examined the relationship between self-reported physical activity and HRQoL in different cancer-treatment periods among 185 lung cancer patients. Results showed that patients that achieved recommended physical activity guidelines had significantly higher HRQoL scores. Patients who engaged in light (50.3%) or moderate physical activity (24.9%) also had significantly higher HRQoL scores than those who were considered sedentary. However, no differences were found between light and moderate activity groups. During active-treatment periods, patients

who engaged in light or moderate activity had significantly higher scores for the overall HRQoL compared to sedentary patients. However, during off-treatment periods, there were no significant differences in the overall HRQoL with different activity levels. Lin, Rau, and Lin (2015a) investigated the effect of self-reported physical activity on the physical and psychosocial symptoms of 122 lung cancer survivors. Significant differences were observed in fatigue, drowsiness, and disturbed sleep between the participants who engaged in more moderate physical activity versus those who were more sedentary. Engaging in light physical activity mitigated only some symptoms, such as nausea and shortness of breath, compared to no improvement in sedentary participants.

These studies indicated that physical activity may play an important role in alleviating the physical and psychological symptoms of lung cancer patients and survivors. Less active participants who do not meet the physical activity guidelines reported lower mental, physical, emotional, social, spiritual well-being, as well as lower overall HRQoL. Compared with less active lung cancer survivors, those who met the physical activity guidelines reported better HRQoL and symptom control. Moreover, participants who engaged in light physical activity also reported significantly higher HRQoL scores and improvement in some symptoms compared to those who were sedentary. However, no differences were found between light and moderate activity groups. Further, it is difficult to judge the validity of these findings given all activity assessments were based on self-report, and not objectively assessed.

Benefits of light-intensity physical activity

Lung cancer is largely a disease of older adults, with median age at diagnosis of 71 years (Coups et al., 2009). The World Health Organization recommends that adults

over 65 years of age and older engage in 150 minutes of MVPA per week (World Health Organization, 2010). The same guidelines apply for cancer survivors over 65 years of age (Schmitz et al., 2010). Lung cancer survivors with advanced-stage disease and those who have undergone a lung resection have reduced pulmonary capacity and peripheral muscle strength which negatively impacts functional categories of HRQoL (Yilmaz, Ozalevli, Ersoz, Yegin, Onen, & Akkocklu, 2013). Therefore, it may be more challenging for lung cancer survivors to achieve the recommended guidelines. Instead, many lung cancer survivors may be limited to light-intensity physical activity. Lin et al. (2015a) found no differences in benefits on overall HRQoL between light and moderate activity, during or off-treatment periods, suggesting light-intensity physical activity may have a positive effect on HRQoL. Indeed, engaging in light-intensity physical activity mitigated some symptoms, such as nausea and shortness of breath.

To further investigate the potential benefits of light-intensity physical activity, Lin, Liu, Tzeng, and Lin (2015b) conducted a longitudinal study on the effects of walking on quality of life among lung cancer survivors (functional capacities of the patients that may affect physical activity levels were not assessed). Approximately 40% of patients gradually reduced their walking frequency during the six-month study, but those who engaged in regular walking over the course of six months had an improved overall quality of life further suggesting light-intensity physical activity has benefit (Lin et al., 2015b). These findings raise the question of whether the benefits of physical activity are dose-dependent and whether short-term and long-term lung cancer survivors would experience similar benefit from varying levels of physical activity. Assessing light-intensity physical activity via self-report is difficult given the large portion of the day the individual is being

asked to recall. Objective assessment of light-intensity physical activity will result in more precise estimation of this activity level and its associations with HRQoL and psychosocial health outcomes.

Effects of comorbid chronic diseases

A majority (80%) of lung cancer survivors have at least one comorbid chronic disease (Wang et al., 2015). Wang et al. (2015) found that lung cancer survivors with comorbid chronic diseases reported lower scores for most HRQoL scales when compared to participants without comorbid chronic diseases. Although comorbid chronic diseases had a significantly negative influence on HRQoL, physical activity had significantly positive influence on HRQoL among these individuals, but not among the other lung cancer survivors without comorbid chronic diseases (Wang et al., 2015). More specifically, lung cancer survivors that engaged in physical activity more than five times a week had higher HRQoL scores. The authors recognize it is possible that lung cancer survivors with severe comorbid chronic diseases cannot exercise, which may influence their ability to be physically active. Future studies examining physical activity, sedentary time, and HRQoL in lung cancer survivors should account for comorbid chronic diseases and any possible differences between the number of chronic conditions and the levels of physical activity and sedentary time.

Objectively Measured Physical Activity and Sedentary Time in Cancer Survivors

The choice of measurement method may have a significant impact on the observed levels of physical activity and sedentary time (Prince et al., 2008). To date only two small studies have examined physical activity among lung cancer survivors using objective accelerometer measures (Cavalheri et al., 2016; Granger et al., 2014). These

studies found that lung cancer survivors were engaging in significantly less physical activity and were more sedentary time compared to healthy counterparts. Self-reported measures of these behaviors are prone to recall error and over-reporting (Ainsworth et al., 2012). Morgan, Gliner, and Harmon (2006) state that most self-report measures, especially questionnaires, do not measure the participants' actual behavior in a typical environment. Self-reports may underestimate the true volume of daily sedentary time, overestimate the true volume of physical activity, and result in exposure misclassification. A systematic review by Prince et al. (2008) compared objective versus self-report measures and concluded that self-report measures were both higher and lower compared to objectively measured levels of physical activity. This systematic review revealed the need for valid, accurate, and reliable measures of physical activity. Vallance, Boyle, Courneya, and Lynch (2015) also found lack of consistency between self-reported and accelerometer-based assessments of MVPA among 197 colon cancer survivors. The authors suggested that studies of cancer survivors using self-report measures may have a considerable amount of exposure misclassification. Celis-Morales et al. (2012) add to the argument with their findings that self-report methods may underestimate the strength of the relationship between physical activity and sedentary time with risk factors. Moreover, the reliability and validity of self-report physical activity measures are highly dependent on participants' activity levels (i.e., active adults have more measurement error than less active adults) (Fjeldsoe, Winkler, Marshall, Eakin, & Reeves, 2013). Light-intensity physical activity and total sedentary time, which together can make up more than 95% of an individual's total daily activity, are difficult to measure reliably by questionnaire, thus few self-report measures can capture all domains of these behaviors in their entirety.

Lynch, Dunstan, Vallance, and Owen (2013) suggested that while self-report measures are important for proving the context in which activities are occurring, they nonetheless provide a substantial overestimate of physical activity time in the context of cancer. Research also now suggests that self-reported sedentary time is an underestimate of true sedentary time as measured by an accelerometer (Stamatakis, Hamer, Tilling, & Lawlor, 2012). In the study by Stamatakis et al. (2012) differential associations with health outcomes were found when comparing self-report and accelerometer-determined sedentary time. Objective measurement of these variables enables accurate, precise, and reliable measurement of the wide spectrum of movement and inactivity throughout the day. Importantly, objective measurement also records patterns of sedentary time and physical activity. For example, accelerometer data (as is being used in this study) can describe how often sedentary time is interrupted ('breaks') and the duration of each 'bout' of sedentary time (or physical activity time). Further, accelerometers are able to determine at what times during the day participants are engaging in physical activity or sedentary time.

A study by Granger and colleagues asked 50 lung cancer patients to wear a tri-axial accelerometer and also self-report their activity levels. As with previous studies that have measured activity using both objective and non-objective measures, the authors found that results differed between the two measures such that participants experienced a decline in self-reported physical activity while objective physical activity did not change over time of the study. These findings further support the notion that self-report may not be an accurate and reliable measure of physical activity. Studies by Granger et al. (2014) and Cavalheri et al. (2016) both demonstrated the feasibility of using accelerometers in

the lung cancer population. Few published studies have objectively characterised physical activity and sedentary time of other cancer survivors. In comparing results from these studies to studies using self-report measures, it is clear that physical activity estimates of cancer survivors derived from self-reported measures are substantially inflated. For example, Lynch and colleagues (2011a) examined data from the National Health and Nutrition Examination Survey and reported that breast cancer survivors recorded four minutes of MVPA per day, on average (0.4% of waking hours assuming 15 hours of wear time). Self-report estimates suggest that breast cancer survivors spend approximately 125 minutes engaged in MVPA per week [an average of just less than 18 minutes per day (2% of waking hours assuming ~15 hours of wake time)].

Boyle, Lynch, Ransom, and Vallance (2015) objectively assessed physical activity and sedentary time in 156 non-Hodgkin's lymphoma survivors. Participants accumulated an average of 8.6 hours in sedentary time, 5.3 hours in light-intensity physical activity, and 30 minutes in MVPA of their 14.5 waking hours. Only 12% of participants accrued 30 minutes in bouts of at least 10 minutes of MVPA as recommended by physical activity guidelines. Being a current smoker and having a greater waist circumference was associated with higher levels of sedentary time and lower levels of MVPA. Lower levels of MVPA were also associated with females and older participants.

Phillips et al. (2015a) prospectively examined associations between objectively measured physical activity of various intensities and sedentary time and HRQoL indicators among 358 survivors of breast cancer. On average, participants wore the accelerometer for approximately 14 hours per day. The participants spent approximately

9.2 hours (66%) of their waking day in sedentary time and 43% achieved at least 150 minutes of MVPA per week. They found objectively measured MVPA to be positively associated with many HRQoL factors such as higher physical well-being, and fewer breast-cancer specific symptoms. Compared with the lowest MVPA quartile at baseline, breast cancer survivors in the highest quartile (≥33 minutes/day) had higher HRQoL after six months suggesting a dose-response relationship between activity levels and HRQoL in breast cancer survivors. In contrast, light-intensity activity and sedentary time and HRQoL score were less consistent and mostly null. Furthermore, sedentary time was found to be positively associated with fatigue.

Vallance and colleagues conducted the first study to examine the prevalence of objectively assessed sedentary time and physical activity among 197 colon cancer survivors (Vallance et al., 2014). On average, participants wore an accelerometer for 14 hours and 20 minutes each day, recording 8.8 hours in sedentary time (61%) and 28.5 minutes engaged in MVPA (3.3%). This study also showed that objectively measured MVPA, but not sedentary time, is positively associated with better HRQoL and cancer-specific symptoms among colon cancer survivors. This study demonstrated the feasibility of collecting accelerometer data from cancer survivors via postal services and provided preliminary evidence suggesting cancer survivors are much less active than previously thought.

George et al. (2014) also objectively measured sedentary time and HRQoL among 54 cancer survivors including breast, lung, hematological, head and neck, cervical, and colorectal survivors. Approximately 70% of their waking time (15.4 hours) was accumulated in sedentary time with an average of 30 minutes accumulated in MVPA.

Unlike the study by Vallance et al. (2014), and similarly to Phillips et al. (2015a), this study showed that objectively measured sedentary time is positively associated with poorer physical HRQoL.

Objective activity monitoring in population-based studies has provided detailed information on how most adults spend their day. These studies highlight the large proportion of waking hours spent sitting (up to 70%) and the very small (less than 5%) amount of time spent in MVPA (Healy et al., 2008; Matthews et al., 2008). This new understanding of the relative volumes of sedentary and physical activity time has led to a shift in the physical activity and health paradigm (Dunstan, Howard, Healy, & Owen, 2012; Yates, Wilmont, Khunti, Biddle, Gorely, & Davies, 2011). Instead of focusing on MVPA (a very small fraction of an individual's day), researchers now have the impetus to study contributions of sedentary time to health outcomes. Our proposed study will advance the field by utilizing more objective measures of the key exposure variables (e.g., sedentary time and physical activity), and thus capturing a more precise and accurate assessment of how lung cancer survivors spend their day.

Study Aims and Hypotheses

The primary aim of this study is to determine prevalence of physical activity and sedentary time using objective measures. Despite the benefits of physical activity and the potential detrimental effects of sedentary behavior, it is hypothesized that objectively assessed sedentary time will be high (>70% of waking hours spent sedentary) in survivorship, and physical activity time will be low (<10 minutes of MVPA per day).

The secondary aims of this study are to (a) investigate how objectively assessed sitting time is associated with HRQoL and fatigue amongst lung cancer survivors. It is

hypothesized that, independent of physical activity, sitting time will be negatively associated with overall HRQoL; (b) investigate how objectively assessed physical activity (MVPA and light-intensity physical activity) is associated with HRQoL and fatigue amongst lung cancer survivors. It is hypothesized that, independent of sitting time, MVPA and light-intensity physical activity will be positively associated with overall HRQoL and fatigue; and (c) examine correlates (e.g., demographic, clinical) of objectively assessed physical activity and sedentary time amongst lung cancer survivors. Given the exploratory nature of this aim, no hypotheses are offered.

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CHAPTER III – Study One

Associations of objectively assessed physical activity and sedentary time with health-related quality of life among lung cancer survivors: A quantile regression approach

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Abstract

Background: Few studies have examined objectively assessed physical activity, sedentary time, and patient-reported outcomes among lung cancer survivors. This study set out to determine associations of objectively assessed moderate-to-vigorous intensity physical activity (MVPA) and sedentary time with health-related quality of life (HRQoL) and fatigue among lung cancer survivors. **Methods**: Lung cancer survivors in Southern Alberta (N=527) were invited to complete a mailed survey that assessed HRQoL [Functional Assessment of Cancer Therapy-Lung (FACT-L)] physical and functional well-being [Trial Outcome Index (TOI)], and fatigue [Fatigue Scale (FS)]. MVPA and sedentary time data was collected using an Actigraph® GT3X+ accelerometer that was worn on the hip for seven consecutive days. Quantile regression was used to examine associations of HRQoL and fatigue with MVPA and sedentary time at the 25th, 50th, and 75th HRQoL and fatigue percentiles. **Results:** A total of 127 lung cancer survivors participated for a 24% response rate (Mean age=71 years; Mean time since diagnosis=75 months). Total MVPA minutes was associated with fatigue at the 25th percentile (β=0.16, p=.046). Total sedentary time was associated with HRQoL at the 75th (β=-0.07, p=.014) percentile and with fatigue at the 50th (β=-0.04, p=.009) percentile. Total sedentary time was also associated with TOI scores at the 25th (β=-0.07, p=.045), 50th (β=-0.07, p=.004) and 75th (β=-0.04, p=.035) percentiles. **Conclusion:** Across the HRQoL, fatigue, and physical and functional well-being distributions, sedentary time was negatively and significantly associated with HRQoL, fatigue, and TOI in lung cancer survivors. Small associations were observed between MVPA and fatigue, but no associations emerged with HRQoL or TOI.

