Identifying Environments Associated with Physical Activity and Sedentary Behaviour in Older Colorectal Cancer Survivors

by

Logan Lawrence

Submitted in partial fulfilment of the requirements
for the degree of Master of Science

at

Dalhousie University
Halifax, Nova Scotia
December 2014

DEDICATION PAGE

I'd like to dedicate this to all my fans…

It's a big question when you think about it: who do you want to dedicate a chapter of your life to? I suppose the obvious answer would be cancer survivors, as without them none of my research would have been possible, but if you follow the logic train you'd end up thanking cancer, and that doesn't sound like a good idea. There are people that were instrumental in allowing this research to happen, but they'll be thanked in good time, which still begs the question: who should this be *dedicated* to?

You, dear Reader, seem like that obvious choice. I mean, you've picked this up and have definitely decided to read it cover to cover, using your careful critical and analytical skills to not only appraise the quality of my work, but situate it within the context of your own learning and studies (whatever those may be). And that's been my aim, these past two years and four months (but who's counting?) As I've stumbled, strolled, barreled down this master's degree track, I've come to learn a heck of a lot. Some of it was intentioned and put to good use, while some of it was just for fun, and may or may not serve any future purpose. But isn't that the point of higher education – to not only learn things, but figure out how to apply them?

I've really enjoyed this whole process, so I suppose, dear Reader, that I'd like to convey that sense of wonder and joy to you. Whatever comes next, look always onward (which isn't to say that you shouldn't shy away from experiencing the present, in all its blazing shades), and strive to piece it all together. There are more pieces than you actually need, and no box to look at to get an idea of how they all fit, so maybe life is more like Lego than a puzzle. But whatever analogy you choose to guide you, enjoy the challenges and mistakes, and learn from them so you do a bit more, a bit better, the next time around.

[… I suppose this is the first thing I've ever produced that will last longer than I will (in theory, barring a digital apocalypse). That's pretty cool, even if no one ever reads it again.]

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Colorectal cancer (CRC) survivors experience a reduction in their quality of life (QOL), even after completing treatment. Physical activity (PA) can improve QOL, but most CRC survivors are not active enough to receive benefits. Moreover, cancer survivors engage in more sedentary behaviour (SB) than the general population, which is also linked to risk of disease. The built environment can influence an individual's activity level, particularly in those who are less inclined to be active. This study identified locations where CRC survivors were active and sedentary, and correlated time spent in PA and SB with QOL. The immediate home environment was found to be the main location for light- and moderate-to-vigorous intensity PA, as well as SB. Moderate-to-vigorous intensity PA was positively correlated with physical QOL, while more time spent sedentary was negatively correlated with QOL. Implications for activity interventions to improve QOL in CRC survivors are discussed, including location-based recommendations.

LIST OF ABBREVIATIONS USED

Abbreviation Used	Meaning
CCS	Canadian Cancer Society
cpm	Counts Per Minute
CRC	Colorectal Cancer
FACT-C	Functional Assessment of Cancer Therapy - Colon
FACT-G	Functional Assessment of Cancer Therapy - General
GIS	Geographic Information System
GPS	Global Positioning System
LPA	Light-intensity Physical Activity (51-1040cpm).
MCS	Mental Composite Score (of the SF36)
MET	Metabolic Equivalent of a Task
MVPA	Moderate-to-Vigorous Physical Activity (>1040cpm)
PA	Physical Activity
PCS	Physical Composite Score (of the SF36)
QEII	Queen Elizabeth II Health Sciences Centre
QOL	Qualify of Life
SB	Sedentary Behaviour (<51cpm)
SF36	Medical Outcome Survey Short-Form 36-item Questionnaire

GLOSSARY

Term Used	Definition
Accelerometer	An electronic device that measures accelerations caused by body movements in one to three orthogonal planes (vertical, mediolaterial and anterioposterior). Data are represented as activity counts in a user-specified period of time (epoch), and translated into time spent in intensity categories using predefined thresholds.
Built Environment	Man-made features of a geographic setting (i.e., parks, sidewalks, buildings, population and housing density)
Calculated Fixes	GPS fixes were X and Y coordinates are unavailable and are calculated based on available information, such as the most recent reported fix
Cancer Survivor	Individuals who have received a cancer diagnosis, regardless of treatment status.
Count	Unit of a standardized acceleration; used in accelerometry to calculate activity level.
Duplicate Fixes	GPS fixes that present duplicate data for a single minute of data; usually due to changes in movement patterns
Epoch	A time sampling interval during which an accelerometer sums activity counts (typically one minute for adult populations).
Mystery Fixes	GPS fixes with no reported coordinates
Older Adult	Individuals aged 50 and older.
Physical Activity	Movement generated by skeletal muscle that raises energy expenditure above a resting level.
Reported Fixes	GPS fixes with known X and Y coordinates
Sedentary Behaviour	Any activity that keeps energy expenditure at a resting level (i.e., desk work, lying down, watching television); determined via accelerometer as <51cpm.
Sedentary Break	Defined as when the accelerometer detects an interruption of continuous ‘sedentary’ counts (>50cpm).
Walkability	The characteristics of an environment (e.g., neighbourhood) that influence one’s ability to walk in it.

ACKNOWLEDGEMENTS

This work would likely still have been possible (although not nearly as enjoyable or relevant) without the support of the agencies that supported it: The Beatrice Hunter Cancer Research Institute Cancer Research Training Program, the Nova Scotia Health Research Foundation's Scotia Scholar, and the Population Intervention in Chronic Disease Prevention Training Program. Not only did these organizations provide me with funding and training opportunities, but they also exposed me to fantastic groups of researchers who not only valued what I did, but encouraged me to pursue excellence in research. A special thanks is due to the nomination committee for the Nova Scotia Health Research Foundation's "The Quest – The John Ruedy Award", as the faith that you had in me renewed my vigour and interest in research.