Introduction

Lung cancer is the leading cause of cancer deaths (American Cancer Society, 2016). Most lung cancer survivors are diagnosed with early stage disease, for which primary treatment is surgical resection. Other treatments include chemotherapy and radiation, and both therapies are associated with numerous side effects (Molina, Yang, Cassivi, Schild, & Adjei, 2008). Lung cancer and the treatment side effects are associated with many symptoms and sequelae (e.g., pain, fatigue, nausea, loss of appetite, depression) that have a major impact on one's health-related quality of life (HRQoL) (Ostroff et al., 2011; Sigimura & Yang, 2006).

Physical activity is one behavior that may play a valuable role in improving patient-reported outcomes (PROs) among lung cancer survivors (Schmitz et al., 2010). A very small body of literature indicates regular and sustained moderate-to-vigorous physical activity (MVPA) is associated with better HRQoL and reduced fatigue among lung cancer survivors (e.g., Coups et al., 2009; Solberg et al., 2012). However these studies have relied on self-reported estimates of physical activity, which may have a substantial impact on observed levels of physical activity (Prince et al., 2008) given self-reported assessment of activity may be prone to recall error and over-reporting (Ainsworth et al., 2012). To date only two small studies have examined physical activity among lung cancer survivors using objective accelerometer measures (Cavalheri et al., 2016; Granger et al., 2014). These studies found that lung cancer survivors were engaging in significantly less physical activity and were more sedentary time compared to healthy counterparts.

Cancer survivors spend upwards of 70% of their day in sedentary behavior, defined as waking activities low in energy expenditure, and include sitting or reclining (Owen, 2012). Sedentary behavior has adverse health consequences that are distinct from the negative effects of physical inactivity (not achieving physical activity public health guidelines) (Owen, Sparling, Healy, Dunstan, & Matthews, 2010). Majority of studies examining objectively assessed sedentary time among cancer survivors are concluding that sedentary time is negatively associated with HRQoL scores (George et al., 2013, George et al., 2014; Phillips et al., 2015a; Phillips, et al. 2015b). In the only study examining sedentary time among lung cancer survivors, Cavalheri et al. (2016) reported survivors with lung resections spent on average 49% of their total day engaged in sedentary behaviors accrued in at least 30-minute bouts. Associations between sedentary behavior and HRQoL and fatigue are unknown among lung cancer survivors.

Accelerometers provide objective, precise, and reliable measurement of the wide spectrum of movement and sedentary time throughout the day. Objective measurement also records how sedentary time and physical activities are accumulated over a defined period of time (i.e., prolonged, unbroken bouts, or through numerous short bouts interspersed with other activities). No studies to date have simultaneously examined associations of objectively assessed physical activity and sedentary behavior with HRQoL and fatigue outcomes among lung cancer survivors. The primary objective of this study was to determine associations of objectively assessed physical activity and sedentary time with HRQoL, fatigue, and physical/functional well-being among lung cancer survivors. It is hypothesized that, independent of physical activity, sitting time will be negatively associated with overall HRQoL and independent of sitting time, MVPA and

light-intensity physical activity will be positively associated with overall HRQoL and fatigue.

Materials and Methods

Participants

The study was approved by the Health Research Ethics Board of Alberta and the Athabasca University Research Ethics Board. All lung cancer survivors were recruited from the Glans-Look Lung Cancer Database at the University of Calgary. The Glans-Look Database includes comprehensive data (e.g., demographics, diagnosis, treatments received) on all non-small cell lung cancer (NSCLC) patients diagnosed from January 1, 1999 to December 31, 2014 in Southern Alberta. Eligibility criteria for this study included (a) previous clinical and/or pathological diagnosis of NSCLC confirmed by chart review, (b) not currently receiving chemotherapy or radiation for lung cancer or any other cancer, (c) community dweller (not living in a hospice or long term care), (d) at least 18 years of age, (e) ability to read and write English, and (f) reside in Alberta, Canada. Only participants able to understand and provide written informed consent and were willing and able to wear an accelerometer for seven days were eligible to participate.

Data Collection

Eligible survivors were mailed a study invitation package containing a letter describing the study and what will be required of the participant. Survivors received a follow-up call following the mailing date. Individuals who could not be reached by phone were sent another letter invitation. Individuals who consented to participate were mailed (via express post) a study package including an Actigraph® GT3X+ accelerometer

(Actigraph, LLC, Pensacola, Florida), along with an instructional pamphlet describing how to use the accelerometer, an accelerometer diary to record wear time, and a health survey. At the end of the seven-day monitoring period, participants returned their signed consent form, completed survey and diary, and accelerometer in the padded postage paid priority post envelope that was provided.

Measures

Demographic and clinical information such as age, gender, diagnosis date, stage, histology, and treatment received (e.g., surgery, chemotherapy, radiation therapy) were obtained from the Glans-Look Database. Information not available from the database, including medical comorbidities, sociodemographic and lifestyle factors were collected by self-report. Demographic characteristics were assessed to control for potentially confounding covariates included sociodemographic (e.g., education, income, marital status) and lifestyle factors (e.g., smoking).

Physical activity and sedentary time were assessed using the ActiGraph® GT3X+ accelerometer, an instrument that records acceleration using a tri-axial accelerometer. The accelerometer is worn on an elasticized band around the waist (over or under clothing) during all waking hours, except while bathing or swimming. Participants were asked to record, in a daily log, the time they put on and took off the monitor each day. These recordings were used to confirm wearing start and end times, as well as non-wear time. For accelerometer data processing, commonly accepted activity count cutoffs were used to categorize sedentary time (<100 counts/minute) from light-intensity activity (100-1,951 counts/minute) and MVPA (≥1,952) from counts/minute) (Freedson et al., 1998; Matthews et al., 2008). Data was processed in 60-second epochs. Non-wear time was

defined as intervals of at least 60 consecutive minutes of zero counts, with allowance for up to two minutes of observations of less than 50 counts per minutes within the non-wear interval (Matthews et al., 2008). At least 600 minutes (10 hours) of wear time and no excessive counts (>20,000 counts per minute) were need to be considered valid days.

HRQoL was assessed by the Functional Assessment of Cancer Therapy-Lung (Cella et al., 1995). This questionnaire is composed of 34 items: physical well-being (7 items), social and family well-being (7 items), emotional well-being (6 items), functional well-being (7 items), and lung cancer-specific symptoms (LCS) (7 items). Participants were asked to indicate how true each statement is for them over the last seven days, on a five-point scale from 0 (not at all) to 4 (very much) where higher scores indicate better HRQoL. A difference of at least 5 points on the FACT-L and 2 to 3 points on the LCS subscale was considered a clinically important difference (Guyatt, Osoba, Wu, Wurwich, & Norman, 2002).

Fatigue was assessed with the 13-item Fatigue Scale (FS) (Cella, 1997). Each item was measured on a 4-point scale from 0 (very much fatigued) to 4 (not at all fatigued) with higher scores indicating less fatigue. A difference of 3 points on the FS is considered a clinically important difference (Cella et al., 2002a).

Physical function and well-being was assessed by generating the Trial Outcome Index-Lung (TOI-L) comprising the sum of the physical and functional well-being scales in addition to lung cancer-specific symptoms subscale. The TOI-L is composed of 23 items where a difference of at least 4 points on the Index is considered to be clinically important difference (Cella et al., 2002b).

Statistical Analysis

Descriptive statistics were used to examine the demographic and clinical characteristics of the sample, as well as objective physical activity and sedentary behavior estimates. MVPA accumulated in at least 10-minute bouts (more synonymous with a physical activity session), and sedentary time accumulated in at least 30-minute bouts were also examined. Quantile regression was used to examine associations of HRQoL, fatigue, and TOI (dependent variables) with MVPA, light-intensity physical activity, and sedentary time (independent variables) at the 25^{th}, 50^{th}, and 75^{th} percentiles. Quantile regression coefficients are interpreted similarly to those of ordinary linear regression coefficients except that a quantile regression coefficient indicates the change in the value at the modeled percentile, not the mean, of the dependent variable. This analysis allows comparison of non-normally distributed PROs across physical activity and sedentary time levels, and because the population is not segmented into smaller samples sizes as it is in linear regression, increased power is gained to better detect any differences (Lê Cook & Manning, 2013). All models were adjusted for the following covariates which were considered to be potential confounders: age, gender, body mass index, current smoker (yes or no), comorbidity (at least two comorbidities vs. no comorbidity), months since diagnosis, stage at diagnosis, surgery (received surgery vs. no surgery), and accelerometer wear time. The MVPA models were also adjusted for sedentary time, and the sedentary time and light-intensity models were also adjusted for MVPA. An α of 0.05 was used as a threshold for determining statistical significance. All models were generated using Stata 14.1 (StataCorp L.P., College Station, TX).

Results

Participant Characteristics

Participants who satisfied the eligibility criteria and had a home address on file were mailed a study invitation letter (N=662). After further eligibility screening and receiving incorrect address notices, the number of eligible and reachable individuals was reduced to 527. Of these, 166 did not respond, and 216 declined participation. A total of 145 survivors agreed to participate. Of the 145 that consented, 18 participants withdrew due to health concerns (n=6), time constraints (n=4), and loss of interest in the study (n=8), for a response rate of 24% (see Figure 1). When comparing study participants to non-responders, there were no significant differences in age, gender, or months since diagnosis.

Information pertaining to the demographic and clinical characteristics of the sample is shown in Table 1 and is summarized here. Of the 127 participants, 57% were female, the mean age was 71 years at recruitment, 85% had a smoking history, with a mean body mass index of 24.1 (SD=13.9) kg/m^2. The mean number of months since diagnosis was 76.4 (SD=47) and at least two chronic diseases were reported by 39% of participants. Adenocarcinoma was the most common histological diagnosis (66%). The majority of participants were diagnosed stage I (53%) with others diagnosed at stage II (23%), III (14%), and IV (10%). Overall, 66% survivors underwent a lung resection while 23% of those received adjuvant therapy. Other treatments included radical chemotherapy and/or radiation (25%) and palliative chemotherapy and/or radiation or targeted therapy (8%).

MVPA

An overview of the descriptive statistics for physical activity and sedentary time, HRQoL, and fatigue variables are displayed in Table 2. Participants had an average of 6.6

valid wear days and 14.1 hours of wear time. Participants averaged 4,596 steps per day. On average, participants spent 14.0 minutes per day engaged in total MVPA and 5.7 minutes per day of MVPA accumulated in at least 10-minute bouts. The adjusted quantile regression estimates for the associations of MVPA with fatigue on the 25th, 50th, and 75th percentiles are shown in Table 3. Total MVPA was associated with fatigue at the 25th (β=0.16, 95% CI: 0.01-0.31) percentile. Stated differently, for every one-minute increase in MVPA, the predicted value of the 25th percentile on the Fatigue Scale will increase (i.e., less fatigue) by .16 points. MVPA accumulated in 10-minute bouts was not associated with HRQoL, fatigue, or TOI.

Light-intensity physical activity

Participants spent approximately 4.1 hours (SD=1.3) in light-intensity physical activity. Total light-intensity physical activity was associated with HRQoL (i.e., FACT-Lung scores) at the 50th (β=0.08, 95% CI: 0.01-0.15) and 75th (β=0.07, 95% CI: 0.02-0.12) percentiles. Total light-intensity physical activity was also associated with fatigue at the 50th (β=0.04, 95% CI: 0.01-0.08) percentile and TOI (e.g. physical and well-being scores) at the 50th (β=0.07, 95% CI: 0.01, 0.12) and 75th (β=0.04, 0.01-0.08) percentiles.

Sedentary time

On average, participants were sedentary for 588.3 (SD=95.4) minutes per day (i.e., 9.8 hours) and accumulated 185.5 (SD=102.3) minutes per day of sedentary time accumulated in at least 30-minute bouts. Total sedentary time was associated with HRQoL at the 75th (β=-0.07, p=.009) percentile and with fatigue at the 50th (B=-0.04, p=.009) percentile. Total sedentary time was also associated with TOI scores at the 25th (β =-0.07, p=.045), 50th (β =-0.07, p=.004), and 75th (β=0.04, p=.035) percentiles.

Sedentary time in at least 30-minute bouts was associated with HRQoL at the 25th (β =-0.06, p=.017), 50th (β =-0.06, p=.012), and 75th (β =-.05, p=.032) percentiles. Sedentary time in at least 30-minute bouts was associated with TOI scores at the 50th (β =-0.05, p=.009) and 75th (β =-0.03, p=.049) percentiles.

Discussion

The primary aim of this study was to determine associations of objectively assessed physical activity and sedentary time with lung cancer-specific HRQoL, fatigue, and TOI among lung cancer survivors. We observed a significant association between objectively assessed MVPA at the low end of the Fatigue Scale (participants with the highest fatigue levels), but no associations with overall HRQoL or TOI scores. Time spent in light-intensity physical activity was significantly associated with less fatigue and higher HRQoL and TOI scores. Conversely, objectively assessed sedentary time was associated with poorer HRQoL, fatigue, and TOI outcomes. This study is the first study to examine associations of objectively assessed MVPA, light-intensity physical activity, and sedentary time with HRQoL, fatigue, and physical and functional well-being.

On average, lung cancer survivors spent 14.0 minutes per day engaged in MVPA and only 5.7 minutes in 10-minute bouts of MVPA. Time spent in MVPA is lower among lung cancer survivors compared to other tumor group studies using objective measures. Other recent studies have reported daily MVPA minutes for breast cancer survivors (Boyle et al., 2016; Phillips et al., 2015a), colon cancer survivors (Vallance et al., 2014), non-Hodgkin's lymphoma survivors (Boyle et al., 2015), and prostate cancer survivors (Gaskin et al., 2016). Collectively these studies report on average survivors are engaging in ~30 minutes per day of total MVPA and ~15 minutes per day of MVPA in 10-minute

bouts. In our study, objectively measured sedentary time was high with 9.8 hours spent being sedentary. This estimate is comparable to older adults, as well as other tumor groups. A systematic review of 59 studies using ActiGraph accelerometers to quantify daily sedentary time found that older adults (60 years or older) spent an average of 68% of their waking time (8.7 hours) in sedentary behavior (Gorman et al., 2014). Comparably, breast cancer survivors have been found to spend an average of 8 to 9 hours in sedentary time (Boyle et al., 2016; Phillips et al., 2015a). Similarly, prostate cancer survivors accumulated ~10 hours of sedentary time (Gaskin et al., 2016), while colon cancer survivors (Vallance et al., 2014) and non-Hodgkin lymphoma survivors (Boyle et al., 2015) accumulated 8.8 and 8.6 hours per day, respectively.

Only one previous study has examined objectively assessed MVPA and sedentary time among lung cancer survivors using accelerometers. Cavalheri et al. (2016) assessed sedentary time and physical activity between 20 lung cancer patients following curative intent lobectomy and 20 healthy controls using the SenseWear armband (SAB, BodyMedia Inc., Pitssburgh, Pennsylvania, USA). Daily step count was measured using the StepWatch activity monitor (SAM; Cyma Corporation, Machester, Connecticut, USA) that was worn above the ankle. Compared to healthy controls, lung cancer survivors took fewer steps each day (8,863 vs. 11,856; p=.009), accumulated more time in prolonged, uninterrupted sedentary time in bouts of 30 minutes or more (49% vs. 42% of waking hours; p=.048) and less time in light-intensity physical activity (19% vs. 12 %, p=.025).

Based on our results, it appears that lung cancer survivors tend to be less active than other cancer survivor groups. Compared to the other tumor groups, lung cancer

survivors are typically older and elderly adults have been found to be severely deconditioned, which contributes to reduced cardiorespiratory fitness (Jones, Haykowsky, Swartz, Douglas, & Mackey, 2007). Those diagnosed with earlier stage disease often undergo a lung resection rendering them with reduced lung capacity and peripheral muscle strength (Bolliger et al., 1996). For example, in comparison with preoperative values, the 6-month post lobectomy and pneumonectomy reductions in FEV are 11% and 36%, respectively and 13% and 28% for VO2max, respectively (Kunimoto, Takashi, Makoto, & Soiciro, 1998). The majority of lung cancer survivors also have a smoking history (87% in the present study) and several comorbidities (40% in the present study reported at least two comorbidities) that further limit their ability to be physically active, and sets them apart from survivors of other types of cancer.

The second major finding of this study pertains to the quantile regression analysis which examined MVPA and sedentary time across the HRQoL, fatigue, and TOI distributions in this study. We found MVPA was significantly associated with fatigue in lung cancer survivors with the poorest fatigue scores (i.e., 25^{th} percentile). Overall, significant associations between MVPA (both total and 10-min bouts) and HRQoL/TOI were not observed which is not congruent with previous research. Research using self-reported MVPA estimates has found that lung cancer survivors who achieved physical activity guidelines had significantly higher HRQoL scores compared to those not meeting guidelines (Coups et al., 2009, Lin et al., 2013; Solberg et al., 2012). Our data suggests that for lung cancer survivors, associations between MVPA and fatigue may only be apparent in survivors with the highest levels of fatigue.

Time spent in light-intensity physical activity was found to have more positive associations with each model (e.g., HRQoL, TOI, and fatigue) compared to MVPA time. These results likely reflect physiologic challenges inherent to lung cancer survivors which, in essence, limits them to light-intensity physical activity. Quantile regression results revealed that light-intensity physical activity was positively associated with higher HRQoL and TOI scores, as well as reduced fatigue, most often in the 50^{th} and 75^{th} percentiles (i.e., those with average or better scores for these patient-reported outcomes). A study on lung cancer survivors by Lin et al. (2015) found no differences in HRQoL scores between self-reported light and moderate physical activity, during or off-treatment periods. These findings, combined with our results, suggest that targeting an increase in light-intensity physical activity, rather than MVPA, may be beneficial and achievable for this population.

Quantile regression analysis also indicated sedentary time was significantly and negatively associated with HRQoL, fatigue, and TOI scores across the distributions of these patient-reported outcomes. Given these associations, sedentary time is an important predictor of HRQoL, fatigue, and TOI among lung cancer survivors. Coefficients for HRQoL and TOI were strongest in the 75th percentile suggesting a greater role for reducing sedentary time with respect to HRQoL and TOI. However, since significant associations emerged across the distributions for HRQoL and TOI, there appears to be role for reducing sedentary time for all lung cancer survivors, regardless of HRQoL or TOI status. Future research should continue to examine associations between sedentary behavior and health outcomes among lung cancer survivors considering that lung cancer survivors spend a majority of their day sedentary and that this behavior has been linked to

poorer health outcomes and mortality (Rezende, Lopes, Rey-Lopez, Matsudo, & Luiz, 2014; Rezende, Rey-Lopez, Matsudo, & Luiz, 2014).

Although there are numerous strengths associated with the use of accelerometers to assess physical activity and sedentary time, some limitations persist. The accelerometer used in this study does not capture water-based activities, cannot distinguish between sitting and standing, and does not detect the context within which sedentary behaviors are occurring (e.g., transport, occupational). Future studies should consider the use of devices with inclinometers to better differentiate between sitting and standing (e.g., activPal®). Additional limitations include the use of data cut-off points that were originally derived using a young adult population (Freedson et al. 1998), and may underestimate the actual intensity of the activity performed by a participant of this largely older adult sample. Future studies may wish to consider using lower cut-off points in older populations that are more representative of their physical activity levels. Lung cancer survivors who did not respond to the study invitation or declined to participate may have considered themselves sedentary and saw themselves as less appropriate to participate in a study that examines physical activity levels (and health in general). In North America, the one and five-year survival rates for lung cancer are ~40% and 17%, respectively (American Cancer Society, 2016; Canadian Cancer Society, 2015). Our sample consists of lung cancer survivors who were at least 18 months post diagnosis (with an average participant being approximately six years post diagnosis, including stage IV survivors who have surpassed their one-year expectancy) and thus may not be representative of all lung cancer survivors.

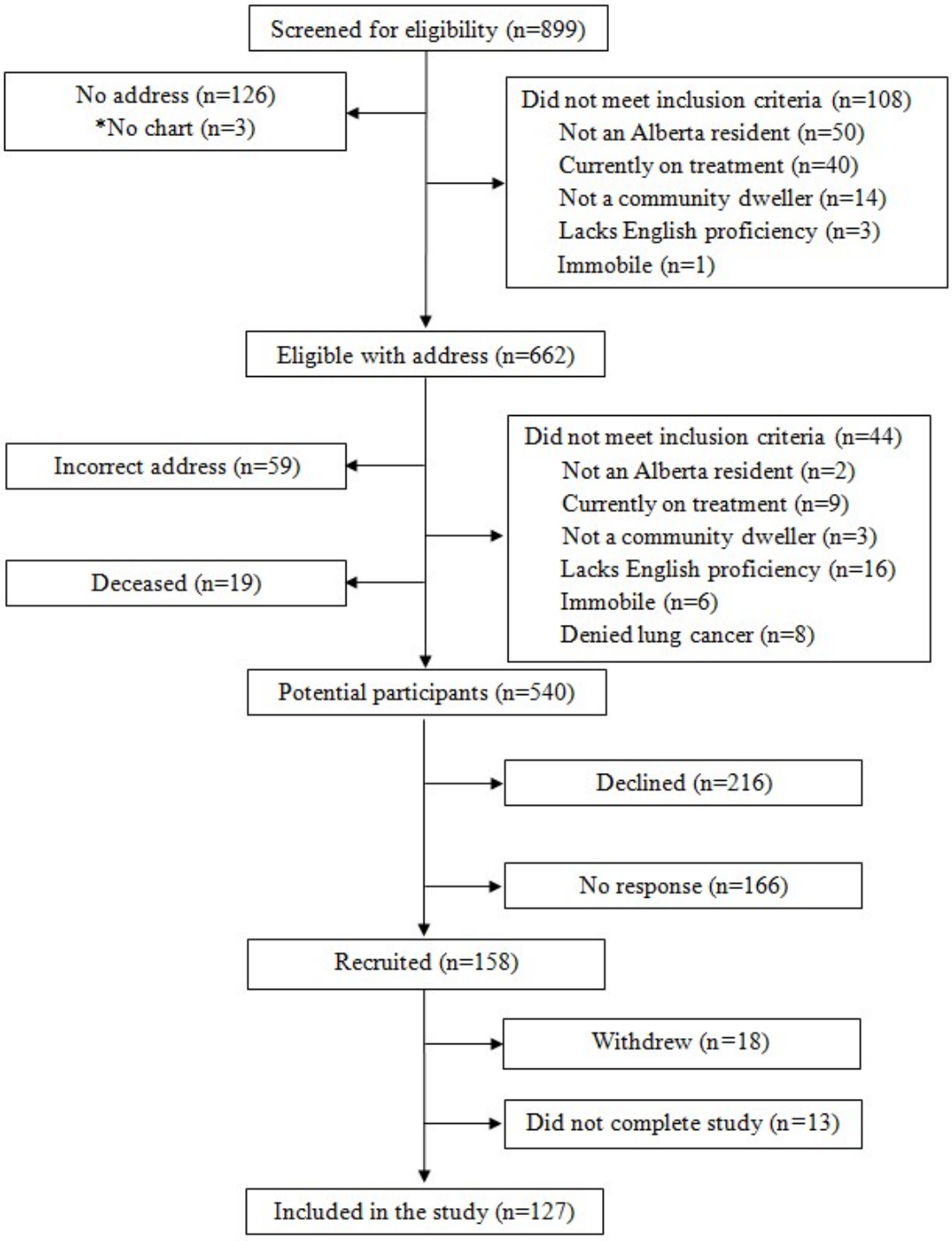
This is the first study to examine associations between objectively assessed physical activity and sedentary time with PROs in a lung cancer survivor population. In particular, this is the first study in the field of exercise and cancer to assess the impact of MVPA, light-intensity physical activity, and sedentary time across the HRQoL, fatigue, and TOI distributions using quantile regression. A common limitation and criticism of physical activity and cancer research is that survivors enrolling in such studies are often healthy with respect to the outcomes of interest. With quantile regression, we were able to examine associations between MVPA, light-intensity physical activity, and sedentary time among participants at low, mid, and high levels of HRQoL, fatigue, and TOI distributions (e.g., examine associations among participants in the lower / 25^{th} percentile of HRQoL scores).

Our results are generated from the largest sample size from the population to date, and a robust response rate (i.e., 24%) in a cancer survivor population that is often perceived as challenging to engage in health-related research. Lung cancer survivors tend to be older and researchers have found several recruitment barriers specific to this population including comorbidities, lower levels of medical literacy, lack of trust and difficulty with compliance (Baggstrom et al., 2011; Klabunde et al., 1999). Although this study is the largest to date to objectively measure physical activity and sedentary time among lung cancer survivors, the 24% of lung cancer survivors that were included in the study may not be representative of all eligible participants, which may limit the generalizability of our results.

We found that overall, lung cancer survivors were not engaged in meaningful amounts of MVPA, while also engaging in high amounts of sedentary time. Increasing

light-intensity physical activity and reducing sedentary time appears important in this population given our findings are suggestive of better HRQoL and physical function and well-being along with reduced fatigue among all lung cancer survivors regardless of their HRQoL or fatigue perceptions. Future research with larger sample sizes and using methodologically stronger study designs (e.g., prospective studies) are needed. Given the associations that emerged with sedentary time, and the challenges of engaging in MVPA in this population, future studies may want to examine ways to facilitate a shift from sedentary time to light-intensity activity. Determining associations between sedentary behavior and survival time after a lung cancer diagnosis is also a key research question that may have immediate clinical consequences.

Figure 1. Flow of participants through the study.



* Patient records advised these individuals were incorrectly coded as having lung cancer.

Table 1

Demographic and clinical characteristics[†]

Characteristic	No. of Respondents	%	Mean ± SD
Demographic			
Sex			
Male	54	42.5	
Female	73	57.5	
Age			71.4±9.0
Marital Status			
Married	81	63.8	
Widowed	16	12.6	
Separated/divorced	20	15.7	
Common-law	5	3.9	
Never married	5	3.9	
Ethnicity			
Caucasian	120	94.5	
Other	7	5.5	
Education			
Some high school	52	40.9	
Trade or apprenticeship	22	17.3	
Some university/college	21	16.5	
Completed university/college	24	18.9	
Completed graduate school	8	6.3	
Annual Family Income			
≤$60,000	77	61	
>$60,000	50	39	
Employment Status			
Retired	89	70.1	
Disability	6	4.7	
Employed part-time	10	7.9	
Employed full-time	15	11.8	
Temporarily unemployed	1	0.8	
Homemaker	6	4.7	

Clinical			
Body mass index (kg/m^2)			24.1±13.9
Normal weight	86	67.7	
Overweight	31	24.4	
Obese	10	7.9	
Months since diagnosis			76.4±47.0
Stage			
I	67	52.8	
II	31	24.4	
III	17	13.4	
IV	12	9.4	
Histology			
Adenocarcinoma	84	66.1	
Squamous cell carcinoma	20	15.7	
Not specified	9	7.1	
Other [a]	14	11.0	
Treatment			
Surgery	82	64.6	
Radical	32	25.2	
Palliative	10	7.9	
None	3	2.4	
Comorbidity history			
At least two comorbidities	50	39.4	
Angina	17	13.4	
Heart attack	16	12.6	
Stroke	6	4.7	
Diabetes	15	11.8	
High blood pressure	58	45.7	
High blood cholesterol	51	40.2	
Other	33	26.0	
Smoking			
Never smoker	16	12.9	
Former smoker	94	75.8	
Current smoker	14	11.3	

Note. Data are presented as the mean (SD: standard deviation) for continuous variables and frequency (percentage) for categorical variables.
[a] Other histology subtypes include: Adenosquamous, BAC, carcinoid, and large cell.
†Numbers may not equal 127 due to missing data.

Table 2

Descriptive statistics for accelerometer-determined physical activity and sedentary time in lung cancer survivors (N=124)

Variable	Mean (SD)	Median	IQR
Physical Activity and Sedentary Time			
Valid days	6.6 (0.8)	-	-
Accelerometer wear time Minutes/day	847.8 (80.0)	-	-
Light-intensity physical activity Minutes/day	245.5 (77.8)	242.6	112.4
Moderate-intensity physical activity Minutes/day	13.6 (16.8)	5.59	17.6
Vigorous-intensity physical activity Minutes/day	0.5 (4.8)	0.0	0.0
MVPA			
Minutes/day	14.0 (17.9)	5.7	17.5
Minutes/day in 10-minute bouts[b]	5.7 (12.3)	0.0	4.2
Percent achieving MVPA guidelines[c]	22.6%	-	-
Steps per day	4578 (2160)	4078	3442
Sedentary time			
Minutes/day	587.2 (95.7)	593.1	126.7
Minutes/day in 30-minute bouts[d]	184.9 (102.1)	170.1	141.9
Health-related Quality of Life and Fatigue			
FACT-Lung (0-144)	111.0 (17.5)	115.0	20.3
TOI-Lung (0-92)	69.8 (12.8)	73.0	15.0
LCS (0-36)	24.7 (5.4)	25.0	7.5
Fatigue (0-52)	39.7 (9.6)	41.0	13.0

Note. Data are presented as the mean (SD: standard deviation), median, and interquartile range (IQR) for continuous variables and frequency (percentage) for categorical variables. Abbreviations: MVPA, moderate-to-vigorous intensity physical activity. [a] Moderate and vigorous minutes combined. [b] MVPA time accumulated in at least 10-minute bouts. [c] Engage in moderate-intensity physical activity for a minimum of 150 minutes of MVPA a week. Activity performed in at least 10-minute bouts. [d] Sedentary time accumulated in at least 30-minute bouts.