Thank you to the organizations that helped with recruitment, such as the Atlantic PATH project (Dr. Louise Parker and Tyler Hinch) and Cancer Care Nova Scotia. I'd particularly like to thank Ostomy Halifax for the warm welcome I received, as not only did you help get me participants, but you also showed me who it was that I was doing all this for.
Also, thank you to Dr. Bruce Colwell, who was willing to put his name on the line (literally) and be the on-site investigator for this project. Ms. Donna Grant and Dr. Paul Johnson, thank you for your assistance in helping recruit participants.

I would like to thank my supervisor (obviously), Dr. Melanie Keats, for being a great supervisor: helping me along, weighing in with insightful feedback, returning edits promptly, and giving me the space needed to blunder through things on my own. Thank you for talking about some of the bigger issues with me, and never making me feel like I was going to be kicked out of your office when our scheduled meeting time had elapsed.

My committee members, Drs. Michelle Stone and Daniel Rainham: thank you for your guidance and support, and for being so human throughout this process: asking how I was, joking with me, challenging my conclusions, and reeling me in when I wanted to do everything. I still describe my proposal defence as “being blindsided” when you both told me my project was too big, and for that, I am very thankful.

Dr. Jerry Singleton, thanks for being a close (some might say intrusive) presence early on, showing me the ropes and explaining what *really* matters in grad school and academia. Your no-BS approach was not only memorable, but helpful, and I was happy to glean some wisdom from your ample offerings.

This is also a fantastic opportunity to mention some of my colleagues that kept me sane by letting me vent about my frustrations, and were more than willing to provide methodological guidance, well-meaning feedback, and alternate perspectives. You made me laugh, think about some of the bigger issues at play, and indulged me when I wanted to go for a beer. Thanks, Josh Goreham, Logan Nealis, and Jill McSweeney.

Mom and Dad (Bill and Adèle, not respectively), while you had little to do with the actual thesis itself, you’re responsible for me, so that has to count for something in all this, stoking a questioning nature and committed work ethic.
Kate-O: Well jeez, I definitely wouldn’t be here if it wasn’t for you. You’ve been with me all the way. Your unwavering support, critical eye, and sharp wit are reflected in not only what I’ve accomplished over the course of my masters degree, but also who I am. If this is for anyone, then it’s for me – but then you. You’re a close second.

CHAPTER ONE: INTRODUCTION

Colorectal cancer (CRC) is a disease that affects thousands of Canadians (Canadian Cancer Society's Steering Committee on Cancer Statistics (CCS), 2012). Incidence and mortality rates increase drastically after the age of 50, which places older adults – a population already at risk for other health problems – squarely in the disease's crosshairs. While survival rates have improved, CRC survivors are at an increased risk of reduced quality of life (QOL) (Arndt, Merx, Stegmaier, Ziegler, & Brenner, 2004). Physical activity (PA) is widely accepted as an important non-pharmaceutical intervention that can improve health, QOL, and disease outcomes in older adults in general as well as those with CRC (Chodzko-Zajko et al., 2009; Mishra et al., 2012). Regrettably, most individuals with CRC are not sufficiently active to receive these benefits (Harriss et al., 2007).

While most research has focused on moderate-to-vigorous intensity PA (MVPA), less is known about the benefits of increasing light-intensity PA (LPA) and reducing sedentary behaviour (SB), although initial research is linked to health benefits (Buman et al., 2010; Powell, Paluch, & Blair, 2011). At this time, it remains unclear if SB is related to QOL. Nevertheless, it has now been integrated into public health guidelines (Canadian Society for Exercise Physiology, 2012), as SB has been linked to an increased risk of mortality in CRC survivors among other negative effects in the general population (Campbell, Patel, Newton, Jacobs, & Gapstur, 2013). This suggests that simply moving more and sitting less could have important health implications for CRC survivors, although little research has examined LPA and SB in this population. This underscores the importance of objectively measuring both LPA and SB as well as MVPA, particularly since SB has health effects independent of level of

MVPA (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). However, little is known about how often these behaviours – particularly LPA and SB – occur in CRC survivors, or how they can be supported.

While physical activities have typically been considered as individually-driven behaviours, mounting evidence suggests that the environment can influence activity levels (Brownson & Hoehner, 2009). By pairing activity monitoring devices with global positioning system (GPS) technology, researchers are able to determine where individuals are engaging in PA and SB, exploring the effect of man-made, or 'built' environments on activity behaviour (Rainham et al., 2012). This study paired GPS technology with objective activity level measurement to better elucidate where CRC survivors engage in PA and SB. Additionally, as little is known about how SB and LPA are associated with QOL, a secondary objective was to examine the relationship between time spent at different activity levels (SB, LPA, and MVPA) with health-related QOL in CRC survivors. A better understanding of where PA and SB occur may lead to improved interventions to reduce SB and increase PA, thereby improving health outcomes in CRC survivors.

CHAPTER TWO: LITERATURE REVIEW

2.1 Colorectal Cancer

Colorectal cancer (CRC) is the third most commonly diagnosed cancer in Canada and is the second leading cause of cancer death in both men and women (CCS, 2012). CRC was expected to account for approximately 29% of cancer diagnoses and 14% of cancer deaths in Nova Scotia in 2013 (CCS, 2013). Surgery is typically used to manage tumours in the colon or rectum, with additional adjuvant treatment (e.g., radiation and/or chemotherapy) used to reduce the risk of recurrence. While there is a noted genetic component to the disease, it is predominantly thought to be a “civilization disorder” (Watson & Collins, 2011, p. 222) as incidence is primarily attributed to lifestyle behaviours such as diet, inactivity, and smoking.

Older adults[1] are at an increased risk of cancer, in part due to molecular changes that occur naturally with age (Carreca, Balducci, & Extermann, 2005). As such, they account for the majority of new cases, with 70% of all cancer diagnoses and 62% of deaths occurring between the ages of 50 and 79 (CCS, 2013). As the proportion of older adults is projected to increase, especially in Atlantic Canada, there will likely be an associated increase in CRC cases (Statistics Canada, 2010). Similar increases in cancer incidence relative to the increasing proportion of older adults have also been predicted in the United States (Smith, Smith, Hurria, Hortobagyi, & Buchholz, 2009). Less aggressive treatments are offered at advanced age, although older cancer survivors have been underrepresented in research and may be undertreated (Koroukian et al., 2010; Puts, Papoutsis, Springall, &

---

[1] In accordance with the American College of Sports Medicine, the term “older adult” will refer to individuals 50 years of age or older “with clinically significant chronic conditions and/or functional limitations” (Nelson et al., 2007).