Table 3

Adjusted quantile regression estimates of MVPA, light-intensity physical activity, and sedentary time at the 25th, 50th, and 75th HRQoL, fatigue, and TOI percentiles

Physical activity / sedentary time (minutes/week)	**Model 1 (HRQoL)**		
	p25 β (95% CI)	p50 β (95% CI)	p75 β (95% CI)
MVPA	0.14 (-0.13, 0.40)	0.01(-0.23, 0.24)	0.10 (-0.30, 0.11)
MVPA 10-min bouts	0.16 (-0.23, 0.54)	0.01 (-0.33, 0.34)	-0.18 (-0.44, 0.09)
Light-intensity physical activity	0.06 (-0.01, 1.33)	0.08 (0.01, 0.15)*	0.07 (0.02, 0.12)**
Sedentary time	-0.06 (-0.14, 0.01)	-0.08 (-0.16, 0.06)	-0.07 (-0.13, -0.02)*
Sedentary time in 30-min bouts	-0.06 (-0.10, -0.01)*	-0.06 (-0.11, -0.01)*	-0.05 (-0.09, -0.01)*
	Model 2 (Fatigue)		
	p25 β (95% CI)	p50 β (95% CI)	p75 β (95% CI)
MVPA	0.16 (0.01, 0.31)*	0.10 (-0.01, 0.20)	0.04 (-0.06, 0.14)
MVPA 10-min bouts	0.13 (-0.18, 0.38)	0.11 (-0.05, 0.27)	0.06 (-0.12, 0.24)
Light-intensity physical activity	0.03 (-0.02, 0.07)	0.04 (0.01, 0.08)*	0.02 (-0.01, 0.05)
Sedentary time	-0.03 (-0.07, 0.02)	-0.04 (-0.07, -0.01)**	-0.03 (-0.05, 0.03)
Sedentary time in 30-min bouts	-0.02 (-0.05, -0.01)	-0.02 (-0.04, -0.01)	-0.01 (-0.04, 0.01)
	Model 3 (TOI)		
	p25 β (95% CI)	p50 β (95% CI)	p75 β (95% CI)
MVPA	0.04 (-0.21, 0.30)	-0.01 (-0.19, 0.16)	-0.06 (-0.20, 0.12)
MVPA 10-min bouts	-0.03 (-0.32, 0.27)	-0.01 (-0.26, 0.23)	-0.10 (-0.29, 0.09)

Light-intensity physical activity	0.07 (-0.01, 0.13)	0.07 (0.01, 0.12)*	0.04 (0.01, 0.08)*
Sedentary time	-0.07 (-0.14, -0.01)*	-0.07 (-0.11, -0.02)**	-0.04 (-0.08, -0.01)*
Sedentary time in 30-min bouts	-0.03 (-0.07, 0.01)	-0.05 (-0.09, -0.01)*	-0.03 (-0.06, -0.01)*

Note. Models adjusted for accelerometer wear time, age, gender, smoking (current smoker), body mass index, comorbidity (less than two vs. two or more), months since diagnosis, stage, and lung surgery (yes or no). The MVPA models were adjusted for sedentary time, and the sedentary time and light-intensity models were adjusted for MVPA.

Abbreviations: MVPA, moderate-to-vigorous intensity physical activity; HRQoL: health-related quality of life; TOI: Trial Outcome Index.

* $p \leq 0.05$; ** $p \leq 0.01$, *b*, unstandardized regression coefficient, CI, confidence interval.

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Chapter IV – Study Two

Demographic and clinical correlates of accelerometer-assessed physical activity and sedentary time in lung cancer survivors

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Abstract

Background: Research to date indicates lung cancer survivors engage in small amounts of moderate-to-vigorous intensity physical activity (MVPA) and excessive amounts of sedentary time. The primary purpose of this study was to determine demographic and clinical correlates of accelerometer-assessed physical activity and sedentary time among a population-based sample of lung cancer survivors. **Methods**: Using the Glans-Look Lung Cancer Database (GLD) at the University of Calgary, lung cancer survivors in Southern Alberta, Canada (N=527) were invited to complete a mailed survey that assessed self-reported demographic variables. Clinical variables were extracted from the GLD. Consenting participants wore an Actigraph® GT3X+ accelerometer on their hip for seven days. Average daily minutes of physical activity and sedentary time were derived from the accelerometer data, and processed using 60-second epochs. Linear regression was used to determine correlates of physical activity and total sedentary time. **Results:** A total of 127 lung cancer survivors participated (Mean age=71 (SD=9.0) years; Mean time since diagnosis=75 months, SD= 47.0), for a 24% response rate. MVPA (total daily minutes) was inversely associated with having ever smoked at least 100 cigarettes (β =-10.6, CI: -21.0, -0.28) and being over 60 years of age (β =-7.4, CI: -14.7, -0.10). Light-intensity physical activity (total daily minutes) was negatively associated with being overweight/obese (β =-27.6, CI: -48.2, -7.1), having ever smoked at least 100 cigarettes (β =-52.8, CI: -91.8, -13.8), and being five or more years since diagnosis (β=-31.3, CI: -56.3, -6.4). Total sedentary time (daily minutes) was positively associated with having smoked at least 100 cigarettes (β=63.4, CI: 22.4, 105.4), being overweight/obese (β=30.8, CI: 8.8, 52.9), and being five or more years post diagnosis (β=31.4, CI: 4.6, 58.2).

Conclusion: In this sample of lung cancer survivors, different demographic and clinical correlates emerged across accelerometer-assessed light, moderate, and vigorous physical activity, and sedentary time. These correlates indicate which lung cancer survivors are most likely to be overly sedentary and benefit most from a targeted intervention.

Introduction

Lung cancer is the second most commonly diagnosed cancer accounting for approximately 14% of all cancer diagnoses and the leading cause of cancer deaths (American Cancer Society, 2016). Lung cancer survivors are usually older adults, 80% of whom have at least one comorbidity, and the majority have undergone a lung resection (Wang et al., 2015). A variety of chronic comorbid diseases and post-treatment symptoms impair multiple psychological and physical dimensions in lung cancer survivors even several years post diagnosis (Coups et al., 2009; Sigimura & Yang, 2006).

Physical activity may play an important role in alleviating the physical and psychological symptoms reported by lung cancer survivors. However, nearly one-quarter of survivors do not meet national physical activity guidelines of a minimum of 150 minutes of moderate-to-vigorous intensity physical activity (MVPA) a week (D'Silva et al., submitted). Emerging research suggests that lung cancer survivors spend more time during the day in sedentary pursuits, compared to survivors of other types of cancer (e.g., breast, colon, lymphoma). For example, we recently observed lung cancer survivors spend approximately 10 hours per day in sedentary pursuits (D'Silva et al.). Sedentary behaviour has adverse health consequences that are distinct from the negative effects of physical inactivity (Owen, Sparling, Healy, Dunstan, & Matthews, 2010) and has been negatively associated with patient reported outcomes in other cancer survivor groups (George et al., 2013, George et al., 2014; Phillips et al., 2015a; Phillips, et al. 2015b).

The factors associated with sedentary behaviors and the consequences of high amounts of daily sedentary time are unknown among lung cancer survivors. In other tumor groups, physical activity and sedentary time are related to socio-demographic and

clinical factors (Boyle et al., 2015; Boyle et al., 2016; Kampshoff et al., 2016; Lynch et al., 2016). Given the potential benefits of engaging in physical activity and the negative effects of sedentary behaviors, identifying correlates of these behaviors may facilitate the development of interventions aimed at increasing physical activity and decreasing sedentary time among lung cancer survivors. Correlates such as demographics (e.g. age) or clinical characteristics (e.g. lung resection) may indicate which survivors are most likely to be overly sedentary and can thus help identify target populations for intervention.

To date only one study has examined correlates of self-reported physical activity among lung cancer survivors (Coups et al., 2009b). Using accelerometers provides a more objective, precise, and reliable measurement of the wide spectrum of movement (e.g., light, moderate, vigorous intensity, steps) and sedentary time throughout the day. To our best knowledge, no studies to date have examined correlates of objectively-assessed physical activity and sedentary time among lung cancer survivors. The primary aim of this study was to determine demographic and clinical correlates of accelerometer-assessed physical activity and sedentary time among a population-based sample of lung cancer survivors. Given the exploratory nature of this aim, no hypotheses are offered.

Materials and Methods

Participants

The study was approved by the Health Research Ethics Board of Alberta and the Athabasca University Research Ethics Board. All lung cancer survivors were recruited from the Glans-Look Lung Cancer Database at the University of Calgary. The GLD includes comprehensive medical information on all non-small cell lung cancer (NSCLC)

patients diagnosed from January 1, 1999 to December 31, 2014 in Southern Alberta. Eligibility criteria for this study included (a) previous clinical and/or pathological diagnosis of NSCLC confirmed by chart review, (b) not currently receiving any treatment for lung cancer or any other cancer, (c) community dweller (not living in a hospice or long term care), (d) at least 18 years of age, (e) ability to read and write English, and (f) reside in Alberta, Canada. Only participants able to understand and provide written informed consent and were willing and able to wear an accelerometer for seven days were eligible to participate.

Data Collection

In June 2016, eligible survivors were mailed a study invitation package containing a letter describing the study and what was required of the participant. Survivors received a follow-up telephone call two to three weeks following the mailing date. Individuals who could not be reached by telephone were sent another invitation letter. Individuals who verbally consented to participate were mailed (via express post) a study package including an Actigraph® GT3X+ accelerometer (Actigraph, LLC, Pensacola, Florida), along with an instructional pamphlet describing how to use the accelerometer, an accelerometer diary to record non-wear periods, and a survey assessing socio-demographic characteristics. At the end of the seven-day accelerometer monitoring period, participants returned their signed consent form, completed survey and diary, and accelerometer in the padded postage paid priority post envelope that was provided.

Measures

Demographic and clinical information including age, sex, diagnosis date, stage, histology, and treatment received (e.g., surgery, chemotherapy, radiation therapy) were

obtained from the GLD. Information not available from the database, including other medical information such as medical comorbidities, smoking history, demographic and other lifestyle factors were collected by self-report.

Physical activity and sedentary time were objectively assessed by the ActiGraph® GT3X+ accelerometer, an instrument that records acceleration using a tri-axial accelerometer. The accelerometer is worn on an elasticized band around the waist (over or under clothing) during all waking hours, except while bathing or swimming. For accelerometer data processing, commonly accepted activity count cutoffs were used to categorize sedentary time (<100 counts/minute) from light-intensity physical activity (100-1,951 counts/minute) and MVPA (≥1,952) from counts/minute) (Freedson et al., 1998; Matthews et al., 2008). Step count was also recorded. ActiGraph® GT3X+ accelerometer has demonstrated highly accurate measurement of steps taken under various walking speeds (Sandroff et al., 2014). Data was processed in 60-second epochs. Non-wear time was defined as intervals of at least 60 consecutive minutes of zero counts, with allowance for up to two minutes of observations of less than 50 counts per minute within the non-wear interval (Matthews et al., 2008). Participants were asked to record, in a daily log, the time they put on and took off the monitor each day. These recordings were used to confirm wearing start and end times, as well as non-wear time. At least 600 minutes (10 hours) of daily wear time and no excessive counts (>20,000 counts per minute) were required to be considered valid wear days. A total of four valid days of wear time was required for inclusion in the analysis.

Statistical Analysis

Descriptive statistics were used to examine the demographic and clinical

characteristics of the sample, as well as physical activity (including steps) and sedentary time estimates. We examined MVPA accumulated in at least 10-minute bouts (more synonymous with a physical activity session), and sedentary time accumulated in at least 30-minute bouts, as per the US Department of Health and Human Services (2008) physical activity recommendations. Linear regression was used to determine correlates of physical activity and total sedentary time. All regression models were adjusted for predictors and accelerometer wear time. Predictor variables included marital status (married vs. not married), education (high school or less vs. more than high school), employment (working vs. not working), BMI (normal weight vs. overweight or obese), comorbidities (less than two vs. two or more comorbidities), smoking (not current smoker vs. current smoker), smoking history (having ever smoked less than 100 cigarettes vs. having ever smoked at least 100 cigarettes or more), age (under 60 years vs. $\geq$60 years), sex (female vs. male), surgery (no surgery vs. surgery received), and months since diagnosis (<60 months vs. >60 months). An α of 0.05 was used as a threshold for determining statistical significance. All models were generated using SPSS 23.

Results

Participant Characteristics

Participants who satisfied the eligibility criteria and had a home address on file were mailed a study invitation letter (N=662). After further eligibility screening and receiving incorrect address notices, the number of eligible and reachable individuals was reduced to 527. Of these, 166 did not respond, and 216 declined participation. A total of 145 survivors agreed to participate. Of the 145 that consented, 18 participants withdrew

due to health concerns (n=6), time constraints (n=4), and loss of interest in the study (n=8), for a final response rate of 24% (see Figure 1).

Of the 127 participants, 57% were female, the mean age was 71 years at recruitment, 85% smoked at least 100 cigarettes in their lifetime, with a mean body mass index of 24.1 (SD=13.9) kg/m^2. The mean number of months since diagnosis was 76.4 (SD=47) and at least two chronic diseases were reported by 39% of participants. The majority of the participants were white (95%), married or common-law (68%), retired (70%), and completed at least high school education (82%). Adenocarcinoma was the most common histological diagnosis (66%). The majority of participants were diagnosed at stage I (53%) with others diagnosed at stage II (23%), III (14%), and IV (10%). respectively. Overall, 66% of survivors underwent a lung resection while 23% of those received adjuvant therapy. Other treatments included radical chemotherapy and/or radiation (25%) and palliative chemotherapy and/or radiation or targeted therapy (8%).

An overview of the descriptive statistics for physical activity and sedentary time are displayed in Table 2. Participants averaged 4,596 (SD=2,160) steps per day. The recommended physical activity guidelines of at least 150 minutes of MVPA per week were not achieved by 77% of lung cancer survivors. On average, participants spent 14.0 (SD=18.0) minutes per day engaged in MVPA and accumulated 5.7 (SD=12.3) minutes per day of MVPA in at least 10-minute bouts. Approximately 4.1 hours (SD=1.3) per day was spent in light-intensity physical activity. Participants were sedentary for 588.3 (SD=95.4) minutes per day (i.e., 9.8 hours) and accumulated an average of 185.5 (SD=102.3) minutes per day of sedentary time in at least 30-minute bouts.