Tourangeau, 2012). These are substantial problems, as advanced age is already associated with a general increase in chronic conditions and other health problems and a corresponding decline in health, function, and quality of life (QOL) (Butler-Jones, 2010; Thompson, Zack, Krahn, Andresen, & Barile, 2012).

While incidence rates for CRC have remained constant over the past 20 years, mortality has gradually decreased, due in part to better prevention efforts and more effective disease management; this has resulted in more CRC survivors[2] (CCS, 2012). While increased survivorship is undoubtedly an improvement, it also implies that more individuals are living with the repercussions of the disease and treatment. For example, conventional treatments can have considerable short-term side effects such as pain, nausea, and vomiting, as well as long-term effects like an increased risk for cardiovascular disease, metabolic syndrome, and impaired nerve function necessary for sexual arousal and bowel movements (American Cancer Society, 2012; Carreca et al., 2005; Khakoo et al., 2011; Kintzel, Pharm, Chase, Schultz, & Rourke, 2008; Sprangers, Taal, Aaronson, & te Velde, 1995; Steinherz, Steinherz, Tan, Heller, & Murphy, 1991). Symptoms such as insomnia, fatigue, constipation, and diarrhea can develop with a CRC diagnosis and persist after adjuvant treatment (Arndt et al., 2004).

In light of this, CRC survivors are at risk for a reduced QOL (Alfano & Rowland, 2006; Hewitt, Rowland, & Yancik, 2003), with QOL scores below those of the general population up to one year after diagnosis (Arndt et al., 2004). CRC survivors are at risk of not only CRC

---

[2] In accordance with the National Cancer Institute's definition, this paper will use the term "survivor" to refer to individuals who have received a CRC diagnosis, regardless of whether they have completed primary and adjuvant treatment (National Cancer Institute, n.d.).

recurrence, but secondary cancers and other comorbidities, such as cardiovascular disease, musculoskeletal problems, and depression (Denlinger & Engstrom, 2011). Poorer QOL is also experienced by CRC survivors who received a stoma (an opening in their abdomen for eliminating bodily waste due to 'sacrificing' a portion or all of their rectum or colon during surgical treatment) (Sprangers et al., 1995). Patients who received a stoma as part of their treatment are more likely to score poorly on functional scales than non-stoma patients (Arndt et al., 2004). As such, CRC survivors both on and off treatment may suffer a loss in health and QOL that have serious physical, emotional, mental, and economic costs (Alfano & Rowland, 2006).

These consequences are particularly salient when considering the context of the older adults who receive a CRC diagnosis and the aging population. Poor QOL can be seen as a surrogate measure for functional limitations and age-related decline, which are related to increased risk of mortality in cancer survivors (Koroukian et al., 2010). As a whole, these findings suggest that as people age, they are not only more likely to suffer health problems, but they are more likely to be affected by a cancer diagnosis, even after they have completed treatment. Due to the expected increase in CRC cases, as well as an increased life expectancy following diagnosis, reducing the negative side effects of treatments, improving QOL, extending survivorship, and reducing the rate of further disease is warranted (DeSantis et al., 2014) . In light of this, PA has garnered a great deal of attention over the past several years given its potential to be a non-invasive treatment modality for cancer patients and survivors.

2.2 Benefits of Physical Activity

The American College of Sports Medicine reports that PA minimizes age-related declines in health, limits the progression of chronic disease, and improves psychological and cognitive profiles (Chodzko-Zajko et al., 2009). Meeting PA guidelines (150 minutes of at least moderate intensity activity per week; Canadian Society of Exercise Physiology, 2012) is linked to reduced risk of disease and injury, improved physical and cognitive function, and mental health in older adults (Benedict et al., 2013; Netz et al., 2012; Warburton, Nicol, & Bredin, 2006a). Exercise, a sub-domain of PA, has strong evidence for improving the ability of older adults to perform activities of daily living (de Vreede, Samson, van Meeteren, Duursma, & Verhaar, 2005) and cognitive function (Mazzeo et al., 1998), among other benefits. While related and overlapping concepts, it is important to distinguish exercise from PA, including within the context of cancer (Broderick, Hussey, & O'Donnell, 2014). Although both can result in fitness and health benefits, exercise refers to a structured, planned activity (e.g., resistance training), while unstructured PA involves any contraction of skeletal muscle and as such can be more easily integrated into daily activities (e.g., walking the dog) (Chodzko-Zajko et al., 2009). As such, it is important to consider all forms of PA (including exercise, active transportation, occupational activities, etc.) when assessing total PA.

PA offers a quadratic dose-response benefit, with those who are the least active standing to gain the most from relatively small increases in their activity level. Specifically, the greatest health benefits are conferred when an individual transitions from being sedentary to engaging in the lowest recommended amount of PA (Warburton, Nicol, & Bredin, 2006b). In short, PA leads to a reduction of disease and disability risk factors

(Warburton et al., 2006a) and is essential for ‘successful aging’ because of its wide array of health benefits (Meisner, Dogra, Logan, Baker, & Weir, 2010). The benefits of PA for older adults are especially relevant to cancer survivors, as Koroukian and colleagues (2010) found that functional limitations and geriatric symptoms such as dementia, depression, and falling led to increased mortality in older adults with CRC.

It is predicted that reducing global inactivity could have enormous impacts on deaths from diseases worldwide, including CRC (Lee et al., 2012). However, there is mixed evidence for the role of PA in CRC prevention; differences between studies in the type of PA measured and different results based on gender make it difficult to draw a definitive conclusion (Harriss et al., 2007). Moradi and colleagues (2008) found that occupational activity decreased risk of colon, but not rectal, cancer in both sexes, while a systematic review and meta-analysis by Harriss and colleagues (2007) suggested that while PA offered a modest reduction in CRC risk, it was insufficient on its own as a public CRC prevention strategy. However, despite the lack of a definitive conclusion on the role of PA in CRC prevention, it is strongly recommended for cancer survivors, particularly for it’s utility in reducing the risk of future comorbidity and managing the long-term effects of cancer treatment (Denlinger & Engstrom, 2011).

The timing of PA is also important in reducing mortality in CRC cancer patients and survivors. Increasing PA following diagnosis has been found to reduce cancer-specific mortality and all-cause mortality in women with stages I-III CRC (Meyerhardt et al., 2006). Post-diagnosis, researchers found a significant mortality reduction between the most active group and the least active, even after adjusting for other recurrence predictors (Meyerhardt et al., 2006). Moreover, being more active post-diagnosis was associated with a greater risk reduction in all-cause mortality than activity level prior to CRC diagnosis, which emphasizes the important of increasing activity levels in CRC survivors (Campbell et al., 2013). Similar results were seen in a prospective female cohort where high PA levels pre-diagnosis were associated with 32% and 37% reductions in CRC-specific and all-cause mortality (respectively), while the same level of activity following diagnosis was associated with 71% and 59% reductions (Kuiper et al., 2012).

While its effects on CRC risk and mortality continue to be studied, PA has consistently been shown to be an effective way to improve physical and psychological outcomes and overall QOL in cancer survivors (Ferrer, Huedo-Medina, Johnson, Ryan, & Pescatello, 2011; Fong et al., 2012). This holds important implications, as there is a high prevalence of unmet physical and psychological needs in older cancer survivors, especially early on in their treatment (Puts et al., 2012). For example, a recent Cochrane review found that aerobic exercise was effective at treating cancer-related fatigue both during and post-treatment (Cramp & Byron-Daniel, 2012). Similarly, another Cochrane review of randomized and clinical control trials demonstrated that exercise improved general QOL scores, social functioning, and emotional well-being, and reduced sleep disturbance anxiety, fatigue, and pain in cancer survivors (Mishra et al., 2012). Many of these benefits are identified as particularly relevant to CRC survivors, which suggests that PA is an important treatment adjunct for this population (Arndt et al., 2004). Indeed, the positive effects of activity on managing disease- and treatment-related symptoms in cancer survivors both during and following treatment are agreed upon by multiple review articles (Courneya, 2003).

Despite these benefits, it is clear that PA often declines with both increasing age (Colley et al., 2011; Health Canada, 2002; Troiano et al., 2007; Westerterp & Meijer, 2001) and with a cancer diagnosis (Courneya & Friedenreich, 1997; Harriss et al., 2007). A recent study found that CRC survivors accumulated less than 30 minutes a day of MVPA (Vallance et al., 2014), with less than ten of those minutes accumulated in bouts of at least ten minutes or more as per activity guidelines (Canadian Society for Exercise Physiology, 2012). Reasons for this disease-related decline vary, but can be attributed to disease- and treatment-related symptoms. In a longitudinal exercise study of CRC survivors, Courneya and colleagues (2005) found that treatment-specific barriers accounted for more than half of all missed exercise sessions. These findings are consistent with those of Lynch, Owen, Hawkes, and Aitken (2010), who found that disease-specific barriers posed the greatest limitation to activity for CRC survivors.

This decline in PA is not unique to the aging population or cancer survivors. Despite self-report measures indicating that Canadian PA levels are increasing (Statistics Canada, 2009), the increasing prevalence of obesity and declining fitness actually suggest a decrease in activity levels (Colley et al., 2011). To achieve health benefits, Canadians aged 18 to 64 are recommended to accumulate at least 150 minutes of moderate-to-vigorous PA (MVPA) a week, through activities such as brisk walking, bicycling, jogging, or cross-country skiing (Canadian Society for Exercise Physiology, 2012). However, national data from the Canadian Health Measures Survey show that most people fail to achieve these guidelines, and more than a third of Canadian adults are moderately active for less than 15 minutes per week (Colley et al., 2011). These findings have important health implications because of the dose-response relationship between PA and health benefits (Canadian

Society for Exercise Physiology, 2004; Chodzko-Zajko et al., 2009; Powell, Paluch, & Blair, 2011).

2.3 Sedentary Behaviour

In addition to a decline in time spent active at a moderate-to-vigorous intensity, time spent in sedentary behaviour (SB) such as watching television may also be increasing. The Canadian Health Measures Survey found that 69% of Canadian adults' waking hours were spent in sedentary pursuits, which was higher than earlier studies (Colley et al., 2011). As time spent sedentary has been shown to have its own detrimental health effects independent of PA levels, it is increasingly considered separate from the classic activity spectrum and being 'inactive' (Colley et al., 2011; Hamilton, Healy, Dunstan, Zderic, & Owen, 2008; Healy et al., 2008). More accurate definitions characterize SB as non-sleeping low energy expenditure *in addition to* a sitting or reclining posture apart from sleeping (Tremblay, 2012), as postural positioning as been noted as a potential contributor to health problems like obesity (Levine et al., 2005).

The increasing awareness of reducing SB extends to cancer survivors, and has been noted as an important addition to the survivor research agenda in hopes of reducing risk of mortality and developing comorbidities as well as improving QOL (Lynch, Dunstan, Vallance, & Owen, 2013). While the relationship between occupational sitting and other health problems is established (van Uffelen et al., 2010), it is currently unclear whether sedentary time is associated with an increased risk of CRC. However, there is evidence to suggest that SB is important for reducing further mortality in CRC survivors. More time spent sitting post-diagnosis was associated with higher all-cause mortality in a sample of CRC survivors, including a statistically significant 62% increase in risk of CRC-related mortality (Campbell et al., 2013). This is problematic, as cancer survivors appear to be more sedentary than the general population (Kim et al., 2013). However, there may be some variation among cancer types, as while a recent study found CRC survivors spend close to 9 hours a day sedentary (Vallance, Boyle, Courneya, & Lynch, 2014), this is less than the 9.5 hours per day spent sedentary in the general Canadian population (Colley et al., 2011).