Correlates of physical activity

Table 3 provides a summary of the associations between demographic and clinical variables with physical activity. Total daily MVPA minutes was negatively associated with being ≥60 years of age (β =-7.4, CI: -14.7, -0.10) and with having ever smoked at least 100 cigarettes (β =-10.6, CI: -21.0, -0.28). No significant associations were found between daily MVPA minutes accumulated in 10-minute bouts and any of the predictor variables. Daily minutes of light-intensity physical activity time was negatively associated with being overweight/obese (β =-27.6, CI: -48.2, -7.1), having ever smoked at least 100 cigarettes (β =-52.8, CI: -91.8, -13.8), and being five or more years since diagnosis (β=-31.3, CI: -56.3, -6.4). The number of steps per day was negatively associated with being ≥60 years of age (β=-1010.4, CI: -2028.4, 7.7), being overweight or obese (β=-1180.7, CI: -1939.1, -422.2), and being a current smoker (β=-1519.5, CI: -3036.5, -2.5,).

Correlates of sedentary time

Average daily sedentary minutes was positively associated with having ever smoked at least 100 cigarettes (β=63.4, CI: 22.4, 105.4), being overweight or obese (β=30.8, CI: 8.8, 52.9), and being five or more years post diagnosis (β=31.4, CI: 4.6, 58.2) (Table 4). Average daily sedentary minutes accumulated in 30-minute bouts was also positively associated with having ever smoked at least 100 cigarettes (β=75.1, CI: 21, 129.1), being overweight/obese (β=43.6, CI: 15.2, 72) and being five or more years post diagnosis (β=36, CI: 1.5, 70.5).

Discussion

The primary aim of this study was to determine demographic and clinical correlates of accelerometer-assessed light, moderate and vigorous intensity physical

activity, steps, and sedentary time among a sample of lung cancer survivors. We observed significant associations of physical activity and sedentary time with clinical factors (e.g., body mass index, smoking history, and time since diagnosis). This study is the first to examine correlates of objectively assessed physical activity and sedentary time among lung cancer survivors.

We found total daily MVPA minutes was associated with being ≥60 years of age and with having ever smoked at least 100 cigarettes. Participants in our study who never smoked recorded twice as many minutes of MVPA compared to participants with a smoking history (25.8 versus 12.2 minutes). Never smokers also accumulated more time in light physical activity (5.2 hours) compared to participants with a smoking history (3.9 hours). Light-intensity physical activity time was also negatively associated with being overweight/obese (27.6 minutes less), and being five or more years since diagnosis (31.3 minutes less). Similar findings have been reported in previous research examining correlates of objectively assessed MVPA in other tumor groups. For example, Kampshoff et al. (2016) also found that older age and a higher body mass index were significantly correlated with lower physical activity among breast cancer survivors. Boyle et al. (2016) found that older age and lower education level were associated with lower physical activity among breast cancer survivors. Boyle et al. (2015) also studied non-Hodgkin lymphoma survivors and found that females, smokers, older age, and participants with a larger waist circumference had lower MVPA levels. In a sample of colon cancer survivors, Lynch et al. (2016) found higher time spend in MVPA was significantly associated with younger age, higher income, being employed, and a lower body mass index. Collectively, it appears age, body size, and smoking are key predictors of MVPA

among cancer survivor populations, while clinical correlates such as cancer stage, months since diagnosis, and treatment(s) received do not appear to be associated with activity levels. This finding may be particularly important given accumulating evidence suggests that obesity is associated with poorer overall survival and progression-free survival in people with cancer (Demark-Wahnefried et al., 2012).Healthy behavior interventions that effectively target modifiable factors such as obesity may improve survival outcomes in cancer patients and survivors.

Average daily sedentary minutes and average daily sedentary minutes accumulated in 30-minute bouts were positively associated with having ever smoked at least 100 cigarettes. In our study, participants who smoked at least 100 cigarettes were found to be more sedentary, spending 10 hours a day sitting or reclining, compared to 8.7 hours in never-smokers. Smoking has been linked to sedentary behavior in previous literature where current smokers reported the highest levels of sedentary behavior, followed by former smokers and then never smokers (Kaufman, Augustson, & Patrick, 2012). Similar findings have been reported in previous research examining correlates of objectively assessed sedentary time in other tumor groups. Boyle et al. (2015) reported that non-Hodgkin lymphoma survivors who were smokers also averaged an additional 85 minutes of sedentary time. Smoking limits cardiorespiratory fitness (Borba et al., 2014; Sperandio et al., 2014) and individuals who smoke may be more likely to be sedentary or engage in other poor health habits.

Higher sedentary time was also observed among survivors with a higher body mass index and who were more than five years post diagnosis. In our study, survivors who were obese or overweight were more sedentary (31 minutes more per day) and

accumulated 44 more minutes in sedentary time recorded in 30-minute bouts compared to participants with a normal body mass index. Studies by Boyle et al. (2016) and Lynch et al. (2016) found a higher body mass index and a greater waist circumference, respectively, were correlated with more sedentary time in breast and colon cancer survivors. Further, participants who were five or more years post diagnosis were found to accumulate more sedentary time (31 minutes) and more sedentary time in 30-minute bouts (36 minutes). From previous research by Solberg et al. (2012) we know that lung cancer survivors become less active the further they are from their lung cancer diagnosis. Considering their compromised lung capacity, treatment-related morbidity, and often complicated and burdensome disease trajectory, it is not surprising that long-term lung cancer survivors are less physically active and more sedentary.

We found that participants accumulated an average of 4,596 steps per day. To date only two other studies have reported steps among lung cancer survivors. Granger et al. (2014) examined lung cancer survivors who were six months post diagnosis and found on average survivors took 6,171 steps per day, while Cavalheri et al. (2016) found that lung cancer survivors 4 to 8 weeks post lobectomy took 8,863 steps each day. Although both studies reported higher steps per day than our study, the use of different devices and differences in sample characteristics (e.g., stage at diagnosis and time since diagnosis) makes it difficult to compare across studies. Our study is the first to report correlates of walking steps among lung cancer survivors as the aforementioned studies did not report any correlates with daily step counts. Steps per day was negatively associated with being >60 years of age (took 1,010 fewer steps than younger survivors), being overweight or obese (took 1,118 fewer steps than normal weight survivors), and being a current smoker

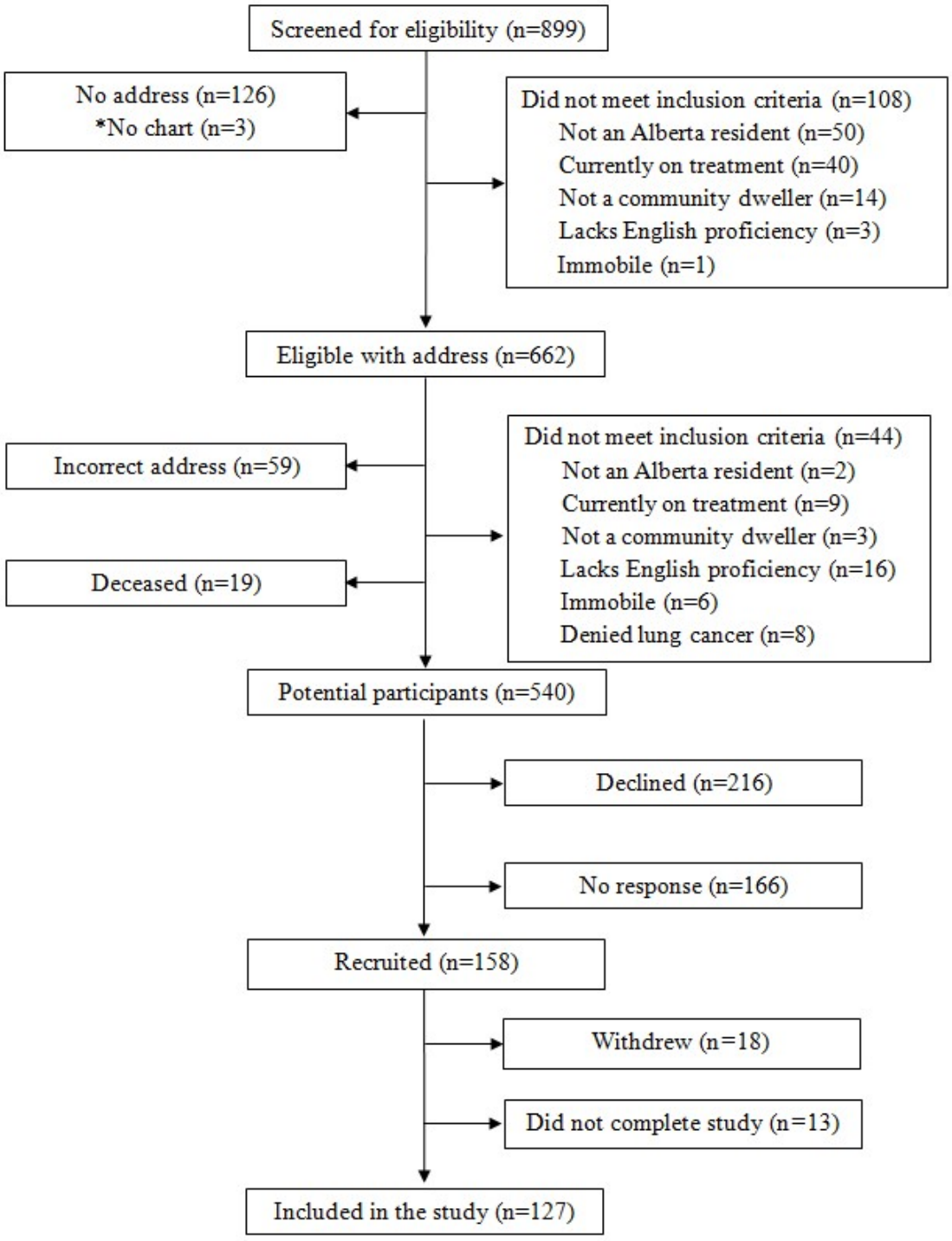
(took 1,519 fewer steps than non-smokers). Given the nature of the lung cancer population (i.e., older adults, multiple comorbidities), interventions designed to facilitate walking may be the most effective in shifting survivors along the activity spectrum. Our data suggest that age, body size, time since diagnosis, and smoking status should be considered when designing such interventions.

There are several limitations that should be considered when interpreting the results of this study. The accelerometer used in this study does not capture water-based activities, does not accurately measure activities such as cycling, and cannot distinguish between sitting and stationary standing (i.e., sedentary time may include periods of standing still as well as sitting). Future studies should consider the use of devices with inclinometers to better differentiate between sitting and standing (e.g., activPal®). Lung cancer survivors who did not respond to the study invitation or declined to participate may have considered themselves sedentary and considered themselves as less appropriate to participate in a study that examines physical activity levels (and health in general). In North America, the one and five-year survival rates for lung cancer are ~40% and 17%, respectively (American Cancer Society, 2016; Canadian Cancer Society, 2015). Our sample consists of lung cancer survivors who were at least 18 months post diagnosis (with an average participant being approximately six years post diagnosis) and may not be representative of all lung cancer survivors. However, we did not find any differences between responders and non-responders in terms of age, gender, or time since diagnosis.

This is the first study to examine demographic and clinical correlates of objectively-assessed physical activity and sedentary time among lung cancer survivors. We found different correlates emerged across different behaviors in the activity spectrum

(i.e., sedentary time, light, moderate, and vigorous intensity activity, and steps). These findings may inform activity and sedentary time interventions for lung cancer survivors. We cannot establish causality given the cross-sectional nature of this study, and future research with larger sample sizes and methodologically stronger study designs (e.g., prospective studies or intervention trials) is needed to gain a better understanding of social determinants of physical activity and sedentary time that are unique to older and overweight lung cancer survivors.

Figure 1. Flow of participants through the study.



* Patient records advised these individuals were incorrectly coded as having lung cancer.

Table 1

Demographic and clinical characteristics[†]

Characteristic	No. of Respondents	%	Mean ± SD
Demographic			
Sex			
Male	54	42.5	
Female	73	57.5	
Age			71.4±9.0
Marital Status			
Married	81	63.8	
Widowed	16	12.6	
Separated/divorced	20	15.7	
Common-law	5	3.9	
Never married	5	3.9	
Ethnicity			
Caucasian	120	94.5	
Other	7	5.5	
Education			
Some high school	52	40.9	
Trade or apprenticeship	22	17.3	
Some university/college	21	16.5	
Completed university/college	24	18.9	
Completed graduate school	8	6.3	
Annual Family Income			
≤$60,000	77	61	
>$60,000	50	39	
Employment Status			
Retired	89	70.1	
Disability	6	4.7	
Employed part-time	10	7.9	
Employed full-time	15	11.8	
Temporarily unemployed	1	0.8	
Homemaker	6	4.7	

Clinical			
Body mass index (kg/m^2)			24.1±13.9
Normal weight	86	67.7	
Overweight	31	24.4	
Obese	10	7.9	
Months since diagnosis			76.4±47.0
Stage			
I	67	52.8	
II	31	24.4	
III	17	13.4	
IV	12	9.4	
Histology			
Adenocarcinoma	84	66.1	
Squamous cell carcinoma	20	15.7	
Not specified	9	7.1	
Other [a]	14	11.0	
Treatment			
Surgery	82	64.6	
Radical	32	25.2	
Palliative	10	7.9	
None	3	2.4	
Comorbidity history			
At least two comorbidities	50	39.4	
Angina	17	13.4	
Heart attack	16	12.6	
Stroke	6	4.7	
Diabetes	15	11.8	
High blood pressure	58	45.7	
High blood cholesterol	51	40.2	
Other	33	26.0	
Smoking			
Never smoker	16	12.9	
Former smoker	94	75.8	
Current smoker	14	11.3	

Note. Data are presented as the mean (standard deviation) for continuous variables and frequency (percentage) for categorical variables.
[a] Other histology subtypes include: Adenosquamous, BAC, carcinoid, and large cell.
[†]Numbers may not equal 127 due to missing data.

Table 2

Descriptive statistics for accelerometer-determined physical activity and sedentary time in lung cancer survivors (N=124)

Variable	Mean (SD)	Median	IQR
Physical Activity and Sedentary Time			
Valid days	6.6 (0.8)	-	-
Accelerometer wear time Minutes/day	847.8 (80.0)	-	-
Light-intensity physical activity Minutes/day	245.5 (77.8)	242.6	112.4
Moderate-intensity physical activity Minutes/day	13.6 (16.8)	5.59	17.6
Vigorous-intensity physical activity Minutes/day	0.5 (4.8)	0.0	0.0
MVPA			
Minutes/day	14.0 (17.9)	5.7	17.5
Minutes/day in 10-minute bouts[b]	5.7 (12.3)	0.0	4.2
Percent achieving MVPA guidelines[c]	22.6%	-	-
Steps per day	4,596 (2160)	4,078	3,442
Sedentary time			
Minutes/day	587.2 (95.7)	593.1	126.7
Minutes/day in 30-minute bouts[d]	184.9 (102.1)	170.1	141.9

Data are presented as the mean (SD: standard deviation), median, and interquartile range (IQR) for continuous variables and frequency (percentage) for categorical variables. Abbreviations: MVPA, moderate-to-vigorous intensity physical activity.
[a] Moderate and vigorous minutes combined. [b] MVPA time accumulated in at least 10-minute bouts. [c] Engage in moderate-intensity physical activity for a minimum of 150 minutes of MVPA a week. Activity performed in at least 10-minute bouts. [d] Sedentary time accumulated in at least 30-minute bouts.