In light of the prevalence of SB, reducing it, even if SB is not replaced with MVPA, may be a potential way to yield substantial health benefits in cancer survivors. Small but significant changes in cardiometabolic profiles were demonstrated in a young, healthy sample with short (8-minute) bouts of cycling after 1 hour of sitting (Altenburg, Rotteveel, Dunstan, Salmon, & Chinapaw, 2013). In a randomized crossover treatment trial of middle-aged adults, Dunstan, Kingwell, and Larsen (2012) showed that a simple 2-minute light- or moderate-intensity walking break after 20 minutes of sitting significantly reduced postprandial insulin and glucose, which are linked to obesity. Some researchers have also noted that light physical activity (e.g., behaviours with a low energy expenditure such as washing dishes; LPA) and breaks in sedentary time are related to body composition (Chastin, Ferriolli, Stephens, Fearon, & Greig, 2012) and can provide health benefits (Hamilton et al., 2008; Healy et al., 2008). These improvements are independent of the PA levels typically associated with improved health outcomes (Healy et al., 2008; Katzmarzyk, Church, Craig, & Bouchard, 2009; Kesse-Guyot et al., 2012; Rhodes, Mark, & Temmel, 2012). As such, reducing SB, and transitioning from time spent sedentary to time spent in LPA, has been deemed to be an important objective in future research (Esliger & Copeland, 2009).

This push to reduce SB relates to the dose-response relationship of PA, and the fact that the greatest reductions in disease and mortality risk occur when advancing from the poorest fitness category to the next highest fitness category (CSEP, 2004; Chodzko-Zajko et al., 2009). This transition can be achieved through low intensity activity that does not require substantial time commitments and can be easily integrated into daily living. Quick, easy activity is feasible in older adults and presents a relatively novel potential to improve health outcomes, which suggests that it is important to examine low-intensity activity in addition to moderate-to-vigorous intensity activity (Gardiner, Eakin, Healy, & Owen, 2011). However, while the relationship between higher-intensity PA and QOL is well established, there is little research on how LPA, time spent sedentary, and breaks in sedentary time relate to short-term health-related QOL.

One reason for this dearth of evidence is that it can be difficult to measure SB and LPA through typical self-report measures. Self-report instruments can fail to detect small changes in PA and breaks in sedentary time (Powell et al. , 2011), and are prone to other biases such as recall error and social desirability (Colley et al., 2011). Over-reporting PA in questionnaires has been noted, as participants are aware that activity is an outcome measure (Courneya et al., 2004). Additionally, Maddison et al. (2009) argue that self-report measures are only sensitive to volitional behaviours and may therefore omit unplanned activities. Occupational and housekeeping activities can make up a substantial portion of older adults total PA, and as such need to be considered when attempting to calculate total activity levels (Ainsworth et al., 2000).

Objective measurement of activity level addresses some of these limitations. Accelerometers are small, portable devices that electronically record (among other variables) detailed information on PA duration and intensity (Powell et al., 2011). These devices detect changes in body movement by using a piezoelectric substance to convert mechanical energy (accelerations) into measurable electrical signals (voltage), which are recorded as 'counts'. These counts are typically analyzed by looking at the frequency of counts over a given time interval, or 'epoch'. The more counts per epoch – typically counts per minute (cpm) – the more intense the activity. Cpm values are used to compute activity intensity based on empirically-derived cut points, which allows health researchers to accurately determine the activity level of a subject. They are a reliable, accurate way to measure the intensity of daily PA (Esliger, Copeland, Barnes, & Tremblay, 2005). These devices pick up small changes in activity that are usually omitted in self-report measures, and provide important insight into light intensity activity and sedentary time especially (Powell et al., 2011) and the Canadian Health Measures Survey (Colley et al., 2011).

Troiano et al. (2007) illustrate the difference between self-report and accelerometer-measured activity data in the National Health and Nutrition Examination Survey. While self-report measures of PA showed that 51% of Americans were meeting activity guidelines, accelerometer data showed that less than 4% of adults were meeting these guidelines. Accelerometers are now commonly used to provide objective information on PA and SB levels in cancer survivors, including CRC (George et al., 2014; Lowe et al., 2014a, 2014b; Lynch et al., 2011; Lynch, Dunstan, et al., 2010; Peddle, Plotnikoff, Wild, Au, & Courneya, 2008; Vallance et al., 2014). However, while these devices are more accurate than self-report PA measures, they do not identify factors that influence activity or elucidate why individuals choose to engage in PA.

2.4 Explaining Activity Through the Built Environment

There has been a growing interest in using multi-level ecological models, originally proposed by Bronfenbrenner (1977) for the field of psychology, for exploring the contextual factors surrounding health behaviours like PA. This kind of approach acknowledges that there are factors outside of an individual's personal control that can influence behaviour, and seeks to improve our understanding of these factors in order to create a more supportive climate for health behaviours (Richard, Gauvin, & Raine, 2011). This kind of approach has been used for many different health behaviours, including PA, fruit and vegetable consumption, injury prevention, and tobacco and alcohol use (Green & Edwards, 2008; Kreuter, De Rosa, Howze, & Baldwin, 2004; Richard et al., 2011; Sallis, 2012).

One of the emerging elements from the ecological approach is the exploration of the role of the built environment (Sallis, Owen, & Fisher, 2008). The built environment is defined as the human-made or human-altered space in which individuals live out their daily lives, and includes such elements as green space, traffic flow, cleanliness of public spaces, perceived safety, and population density (Renalds, Smith, & Hale, 2010). For instance, Sallis and colleagues (2008) present an ecological approach to the concept of 'Active Living.' They describe the components of active living as being influenced by not only intrapersonal factors (i.e., demographic, biological, social), but also political and perceived environmental factors (i.e., safety, accessibility, convenience). Some scholars have argued that the built environment might play an especially prominent role in influencing PA in those already less psychologically inclined to be active (Ding et al., 2012).

However, defining precisely what aspect of the built environment is supportive of PA is a difficult task. Environmental aspects such as land use mix, vegetation, the number of intersections, houses, and people in a given area (Troped et al., 2010), urbanicity (Rainham et al., 2012), perceived safety (Gay, Saunders, & Dowda, 2011), access to recreational facilities (Brownson & Hoehner, 2009), and perceived 'walkability' of one's neighbourhood (Ding et al., 2012; Rosenberg, Huang, Simonovich, & Belza, 2012) can all explain variance in PA participation. Furthermore, some of these environmental factors are co-related with attributes such as social capital, mental health, and substance abuse, which makes inferring causation difficult (Renalds et al., 2010).

While walking is the most popular mode of PA for adults (Chodzko-Zajko et al., 2009; Rosso, Auchincloss, & Michael, 2011), aging and disability can impair mobility (Rosenberg, Huang, Simonovich, & Belza, 2012). This suggests that the walking environment may play a unique role in facilitating or impairing PA for older adults. For instance, an elderly man with balance problems may not feel safe walking outside if the sidewalks are icy, which means the environment is prohibiting him from being active. 'Walkability' is an aggregate measure of how features such as population, housing, and intersection density and distribution of land use mixes (i.e., residential, retail, institutional) influence the ability of individuals to walk (Cerin, Saelens, Sallis, & Frank, 2006).

Walkability has been examined in a number of studies in order to understand how the environment influences PA (Adams et al., 2012; Berke, Koepsell, Moudon, Hoskins, & Larson, 2007; Cerin et al., 2006; Renalds et al., 2010; Rosenberg et al., 2012; Saelens & Handy, 2008; Sallis et al., 2006; Troped, Wilson, Matthews, Cromley, & Melly, 2010). Adams and colleagues (2012) found significant differences in time older adults spent in MVPA between neighbourhoods classified with either 'high' and 'low' walkability; in some cases, almost twice as much MVPA occurred in the highly-walkable neighbourhoods. Even after adjusting for age, household income, and education, residents of "highly walkable/recreationally dense" neighbourhoods (Adams et al., 2012, p.761) reported on average more time walking for errands and lower body mass index (BMI). Similarly, in a large group of older adults aged 65 and older, Berke, Koepsell, Moudon, Hoskins, and Larson (2007) found that more 'walkable' neighbourhoods were associated with more PA, which is consistent with other reports on the importance of walkability (Boone-Heinonen, Gordon-Larsen, Guilkey, Jacobs, & Popkin, 2011; Rhodes, Brown, & McIntyre, 2006).

While they highlight several important built environment characteristics, current assessments of the effect of the environment on PA typically rely on a 'buffer zone' method of assessing environmental features on PA (Berke et al., 2007; Brownson & Hoehner, 2009; Ding et al., 2012). This method relates an individual's PA to environmental features within a 'buffer zone' (typically 0.5 – 2 km) around their home or work place, and operates under the assumption that the presence environmental features that promote (or impede) PA within an individual's immediate environment explain PA behaviour. However, this approach has been criticized and shown to explain little variance in activity when compared to more accurate measures of the environments where PA is occurring (Rainham et al., 2012; Troped et al., 2008). The objective measurement of where an individual actually engages in PA and SB promises to further our understanding of how the environment influences activity levels.

Similar to the technological advances that allowed for accelerometry, Geographic Information System (GIS) technology and GPS data 'loggers' provide researchers with an accurate location of participants during their day-to-day activities (Brownson & Hoehner, 2009). This precise technology can then be used in conjunction with accelerometry; time-matched co-measurement of activity and location provides information on the intensity of activity the individual is engaging in and exactly where the activity is occurring, which in turn leads to a better understanding of how the environment influences PA. For example, it can be used to better understand transport-related activity (Duncan, Badland, & Mummery, 2009) and how much activity occurs in playgrounds and parks (Quigg, Gray, Reeder, Holt, & Waters, 2010). Linking accelerometer data with data collected from GPS loggers to examine location-based activity patterns has been done before in youth (Maddison et al., 2009; Rainham et al., 2012), and middle-aged adults (Rodriguez, Brown, & Troped, 2005; Troped et al., 2008), but has only recently begun to be explored in older age groups (Rosenberg et al., 2012) and cancer survivors (Keats, Blanchard, Tyrrell, Rainham, & Younis, 2012). Further study of the environments that CRC survivors are active and sedentary in would improve our understanding of how the environment influences these behaviours, which could then be used to modify PA and SB in order to improve health outcomes in CRC survivors.

2.5 Purpose

Higher levels of PA are associated with better health outcomes and QOL in older adults with CRC, but many factors influence PA behaviour. Accordingly, the purpose of this pilot study was to identify locations where older CRC survivors are engaging in different activity levels (i.e., time spent in MVPA, LPA, and SB). Additionally, while the association between MVPA and QOL is well-known, the associations of LPA, SB, and breaks in SB with QOL in this population have been less extensively study and were therefore also explored.

2.6 Research Questions and Hypotheses

1. Where are CRC survivors engaging in active and sedentary behaviours?

Hypothesis: Certain environments, such as the home and work place, will be the main locations for the majority of sedentary time (Healy et al., 2012; Marshall & Ramirez, 2011). Other locations, such as green space and parks, will be associated with the majority of time spent at MVPA (McGowan et al., 2013; Rainham et al., 2012). As little is currently known about LPA, no hypotheses will be made on where the majority of LPA is accumulated.

2. How is time spent at different activity levels related to self-reported QOL?

Hypothesis: Greater time spent at MVPA and LPA will be associated with better QOL scores. Conversely, greater sedentary time and fewer sedentary breaks will be associated with poorer QOL scores.