Table 3.

Demographics and clinical correlates of accelerometer-derived physical activity

	MVPA		MVPA in 10-minute bouts		Light-intensity physical activity		Steps	
Variable	*b* (95% CI)	*p*	*b* (95% CI)	*p*	*b* (95% CI)	*p*	*b* (95% CI)	*p*
Gender	3.5 (-3.7, 10.7)	.331	.98 (-4.2, 6.2)	.708	-9.2 (-36.2, 17.8)	.501	121.6 (-872.3, 1115.5)	.809
Age	-7.4 (-14.7, -0.1)	.047*	-2.2 (-7.5, 3.1)	.416	-20.5 (-48.1, 7.2)	.145	-1010.4 (-2028.4, 7.7)	.052
Marital status	-3.1 (-10.2, 3.9)	.381	-1.0 (-6.1, 4.1)	.698	7.7 (-18.9, 34.3)	.566	186.2 (-793.1, 1165.5)	.707
Education	5.1 (-2.1, 12.3)	.166	3.0 (-2.2, 8.3)	.252	3.1 (-24.23, 30.0)	.821	282.1 (-722.1, 1286.3)	.579
Employment status	2.3 (-7.0, 11.6)	.631	2.0 (-4.7, 8.8)	.555	9.33 (-25.8, 44.5)	.559	921.1 (-372.4, 2214.5)	.161
Body mass index	-3.2 (-8.7, 2.2)	.243	-2.2 (-6.1, 1.7)	.268	-27.6 (-48.2, -7.1)	.009**	-1118.4 (-1873.9, -362.9)	.004**
Months since diagnosis	-.05 (-6.6, 6.5)	.988	-.35 (-5.1, 4.4)	.886	-31.3 (-56.3, -6.4)	.014*	-599.3 (-1516.7, 318.1)	.198
Stage at diagnosis	-.04 (-1.9, 2.0)	.969	.10 (-1.3, 1.5)	.887	-2.1 (-9.5, 5.4)	.585	-87.5 (-361.0, 185.9)	.527
Surgery	2.8 (-5.5, 11.2)	.501	1.5 (-4.5, 7.6)	.614	28.8 (-2.8, 60.3)	.074	874.7 (-287.3, 2036.8)	.139
Comorbidities	-.02 (-6.9, 6.9)	.996	-.81 (-5.8, 4.2)	.748	-13.9 (-40.1, 12.2)	.145	-271.0 (-1233.4, 691.4)	.578
Smoking history	-10.6 (-20.9, -.28)	.044*	-5.1 (-12.6, 2.4)	.177	-52.8 (-91.8, -13.8)	.009**	-1393.6 (-2830.5, 43.4)	.057
Current smoker	-9.5 (-20.6, 1.5)	.090	-5.6 (-13.5, 2.3)	.161	-25.7 (-66.9, 15.5)	.218	-1519.5 (-3036.5, -2.5)	.050*

Note. MVPA time recorded in minutes per day. All regression models were adjusted for predictors and accelerometer wear time.
Abbreviations: MVPA, moderate-to-vigorous intensity physical activity.
Age was categorized as under 60 years or ≥60 years. Marital status was coded as Married/Common-law or Never-married/Separated/Divorced. Education was coded as high school or less and more than high school. Employment status was coded as working or not working. Body mass index was coded as under ≤25 (normal) or over 25 (overweight/obese). Month since diagnosis was coded

as under five years or ≥5 years. Surgery was either yes or no. Comorbidities were coded as less than two or two or more. Smoking history was defined as having ever smoked at least 100 cigarettes.
* $p < .05$; ** $p < .01$. *b*, unstandardized regression coefficient, CI, confidence interval.

Table 4

Demographics and clinical correlates of accelerometer-derived sedentary time variables

	Sedentary time		Sedentary time in 30-minutes	
Variable	*b* (95% CI)	*p*	*b* (95% CI)	*p*
Gender	5.5 (-23.5, 34.6)	.706	29.7 (-7.7, 67.1)	.118
Age	27.9 (-1.9, 57.6)	.066	28.9 (-9.4, 67.2)	.138
Marital status	-4.6 (-33.2, 24.0)	.750	-28.6 (-65.5, 8.2)	.126
Education	-8.2 (-37.5, 21.1)	.581	-2.9 (-40.6, 34.9)	.880
Employment status	-11.6 (-49.4, 26.2)	.544	-6.8 (-55.4, 41.9)	.783
Body mass index	30.9 (8.8, 52.9)	.007**	43.6 (15.2, 72.0)	.003**
Months since diagnosis	31.4 (4.6, 58.2)	.022*	36.0 (1.4, 70.5)	.041*
Stage at diagnosis	2.0 (-6.0, 10.0)	.618	5.4 (-4.8, 15.7)	.296
Surgery	-31.6 (-65.6, 2.3)	.068	-37.2 (-80.9, 6.5)	.095
Comorbidities	13.9 (-14.2, 42.1)	.328	14.8 (-21.4, 51.0)	.418
Smoking history	63.4 (21.4, 105.4)	.003**	75.1 (21.0, 129.1)	.007**
Current smoker	35.6 (-8.8, 79.9)	.115	-32.5 (-89.6, 24.5)	.261

Note. Sedentary time recorded in minutes per day. All regression models were adjusted for predictors and accelerometer wear time.
Age was categorized as under 60 years or ≥60 years. Marital status was coded as Married/Common-law or Never-married/Separated/Divorced. Education was coded as high school or less and more than high school. Employment status was coded as working or not working. Body mass index was coded as under ≤25 (normal) or over 25 (overweight/obese). Month since diagnosis was coded as under five years or ≥5 years. Surgery was either yes or no. Comorbidities were coded as less than two or two or more. Smoking history was defined as ever having smoked at least 100 cigarettes.
* $p < .05$; ** $p < .01$. *b*, unstandardized regression coefficient, CI, confidence interval.

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CHAPTER V — Conclusion

This is the first study to examine associations between objectively assessed physical activity and sedentary time with patient reported outcomes in a lung cancer survivor population. In particular, this is the first study in the field of exercise and cancer to assess the impact of MVPA, light-intensity physical activity, and sedentary time across the HRQoL, fatigue, and TOI distributions using quantile regression. We found that overall, lung cancer survivors were not engaged in meaningful amounts of MVPA and reported less daily MVPA time compared to other tumour groups. Our participants were also found engaging in high amounts of sedentary time, consistent with findings across tumour groups. Across the HRQoL, fatigue, and physical and functional well-being distributions, quantile regression revealed that sedentary time was negatively and significantly associated with HRQoL, fatigue, and TOI in lung cancer survivors. Light-intensity physical activity was positively associated with higher HRQoL and TOI scores, as well as reduced fatigue, but weaker associations were found with MVPA. Our findings suggest that targeting an increase in light-intensity physical activity, rather than MVPA, may be a more effective for this population. Increasing light-intensity physical activity and reducing sedentary time appears important in this population given our findings are suggestive of better HRQoL and physical function and well-being along with reduced fatigue among all lung cancer survivors regardless of their HRQoL or fatigue perceptions.

This study is also the first to examine correlates of objectively assessed physical activity and sedentary time among lung cancer survivors. We found different correlates emerged across different behaviors in the activity spectrum (i.e., sedentary time, light, moderate, and vigorous intensity activity, and steps). Linear regression revealed that lung

cancer survivors were found to be less active if they were older, had a smoking history, were overweight or obese, and were more than five years post diagnosis. Given the nature of the lung cancer population (i.e., older adults, multiple comorbidities), combined with the benefits associated with light-physical activity, interventions designed to facilitate walking may be the most effective in shifting survivors along the activity spectrum. Our data suggest that when designing such interventions that age, body size, time since diagnosis, and smoking status should be considered.

CHAPTER VI — Future Directions

With the aging population and increasing availability of better treatments (e.g. immnotherapies and targeted agents) lung cancer patients are living longer and the lung cancer survivor population will continue to grow. Although lung cancer survivors represent a small number of the survivorship population, these individuals have lost-lasting side effects from their treatments and multiple comorbidities that impact their quality of life and the ability to be physically active. HRQoL has become an important prognostic predictor among lung cancer survivors. Based on our results, and other studies published to date, physical activity can alleviate some patient reported treatment side-effects and increase symptom control, as well as improve HRQoL. Lung cancer survivors are a diverse group with varying levels of HRQoL and varied symptoms, and can thus be expected to be anywhere along the physical activity continuum. This diversity should be taken into account and will require an individualized approach towards increasing physical activity levels and decreasing sedentary time among lung cancer survivors.

The current literature examining physical activity, sedentary behavior, and HRQoL in lung cancer is relatively limited compared to other tumor groups (e.g., breast,

prostate, and colon). Moving forward in this area of research, several important questions remain. Future research with larger sample sizes using methodologically stronger study designs (e.g., prospective studies) are needed. Prospective studies will provide a deeper understanding of how physical activity and sedentary behavior changes throughout the lung cancer trajectory. For example, there may be particular timepoints where lung cancer survivors have more difficulty with maintaining physical activity (or ambulatory activity such as walking). It is these timepoints where intervention may be more necessary and relevant. Since most lung cancer survivors are sedentary, we need to better understand the role of sedentary behavior among lung cancer survivors. More specifically, how to effectively reduce sedentary time and introduce breaks into prolonged sitting activities. Since this is the first study to examine patient reported outcomes (e.g., HRQoL), future studies should examine other health outcomes that have been negatively associated with sedentary behavior in other populations such as metabolic outcomes (body mass index, waist circumference), psychosocial health (e.g., depression), and clinical outcomes such as recurrence and survival. Determining associations between physical activity, sedentary behavior, and survival time after a lung cancer diagnosis is also a key research question that may have immediate clinical consequences for lung cancer care. We have shown light-intensity physical activity to be associated with reduced fatigue and higher HRQoL among lung cancer survivors. Increasing light-intensity physical activity could displace sedentary time and therefore reduce the daily time spent in sedentary behavior. This could be as simple as increasing one's step count with more walking. Light-intensity physical activity may also be most appropriate for this population in consideration of their older age and multiple

comorbidities. For this inactive and deconditioned population, it may be more prudent to intervene with the aim of increasing light-intensity physical activity as opposed to the more traditional approach of targeting moderate and vigorous intensity physical activity (which may not be feasible for many lung cancer survivors). Nonetheless, determining the optimal type, frequency, dose, safety, and feasibility of physical activity for lung cancer survivors, is more complex, but warranted.

Using qualitative approaches may also provide a more detailed, contextual, and rich understanding of physical activity and sedentary time in the lung cancer context. Lung cancer survivors' perceptions of physical activity, how these views can be modified to increase participation, as well as barriers to physically activity and motivations to become less sedentary, are fundamental research questions. We found that older and overweight lung cancer survivors with a smoking history were more prone to lower physical activity levels. Studies are needed to gain a better understanding of social determinants that are unique to these lung cancer survivors. Further, since most lung cancer survivors are over 70 years of age and retired, economic implications should also be explored.

Results from our study and previous literature indicate that it is common for lung cancer survivors to decrease their physical activity levels after their cancer diagnosis. Based on our results, long-term survivors (i.e., more than five years post diagnosis) were found to be less active and more sedentary than survivors who were more proximal to their diagnosis. Important findings may come from following newly diagnosed lung cancer patients and noting how and why their physical activity levels may change during the course of their disease and into survivorship. Perhaps patients who were physically

active (i.e. were achieving the recommended physical activity guidelines) prior to diagnosis require a different approach toward increasing their physical activity levels from those who were inactive. In addition, future studies could determine if physical activity levels can predict compliance to treatment, number of treatment complications and side-effects, treatment completion, and disease progression and recurrence.

Taking an individualized approach towards designing interventions is inclined to yield wanted results. Future intervention studies should include a diverse population (e.g. resectable and non-resectable cases, short-term and long-term survivors) and must demonstrate the benefits, safety, and feasibility of physical activity under investigation. It may be expected that some lung cancer survivors will encounter challenges in becoming more active or in maintaining recommended physical activity levels. The thought of exercise may be initially overwhelming to some, but a well-tailored, structured exercise program could be flexible and introduced gradually in a controlled environment.

Future exercise programs must be based on evidence-based research and will require the commitment of healthcare professionals and governing bodies to become implemented into the cancer trajectory and offered as a standard of lung cancer care. Implementing any exercise program will be a challenge that considers this very diverse population and the already limited healthcare resources.

Appendix A: Ethics Approval

Health Research Ethics Board of Alberta
Cancer Committee
1500, 10104 - 103 Avenue NW
Edmonton, Alberta, T5J 4A7
Telephone: (780) 423-5727
Fax: (780) 429-3509
Email: cancer@hreba.ca

CERTIFICATION OF RESEARCH ETHICS REVIEW

This is to acknowledge that the following study has been reviewed and on behalf of the Health Research Ethics Board of Alberta (HREBA) – Cancer Committee (CC). I am granting approval to your participation in the research study.

Ethics ID:	HREBA.CC-16-0142
Principal Investigator:	Dafydd (Gwyn) Bebb
Co-Investigator(s):	Jeff Vallance
Student Co-Investigator(s):	Adrijana D'Silva
Study Title:	Accelerometer-determined physical activity, sedentary time, and patient-reported outcomes among a provincial sample of lung cancer survivors

Effective: May 9, 2016 **Expires:** May 9, 2017

The following documents have been reviewed and are approved for use:

- Invitation Letter, 3, May 3, 2016
- Accelerometer Diary, 1, March 30, 2016
- Consent Form, 3, May 3, 2016
- Questionnaire, 1, March 30, 2016
- Protocol, 1, March 30, 2016

This Committee has been constituted following the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (TCPS 2) and is in compliance with TCPS 2, the Health Information Act (HIA), Good Clinical Practice (GCP) Guidelines of the International Council on Harmonization (ICH), Part C, Division 5 of Health Canada's *Food and Drug Regulations* (FDR), the Therapeutic Products Directorate Guidelines/ICH Harmonized Tripartite Guidelines –Good Clinical Practice: Consolidated Guidelines and the National Institutes of Health-Code of Federal Regulation in the United States. Our institution has been approved by the Office for Human Research Protections, US Department of Health and Human Services.
The deliberations of the Cancer Committee included all elements described in Section 50 of the HIA and found the study to be in compliance with all applicable requirements of the Act.
The HREBA – Cancer Committee determined that consent will be obtained from study participants for disclosure of the health information to be used in the research.
The membership of this Committee complies with the membership requirements for Research Ethics Boards defined in Part C, Division 5 of the *Food and Drug Regulations* . This Committee carries out its functions in a manner consistent with Good Clinical Practices and has reviewed and approved the clinical trial protocol and informed consent form for the trial which is to be conducted by the Qualified Investigator named above at the specified clinical trial site. This approval and the views of the Committee have been documented in writing.
Members of the Committee who are named as investigators or co-investigators in research studies do not participate in discussion(s) related to, nor vote on, such studies when they are presented to the Committee. It is not our policy to release the names of the Committee membership, however, an outline of its composition can be provided.
Please refer to the accompanying letter for conditions of approval.