CHAPTER THREE: METHODOLOGY

3.1 Study Design and Procedure

This study employed a cross-sectional design. Based on past exploratory work, approximately 20 participants is sufficient to adequately provide a variety of activity levels and environments visited for this kind of descriptive pilot study (Webber & Porter, 2009). Data collection took place over a 9-day period. Eligible participants were those individuals aged 50 or older that had received a medical diagnosis of CRC. Eligible participants were: 1) either receiving active treatment for colon and/or rectal cancer at the Queen Elizabeth II hospital (QEII) in Halifax, NS or a survivor of colon and/or rectal cancer; 2) received physician approval to participate (for patients currently receiving treatment); 3) ability to provide informed consent; and 4) able to read and write English. Participants were excluded if: 1) they had received treatment for any other cancers within the past year, 2) they were unable to engage in PA due to significant medical or physical limitations, or 3) their referring health care provider believed participation would negatively impact their course of treatment, health, or QOL.

Participants currently receiving treatment became aware of the study through a member of their care team (i.e., physician, nurse practitioner) or via advertisements within the QEII facilities, and received their approval to participate from a member of their care team. CRC survivors were recruited via their involvement with cancer interest groups, posters in the community, social media, or electronic communication with different survivor groups (e.g., Cancer Care Nova Scotia, Ostomy Halifax). The Atlantic Partnership for Tomorrow's Health (Atlantic PATH), a local longitudinal cohort database, also sent an information letter to the CRC survivors they had on file that met eligibility criteria explaining the study on behalf of this study's investigators.

Interested parties were directed to contact a member of the research team; as such, all participants were self-identified. Participants completed a brief screening questionnaire over the phone in order to determine eligibility, and received a more detailed explanation of the study goals and methods. Eligible participants then met with a member of the research team, completed the informed consent process, provided medical and demographic information, and completed a questionnaire assessing health-related QOL (see section 3.2 for full measures description). They were then fitted with an accelerometer (ActiGraph GT3X; Pensacola, FL) and a GPS data logger (Qstarz; Taipei, Taiwan) on their right hip to record their activity level (including SB) and geographic location, respectively. They were directed to wear the devices continuously during waking hours over the next nine days, meeting with the investigator to return the device on the ninth day. The first and last days only had partial data and were excluded from analysis, leaving seven days of data; this 'delayed start time' was also used to reduce the subject reactivity to the novelty of the devices, thereby providing a more reliable indication of their activity level (Esliger et al., 2005).

After the purpose of these two devices was explained, participants were provided with written instructions on charging protocol and device care (including removing the devices when sleeping, participating in contact sports, bathing, swimming, or any other time they might get wet). They were also shown how to disable the GPS, in adherence to the ethical principal of voluntary participation, as participants may not want the investigators to know where they were at all times. This protocol is consistent with similar

GPS/activity studies (Oliver, Badland, Mavoa, Duncan, & Duncan, 2010; Rainham et al., 2012; Rodriguez et al., 2005). Finally, participants were also given an activity log and instructed to record the duration, relative intensity, and location of any activities performed while not wearing the accelerometer (e.g., play contact sports or swim), as this has been identified as a limitation in related research (Oliver et al., 2010; Rodriguez et al., 2005). To maximize adherence, participants were provided with suggestions and resources designed to improve wear-adherence for the accelerometer and GPS, such as recording when they put on and removed the devices on the activity log, keeping the devices on their bedside table at night, or leaving a reminder note on the fridge.

Following preliminary data analysis, participants with any missing questionnaire responses or large gaps in GPS or accelerometer data that were not explained by their activity logs were contacted in order to better understand a) why the device(s) were not worn, b) what activities were performed during that time, and c) where the activities were performed. While this information was not formally analyzed, it was helpful to develop a better understanding of why some data was not reported or adherence was less than optimal.

3.2 Measures

See *Appendix A* for a copy of the full questionnaire.

Demographics: Information on age, sex, height and weight, education, ethnicity, marital status, household income, and employment status were requested, as this kind of demographic information has been shown to be related to PA in cancer patients and survivors (Peddle, Plotnikoff, Wild, Au, & Courneya, 2008; Speed-Andrews et al., 2012). Other potential covariates of interest included access to a vehicle, primary mode of transportation, and presence of home exercise equipment (Shibata, Oka, Harada, Nakamura, & Muraoka, 2009). Height and weight were used to calculate BMI to provide a measure of body composition. Other factors that can affect health, such as the presence of co-morbid conditions (i.e., hypertension, hyperlipidemia, diabetes) were also collected.

Disease-Specific Information: Medical variables such as primary diagnosis, disease stage and grade, time since diagnosis, and treatment start date and type (i.e., surgery, chemotherapy, radiation) were also requested for descriptive purposes as they may be associated with PA (Speed-Andrews et al., 2012).

Health-related Quality of Life: QOL was assessed two different ways: general QOL and cancer-specific QOL. General QOL was assessed with the Quality Metric™ Medical Outcome Survey Short Form 36-item questionnaire Version 2 (SF36). This reliable, valid, and widely-used survey assesses physical and mental health and wellness (Cheak-Zamora, Wyrwich, & McBride, 2009). Eight subscales (physical function, bodily pain, general health, physical and emotional roles, vitality, social functioning, and mental health) are used to calculate 2 summary scores reflective of overall QOL: Physical Component Summary (PCS) and Mental Component Summary (MCS) (see *Appendix B* for information on how these components are constructed). PCS and MCS scores are the sums of the items of the related subscales after negatively-worded items have been reverse-scored. Age-stratified population-normative data is available for comparison (SF-36, 1998).

Cancer-specific QOL was assessed with the Functional Assessment of Cancer Therapy – Colorectal questionnaire (FACT-C) The FACT-C has been shown to be a valid and reliable way to assess physical, social, emotional, and functional well-being (Ward et al., 1999). Each item is rated on a five-point scale with verbal anchors of *not at all* (0), *a little* *bit* (1), *somewhat* (2), *quite a bit* (3), and *very much* (4). It can differentiate between groups based on functionality, and comprises both a general scale that can be used relative to other cancers as well as a CRC-specific subscale. The FACT-C has previously been used to relate QOL to PA (Courneya & Friedenreich, 1997). Additionally, the widely used Functional Assessment of Cancer Therapy – General can be computed from completing the FACT-C, and will also be scored so as to allow for comparisons across other cancer types.