Approved on behalf of CC by, **Date:**

Jackson Wu , HREBA-CC May 9, 2016

May 20, 2016

Mrs. Adrijana D'Silva
Faculty of Health Disciplines\Centre for Nursing & Health Studies
Athabasca University

File No: 22204

Expiry Date: May 19, 2017

Dear Adrijana D'Silva,

The Faculty of Health Disciplines (CNHS) Departmental Ethics Review Committee, acting under authority of the Athabasca University Research Ethics Board to provide an expedited process of review for minimal risk student researcher projects, has reviewed you project, 'Accelerometer-determined physical activity, sedentary time, and patient-reported outcomes among a provincial sample of lung cancer survivors'. Your application has been **Approved on ethical grounds** and this memorandum constitutes a ***Certification of Ethics Approval***. You may begin the proposed research.

AUREB approval, dated May 20, 2016, is valid for one year less a day.

As you progress with the research, all requests for changes or modifications, ethics approval renewals and serious adverse event reports must be reported to the Athabasca University Research Ethics Board via the Research Portal.

To continue your proposed research beyond May 19, 2017, you must apply for renewal by completing and submitting an Ethics Renewal Request form. Failure to apply for **annual renewal** before the expiry date of the current certification of ethics approval may result in the discontinuation of the ethics approval and formal closure of the REB ethics file. Reactivation of the project will normally require a new Application for Ethical Approval and internal and external funding administrators in the Office of Research Services will be advised that ethical approval has expired and the REB file closed.

When your research is concluded, you must submit a Project Completion (Final) Report to close out REB approval monitoring efforts. Failure to submit the required final report may mean that a future application for ethical approval will not be reviewed by the Research Ethics Board until such time as the outstanding reporting has been submitted.

At any time, you can login to the Research Portal to monitor the workflow status of your application.
If you encounter any issues when working in the Research Portal, please contact the system administrator at research_portal@athabascau.ca.
If you have any questions about the REB review & approval process, please contact the AUREB Office at (780) 675-6718 or rebsec@athabascau.ca.
Sincerely,

Sherri Melrose
Chair, Faculty of Health Disciplines (CNHS) Departmental Ethics Review Committee
Athabasca University Research Ethics Board

Appendix B: Invitation Letter

Invitation Letter
Letter number: 1111

Month 0, 2016

<First Name <Last Name>
Address
City, AB, Postal Code

Dear <First Name>,

My name is Adrijana D'Silva and I am a graduate student in the Centre for Nursing and Health Studies at Athabasca University. I am conducting research on how physical activity levels are associated with health outcomes such as quality of life and fatigue in lung cancer survivors. My supervisor for this study is Dr. Jeff Vallance, an Associate Professor at Athabasca University. This study has been approved by the Athabasca University Ethics Committee and the Health Research Ethics Board of Alberta. I am contacting you to see if you might be interested in participating.

In this study, we want to get a better understanding of how active lung cancer survivors are, and what are the main factors that effect physical activity levels. This is the first study of its kind in the world. For this study, **you will not be asked to do any exercise tests or follow any program**. You can be in the study whether you are active or not. The research team will ask you to complete a one-time 30-minute survey and wear a small activity monitor (you wear it on your hip) for 7 days. The survey asks about yourself, your quality of life, attitudes about life, and your health. If you agree to be in the study, you will be sent you a survey and activity monitor in the mail.

Your participation in this study is completely voluntary. It is only through voluntary participation in research projects that we increase our knowledge about issues that are important to cancer survivors. We hope that you find the time to help us out. If you have any questions about the study, please do not hesitate to contact me at **(403) 521-3907** or via email at **asevo@ucalgary.ca**.

If we do not hear from you within two weeks, we will follow-up with a telephone call. If we are unable to reach you by phone, one more letter will be sent. If you do not wish to participate please call **(403) 521-3907** and leave a message stating your letter number (above) and that you do not wish to participate (please do *not* leave your name). We will not contact you further.

Thank you for considering our research study.

Sincerely,

Adrijana D'Silva
Graduate Student
Centre for Nursing and Health Studies
Athabasca University

Appendix C: Study Information Letter

Study Information Letter

Title of Study: Accelerometer-determined physical activity, sedentary time, and patient-reported outcomes among a provincial sample of lung cancer survivors

This information letter is designed to give you an idea of what our research study is about. Please read this form carefully to make sure you are aware of all the information it provides. You can keep this form for your records. Participation in this study is entirely voluntary.

Why am I being asked to take part in this research study?

You are being asked to take part in this study because you have been diagnosed with lung cancer at some point in time. Lung cancer patients who are physically active following their diagnosis indicate they have better quality of life and health compared to those patients that are inactive. This study is being done because all data on physical activity and lung cancer patients are derived from self-report measures. However, self-report physical activity may be prone to lots of mistakes. By using a more objective activity monitor (on your hip), we can accurately determine the percentage of time a person is sedentary throughout the day. To date, we do not know how and if objectively determined activity and sedentary behavior are associated with health outcomes in lung cancer survivors.

What is the reason for doing this study?

We know that being active is good for people's health and wellbeing. But we don't know much about the physical activity and sedentary habits of lung cancer survivors. We are interested in finding out a little bit about your general health and then seeing what your current physical activity level is, and how sedentary you are. We are interested in how these activities are related to your quality of life and psychosocial health. The purpose of our study is to further understand how physical activity and sedentary behavior can affect your health.

What will I be asked to do?

- Complete a one-time 30 minute survey.
- Wear a small activity monitor around your waist for 7 consecutive days. This device records how active you are. It is unobtrusive, and you can take it off anytime. If you miss a day, that's okay, just put the monitor back on as soon as you remember.
- Complete an activity monitor daily log to record when you took off, and put on, the monitor (this will take approximately 5 minutes per day).
- When you have finished the survey, return the finished survey in the self-addressed business reply envelope that is enclosed for you, and mail the envelope back to us. You do not have to pay for postage. We will do that for you.
- *It is very important that you don't change your normal physical activity and any walking behavior during this study*. We want to know what it is that you normally do. Doing more physical activity than normal will not improve the results of this study. We will actually get more helpful information if you keep doing the activities that you normally do and don't change anything. Once you have completed the survey you are free to change any physical activity habits at that time if you choose.

Are There Any Benefits To Participating In This Study?

You are not expected to get any benefit from being in this research study. The information collected in this study will be used for research and teaching purposes, and to help develop guidelines for helping improve the quality of life and health of people with lung cancer.

Are There Any Risks With Being In This Study?

We are only asking you to wear an accelerometer and continue on with your normal daily activities. We are not asking you to start an exercise program and no exercise intervention is being delivered.

Can I Withdraw From This Study?

You may withdraw from the study at any time if you wish to do so. If you decide to stop being in the study, we encourage you to inform the study coordinator of your wish. Should you decide to withdraw from the study at any time, information collected on you up until that point would still be utilized in this study unless you request to remove the information all together.

What if I am not a very active person?

We would still like you to participate in this study, even if you think that you are not a very active person. For the study to be successful, we need information from people who have a wide range of activity levels; from those who think they are inactive, all the way to those who are active every day.

Will I be paid to be in the research study?

To show our appreciation for your participation, we will mail you a $5 Tim Horton's gift card with the study package.

Do I have to travel somewhere to be in this study?

No, you do not need to travel anywhere to be in this study. This study is a home-based study. That means that this study can be done in the comfort of your own home.

Will My Personal Information Be Kept Confidential?

Identifiable health information will be collected from you and from your Provincial Electronic Health Record during this study and retained for five years. Any research proposal to use information that identifies you for a purpose other than this study must be approved in advance by the Health Research Ethics Board of Alberta – Cancer Committee.

Direct access to your identifiable health information collected for this study will be restricted to the researchers who are directly involved in this study except in the following circumstances: your identifiable health information may need to be inspected or copied from time to time for quality assurance (to make sure the information being used in the study is accurate) and for data analysis (to do statistical analysis that will not identify you).

Any disclosure of your identifiable health information will be in accordance with the Alberta Health Information Act. As well, all research persons looking at your records on-site at the Tom Baker Cancer Centre will follow the relevant Alberta Health Services and relevant Health Research Ethics Board of Alberta – Cancer Committee policies and procedures that control these actions. Any disclosure of your identifiable health information to another individual or organization will need the approval of the Health Research Ethics Board of Alberta – Cancer Committee. Your identifiable health information collected as part of this study which includes will be kept confidential in a secure AHS facility.

The researchers who are directly involved in your study may share information about you with other researchers, but you will not be identified in that shared information except by a number. The key that indicates what number you have been assigned will be kept secure by the researchers directly involved with your study and will not be released. Although absolute confidentiality can never be guaranteed, we will make every effort to keep your identifiable health information confidential, and to follow the ethical and legal rules about collecting, using and disclosing this information in accordance with the Alberta Health Information Act and other regulatory requirements.

The information collected during this study will be used in analyses and will be published and/or presented to the scientific community at meetings and in journals, but your identity will remain confidential. It is expected that the study results will be published as soon as possible after completion.

Who Do I Call If I Have Questions?

If you have further questions you may contact the Adrijana D'Silva at **(403) 521-3907** or **asevo@ucalgary.ca**.

Accelerometer pictured above on waist.

Appendix D: Activity Monitor Log

Study ID

Lung Cancer Survivors Study

Activity Monitor Log

1

Activity monitor instructions

1. Put on the activity monitor right after you get out of bed in the morning and record this time in the activity log below.

2. Wear the activity monitor throughout the day, even when you may take a nap.

3. The monitor is NOT waterproof - so PLEASE do not wear it in the bath or shower or if you go swimming.

4. If there are any times of the day that you do NOT wear the monitor between getting up in the morning and going to bed at night, please fill in this daily log as described on the next page.

5. Take off the activity monitor just before you get in bed at night and record this time in the activity log.

Daily log instructions

For any period of time that you did NOT wear the monitor between getting up in the morning and going to bed at night, list:

- what activity you were doing
- the time you started the activity
- the time you stopped the activity

You may combine routine activities but other activities should be reported separately.

Examples of activities considered to be "routine activities" that may be combined are:

- Taking a shower
- Shaving
- Drying your hair
- Getting dressed
- Applying make-up
- Preparing and eating breakfast
- Brushing your teeth
- Getting ready to go to bed

* Only record activities lasting **10 MINUTES** or longer.

Example:

You went for a swim so you had to remove the monitor. You were swimming from 8:30 until 9:00 am then you changed into your clothes and put the monitor back on. In the daily log, you would list the following:

What activity were you doing? *Went Swimming*

At what time did you start this activity? *8:30* (24 Hour)

At what time did you stop this activity? *9:00* (24 Hour)

You do **NOT** need to list the time you spent changing into exercise clothes if it took less than 10 minutes.

You do **NOT** need to list the time you were showering and changing clothes if it took less than 10 minutes.

Frequently asked questions

1. **After I swim, I typically spend 20 minutes in the locker room getting ready to leave. What if I put on the monitor after I am done getting ready? What should I write in the log?**

   Answer: Because getting ready took more than 10 minutes, you need to tell us what activities you did in the locker room to get ready and leave. First, as in the example above, you would list the 30 minutes you went swimming. If from 9:00 to 9:20 am you took a shower, got dressed, and dried your hair, you would fill out the daily log as follows:

> What activity were you doing? *Took a shower, got dressed, dried my hair*
>
> At what time did you start this activity? *9: 0 0* (24 Hour)
>
> At what time did you stop this activity? *9: 2 0* (24 Hour)

2. **Why did you combine "took a shower, got dressed and dried my hair" into one statement? I would have separated those activities.**

   Answer: We consider taking a shower, getting dressed and drying hair to be routine activities. You can combine routine activities.

3. **What if I forget to wear the monitor for part of the day?**

   Answer: We hope you will wear the monitor throughout the day. However, if you do forget, you will need to list each activity you did during that period of time. For each activity, you will need to list the time the activity began and ended.

****Remember** - the only times that you need to **take off** the activity monitor during the day are when you are doing a water-based activity.

DAY 1 ☐☐ / ☐☐ / 2 0 ☐☐

Day Month Year

M T W Th F Sa Su

○ ○ ○ ○ ○ ○ ○

(Shade bubble for day of week)

What time did you get out of bed this morning? ____ : ____ (24 Hour)

What time did you put on the monitor this morning? ____ : ____ (24 Hour)

What time did you take off the monitor this evening? ____ : ____ (24 Hour)

What time did you get into bed this evening? ____ : ____ (24 Hour)

Did you wear the monitor all day? (Shade bubble) Yes ○ No ○

IF NO, answer the following questions.

For any period of time that you did NOT wear the monitor between getting up in the morning and going to bed at night, list: what you were doing, the time you began, and the time you stopped. You may combine routine activities but other activities should be reported separately. Only record activities lasting **10 MINUTES** or longer.

List activities you did when you were NOT wearing the monitor

What activity were you doing? _____

At what time did you start this activity? ____ : ____ (24 Hour)

At what time did you stop this activity? ____ : ____ (24 Hour)

What activity were you doing? _____

At what time did you start this activity? ____ : ____ (24 Hour)

At what time did you stop this activity? ____ : ____ (24 Hour)

What activity were you doing? _____

At what time did you start this activity? ____ : ____ (24 Hour)

At what time did you stop this activity? ____ : ____ (24 Hour)

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What activity were you doing? ____________________

At what time did you start this activity? ____:____ (24 Hour)

At what time did you stop this activity? ____:____ (24 Hour)

What activity were you doing? ____________________

At what time did you start this activity? ____:____ (24 Hour)

At what time did you stop this activity? ____:____ (24 Hour)

What activity were you doing? ____________________

At what time did you start this activity? ____:____ (24 Hour)

At what time did you stop this activity? ____:____ (24 Hour)

What activity were you doing? ____________________

At what time did you start this activity? ____:____ (24 Hour)

At what time did you stop this activity? ____:____ (24 Hour)

What activity were you doing? ____________________

At what time did you start this activity? ____:____ (24 Hour)

At what time did you stop this activity? ____:____ (24 Hour)

What activity were you doing? ____________________

At what time did you start this activity? ____:____ (24 Hour)

At what time did you stop this activity? ____:____ (24 Hour)

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Appendix E: Activity Monitor Instructions

How to use the activity monitor

The activity monitor is a tool that measures your movements throughout the day.

Begin wearing the monitor the first day after receiving it in the mail. **For this assessment, it is important that you don't change your regular physical activity level**. Just do what is normal for you, as we want an average idea of how active you normally are.

Follow these steps every day for the next seven (7) days.

Step 1

Make sure to put the accelerometer on as soon as you wake up.

Step 2

Clip the activity monitor to your waistband or belt, directly above your knee. Place it on the same side of your body as the hand that you write with. It is small and light so you should not even notice it is there. See Figure 1 below to see where to place the monitor.

The monitor must remain upright to record correctly. It cannot be tilted forward, backward or side-to-side.

Figure 1: Where to place the activity monitor.

Step 3

Wear the monitor all day, except when taking a shower, bathing, or swimming.

Step 4

When you are ready to go to bed, remove the monitor.

Step 5

If you forget to put the monitor on one day, that is okay. Just record this information in the monitor log.

Step 5

After wearing the monitor for 7 days, place it in the postage paid envelope along with your completed survey and signed consent form. Return the envelope to us. **The monitor is very expensive (~$350) and must be used by other people in the study. So please take extra care with it and return it to us as soon as you are finished wearing it for 7 days.**

Appendix F: Questionnaire

Physical activity and health survey for lung cancer survivors

Dr. Jeff Vallance
Athabasca University

Dr. Gwyn Bebb
University of Calgary

Ms. Adrijana D'Silva
University of Calgary

Instructions

Thank-you for agreeing to participate in this study! In this questionnaire, we are going to ask you a series of questions about yourself. There are no right or wrong answers and all we ask is that you provide responses that are as honest and accurate as possible. The questionnaire should take about 30 minutes to complete. It is important to complete all questions.

It is important to complete this questionnaire prior to wearing your accelerometer for the 7-day period. You can put your accelerometer on after completing the questionnaire. After you have worn your accelerometer for 7 full days please place the questionnaire and accelerometer back in the stamped and addressed envelope provided. Remember to include the Accelerometer Diary.

For further information or if you have any questions about completing the questionnaire, please contact Adrijana D'Silva at 403-521-3907 or email at asevo@ucalgary.ca. You can also contact the principal investigator, Dr. Jeff Vallance at 403-488-7182 or email at jeffv@athabascau.ca.

In this first part of the survey, we would like you to recall your **average weekly physical activity** in the past month. Considering a typical week (7 days) this past month how many times per week on average, and for how long (duration), did you perform the following kinds of physical activity?

When answering these questions please:

- Only count physical activity sessions that lasted **10 minutes or longer** in duration.
- **Include only the physical activities that you did during your leisure time** (e.g., going to the gym, the fitness centre at the leisure centre, walking the dog, going for a walk, swimming, bicycling). **Do not** include activities you do at work or around the house (e.g. mowing the lawn).
- If you have not performed any physical activity, please write '0' in that space.
- Note that the difference between the three categories is the intensity of the activity.
- Please write the average frequency (i.e., times per week) on the first line and the average duration (i.e., in minutes/hours) on the second line.

In the past month, my average weekly physical activity has been:

	Times Per Week	Average Duration
a. STRENUOUS PHYSICAL ACTIVITY (HEART BEATS RAPIDLY, SWEATING) (e.g., Aerobics classes, jogging, swimming laps, hard bicycling, singles tennis, soccer)	_____	_____
b. MODERATE PHYSICAL ACTIVITY (NOT EXHAUSTING, LIGHT SWEATING) (e.g., brisk walking, doubles tennis, easy bicycling, pilates, yoga, easy swimming, popular and folk dancing)	_____	_____
c. MILD PHYSICAL ACTIVITY (MINIMAL EFFORT, NO PERSPIRATION) (e.g., easy walking, bowling, lawn bowling, shuffleboard, golf with a power cart)	_____	_____

Please estimate how many hours and/or minutes you spend *sitting* each day in a typical week, in the following situations.

Please write your answer for each situation in the boxes below:

	On a WEEK day		On a WEEKEND day	
	Hours	Minutes	Hours	Minutes
1. While travelling to and from places				
2. While at work				
3. While watching television				
4. While using a computer at home				
5. In your leisure time, NOT including television (eg visiting friends, movies)				

Below is a list of statements that other people with lung cancer have said are important to their quality of life. **Please indicate the extent to which you have experienced each of the statements during the past 7 days** whether or not they are associated with symptoms related to cancer by circling the appropriate number using the following scale. It is important that you answer these questions even if it has been many months or years since your cancer diagnosis. If you do not experience any of the particular symptoms please indicate so by circling 0 (not at all).

Please circle or mark one number per line to indicate your response as it applies to the past 7 days.

	Not at all	A little bit	Some-what	Quite a bit	Very much
1. I have a lack of energy	0	1	2	3	4
2. I have nausea	0	1	2	3	4
3. Because of my physical condition, I have trouble meeting the needs of my family	0	1	2	3	4
4. I have pain	0	1	2	3	4
5. I am bothered by side effects of treatment	0	1	2	3	4
6. I feel ill	0	1	2	3	4
7. I am forced to spend time in bed	0	1	2	3	4
8. I feel close to my friends	0	1	2	3	4
9. I get emotional support from my family	0	1	2	3	4
10. I get support from my friends	0	1	2	3	4
11. My family has accepted my illness	0	1	2	3	4
12. I am satisfied with family communication about my illness	0	1	2	3	4
13. I feel close to my partner (or the person who is my main support)	0	1	2	3	4
Regardless of your current level of sexual activity, please answer the following question. If you prefer not to answer it, please mark this box ☐ *and go to the next section.*					
14. I am satisfied with my sex life	0	1	2	3	4

	Not at all	A little bit	Some-what	Quite a bit	Very much
15. I feel sad	0	1	2	3	4
16. I am satisfied with how I am coping with my illness	0	1	2	3	4
17. I am losing hope in the fight against my illness	0	1	2	3	4
18. I feel nervous	0	1	2	3	4
19. I worry about dying	0	1	2	3	4
20. I worry that my condition will get worse	0	1	2	3	4
21. I am able to work (including work at home)	0	1	2	3	4
22. My work (including work at home) is fulfilling	0	1	2	3	4
23. I am able to enjoy life	0	1	2	3	4
24. I have accepted my illness	0	1	2	3	4
25. I am sleeping well	0	1	2	3	4
26. I am enjoying the things I usually do for fun	0	1	2	3	4
27. I am content with the quality of my life now	0	1	2	3	4
28. I have been short of breath	0	1	2	3	4
29. I am losing weight	0	1	2	3	4
30. My thinking is clear	0	1	2	3	4
31. I have been coughing	0	1	2	3	4
32. I am bothered by hair loss	0	1	2	3	4
33. I have a good appetite	0	1	2	3	4
34. I feel tightness in my chest	0	1	2	3	4
35. Breathing is easy for me	0	1	2	3	4
36. Have you ever smoked? (check one) No ___ Yes ___ If yes:					
37. I regret my smoking	0	1	2	3	4

Please circle or mark one number per line to indicate your response as it applies to the past 7 days.

	Not at all	A little bit	Some-what	Quite a bit	Very much
1. I feel fatigued	0	1	2	3	4
2. I feel weak all over	0	1	2	3	4
3. I feel listless ("washed out")	0	1	2	3	4
4. I feel tired	0	1	2	3	4
5. I have trouble starting things because I am tired	0	1	2	3	4
6. I have trouble finishing things because I am tired	0	1	2	3	4
7. I have energy	0	1	2	3	4
8. I am able to do my usual activities	0	1	2	3	4
9. I need to sleep during the day	0	1	2	3	4
10. I am too tired to eat	0	1	2	3	4
11. I need help doing my usual activities	0	1	2	3	4
12. I am frustrated by being too tired to do the things I want to do	0	1	2	3	4
13. I have to limit my social activity because I am tired	0	1	2	3	4

Over the last 2 weeks, how often have you been bothered by any of the following problems? For each item (a through j), please circle the most appropriate number.

	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling/staying asleep, sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself – or that you are failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

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10. If you checked off any problem on this questionnaire so far, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all	Somewhat difficult	Very difficult	Extremely difficult
0	1	2	3

The following five statements are very broad and require you to think about your life in general without reference to any particular area of your life. The questions below ask how you feel about your life right now. You may agree or disagree with each of the five statements by **placing a number between 1 and 7 on the line beside each of the five statements**.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

_____1. In most ways my life is close to my ideal.

_____2. The conditions of my life are excellent.

_____3. I am satisfied with my life.

_____4. So far I have gotten the important things I want in life.

_____5. If I could live my life over, I would change almost nothing.

A number of statements which people have used to describe themselves are given below. Use the rating scale and circle the response that best indicates **how you feel right now**.

Not At All	Somewhat	Moderately So	Very Much So
1	2	3	4

1. I feel calm	1	2	3	4
2. I am tense	1	2	3	4
3. I feel at ease	1	2	3	4
4. I am presently worrying over possible misfortunes	1	2	3	4
5. I feel frightened	1	2	3	4
6. I feel nervous	1	2	3	4
7. I am jittery	1	2	3	4
8. I am relaxed	1	2	3	4
9. I am worried	1	2	3	4
10. I feel steady	1	2	3	4

The following statement will ask about your sleep habits in the past month:

1. During the past month: What time have you usually gone to bed? _____
2. How long (in minutes) has it taken you to fall asleep each night? _____
3. What time have you usually gotten up in the morning? _____
4. How many hours of actual sleep do you usually get at night? (this may be different than the number of hours you spend in bed) _____

During the past month, **how often have you had trouble sleeping because you**...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a) Cannot get to sleep within 30 minutes	0	1	2	3
b) Wake up in the middle of the night or early morning	0	1	2	3
c) Have to get up to use the bathroom	0	1	2	3
d) Cannot breathe comfortably	0	1	2	3
e) Cough or snore loudly	0	1	2	3
f) Feel too cold	0	1	2	3
g) Feel too hot	0	1	2	3
h) Have bad dreams	0	1	2	3
i) Have pain	0	1	2	3
j) How often have you taken medicine to help you sleep?	0	1	2	3
k) How often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	0	1	2	3
l) How much of a problem has it been to keep up enthusiasm to get things done?	0	1	2	3
m) How would you rate your sleep quality overall? (circle one)	Very good 0	Fairly good 1	Fairly bad 2	Very bad 3

Indicate for each of the statements below the degree to which this change occurred in your life *as a result of your experience with lung cancer*, using the following scale.

To what degree did you experience this change?

	Not at all	A very small degree	A small degree	A moderate degree	A great degree	A very great degree
1. My priorities about what is important in life.	1	2	3	4	5	6
2. An appreciation for the value of my own life.	1	2	3	4	5	6
3. I developed new interests.	1	2	3	4	5	6
4. A feeling of self-reliance.	1	2	3	4	5	6
5. A better understanding of spiritual matters.	1	2	3	4	5	6
6. Knowing that I can count on people in times of trouble.	1	2	3	4	5	6
7. I established a new path for my life.	1	2	3	4	5	6
8. A sense of closeness with others.	1	2	3	4	5	6
9. Willingness to express emotions.	1	2	3	4	5	6
10. Knowing I can handle difficulties.	1	2	3	4	5	6
11. I'm able to do better things with my life.	1	2	3	4	5	6
12. Being able to accept the way things work out.	1	2	3	4	5	6

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	Not at all	A very small degree	A small degree	A moderate degree	A great degree	A very great degree
13. Appreciating each day.	1	2	3	4	5	6
14. New opportunities are available which wouldn't have been otherwise.	1	2	3	4	5	6
15. Having compassion for others.	1	2	3	4	5	6
16. Putting effort into my relationships.	1	2	3	4	5	6
17. I'm more likely to try changing things which need changing.	1	2	3	4	5	6
18. I have a stronger religious faith	1	2	3	4	5	6
19. I discovered that I'm stronger than I thought I was.	1	2	3	4	5	6
20. I learned a great deal about how wonderful people are.	1	2	3	4	5	6
21. I accept needing others.	1	2	3	4	5	6

This part of the questionnaire is needed to help understand the characteristics of the people participating in the study. For this reason, it is very important information. All information is held in strict confidence.

Current marital status:

□ Never married □ Common Law □ Widowed □ Married □ Separated/divorced

Education (please check highest level attained):

□ Some high school □ High school diploma □ Some university or college □ Completed university or college

□ Completed graduate school □ Trade or apprenticeship

Annual family income:

□ < $20,000 □ $20-39,999 □ $40-59,999

□ $60-79,999 □ $80-99,999 □ >$100,000

Employment status:

□ Disability □ Retired □ Part-time

□ Full-time □ Homemaker □ Temporarily unemployed

Please weigh yourself and measure your height without shoes and report it here:

Height: _____ Weight: _____

Has a doctor or nurse ever told you that you have had the following? Please check all that apply.

a. Angina ____yes ____no d. High blood pressure ____yes ____no

b. Heart attack ____yes ____no e. High blood cholesterol ____yes ____no

c. Diabetes ____yes ____no f. Stroke ____yes ____no

g. Other_____

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Are you currently on any medications? If so, please specify on the line below:

_____

People come from many different cultural and racial backgrounds. What best describes your background?

_____	White	_____	Southeast Asian
_____	Aboriginal (First Nations, Metis, Inuit)	_____	Arab
_____	South Asian (e.g., East Indian, Pakistani, Sri Lankan)	_____	West Asian (Afghan, Iranian)
_____	Black	_____	Japanese
_____	Filipino	_____	Korean
_____	Latin American	_____	Chinese

Have you smoked at least 100 cigarettes in your entire life? (approximately 5 packs)

No_____ Yes_____

If you answered NO, please skip the following questions. If you answered YES, please tell me more about your smoking history.

How old were you when you first started smoking cigarettes?

_____

On the average, about how many cigarettes did you now smoke each day?

_____ cigarettes

Do you now smoke cigarettes?

No_____ Yes_____

If you answered NO, how old were you when you stopped smoking?

_____ years of age

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If you answered YES, about how many cigarettes do you now smoke each day?

_____ cigarettes

Please place your completed survey as well as your accelerometer and accelerometer diary in the enclosed reply envelope, and place in your nearest Canada Post mailbox or store.

If there are any other comments you would like to make, please do so in the space below.

Thank you for participating in our study!