Physical Activity: Objective measures of PA and SB were collected using accelerometers. The ActiGraph GT3X tri-axial accelerometer is a small (3.8 x 3.7 x 1.8 cm), light, and rechargeable device that detects movement across three dimensions and has been found to be a reliable instrument for measuring free-living PA (Santos-lozano et al., 2012; Sasaki, John, & Freedson, 2011). ActiGraph accelerometers have been used in large scale studies such as the National Health and Nutrition Examination Survey (Evenson, Buchner, & Morland, 2012; Troiano et al., 2007) and the Canadian Health Measures Survey (Colley et al., 2011). As the GT3X is not waterproof or shockproof, participants had to remove it for bathing, swimming, and activities where it may be damaged. Accordingly, participants were provided with an activity log to record the location and duration of activities they performed while not wearing the accelerometer. Participants were also able to record activities they performed if they forgot to wear the accelerometer for a period of time.

Built Environment: GPS loggers have been used successfully to identify and pair geographic locations with accelerometer-derived PA data (Rainham et al., 2012; Troped et al., 2008). The Qstarz BT-Q1000XT GPS logger is small, lightweight, device that can record the position of the wearer every second and has a battery life of up to 42 hours (Qstarz

International Co., 2012). While the device is marketed as being accurate within ~3 meters in an urban setting, one study showed this accuracy was closer to 5m in dense urban surroundings (Schipperijn et al., 2014). However, this model is still regarded as one of the best commercially-available GPS units in terms of accuracy when compared to other models (Duncan et al., 2013). It has been found to be feasible for use in an older adult population (Rosenberg et al., 2012).

3.3 Analysis

3.3.1 Physical Activity

3.3.1.2 Cut Point Criteria

Accelerometer data were analyzed in one-minute epochs, using cpm values to determine intensity, or time spent at different activity levels. There are many published PA intensity thresholds, or *cut points*, for different degrees of activity intensity, which allows for some degree of comparison between studies (Colley et al., 2011; Sasaki et al., 2011) (see *Appendix C* for a summary of different cut points). However, using different cut points on identical data can have a dramatic effect on the resulting time spent at different intensities and the strength of the data's relation to health outcomes, which suggests that careful selection of cut points is required (Ainsworth et al., 2000; Gorman, Yang, Khan, Liu-Ambrose, & Ashe, 2011; Loprinzi et al., 2013).

Hall, Howe, Rana, Martin, and Morey (2013) caution against using general 'adult' cut points when studying older adults, as they are typically derived from younger, healthier populations and do not reflect the actual energy expenditure of activities of older adults. This group recently used treadmill walking and indirect calorimetry to measure the energy expenditure of older adults at given workloads and found that energy requirements were considerably higher than reported in previous studies of young and middle-aged adults, and that individuals with chronic conditions used more energy than individuals without chronic conditions at similar work loads (Hall et al., 2013). This gives compelling evidence for the careful use of older adult-specific cut points to ensure accuracy of PA data. As such, this study used cut points designed specifically for older adults by Copeland and Esliger (2009) that have since been used in other aging and activity research (Buman et al., 2010; Gardiner et al., 2011; Kerr et al., 2012). Appendix C illustrates where the Copeland and Esliger (2009) cut points fit into the substantial range of existing cut points. Appendix D provides a comparison between the development parameters of Copeland and Esliger cut points relative to the more commonly used cut points of Freedson, Melanson, and Sirard (1998), which have been used to assess PA in cancer survivors (Lynch et al., 2011; Lynch, Dunstan, et al., 2010; Vallance et al., 2014).

There are three intensity categories for activity level cut points: sedentary (SB) (≤ 50cpm), light-intensity (LPA) (51 – 1040cpm), and moderate-to-vigorous (MVPA) (≥1041cpm). Although researchers have suggested using inclinometers to better understand the postural (seated or reclined) component of SB (Gardiner et al., 2011; Saunders et al., 2013), this type of analysis is predominately seen in exploratory research (Hamilton, Hamilton, & Zderic, 2007; Levine et al., 2005). As little information on integrating cut point and inclinometer data exists in free-living populations, this study used the low energy expenditure criteria offered by Copeland & Esliger (2009) (≤ 50cpm) to define SB to facilitate comparisons with existing research using these cut points.

While eschewing the more conventional "Freedson" cut points (1998) used by many studies limits the generalizability of our findings, there is substantial evidence to support the use of age-specific cut points for active reflecting PA. Based on research examining the true energy cost of performing activities at older ages, Copeland and Esliger (2009) attest that these cut points are conservative estimates and that light-intensity activity is unlikely to be classified as MVPA. The activities performed during these calibration studies are also important as they ultimately determine the accuracy and generalizability of the developed cut points (Ainsworth et al., 2000; Troiano, 2005). Instead of using running as the form of physical activity in the calibration studies, these cut points were developed from walking, which is the most popular form of activity for adults (Chodzko-Zajko et al., 2009; Hurst, 2009); as such, these cut points are especially relevant to our population. Additional support for the use of these cut-points comes from a study of 765 older adults (defined as 65+), where time spent between 1041-1951 counts/min (from Copeland and Esliger's "MVPA" cut-point to the widely-used MVPA cut-point of Freedson and colleagues [1998]) was better related to health and well-being than the 1951+ counts/min standard of Freedson and colleagues (Buman et al., 2010).

3.3.1.2 Activity Bout Criteria

Minimum bout length for MVPA is typically defined as at least 10 minutes (Hardman, 2001), and has been adopted nationally (National Institutes of Health Consensus Development Panel on Physical Activity and Cardiovascular Health, 1996; Public Health Agency of Canada, 2011). However, this minimum duration for a bout to 'count' towards an individual's health stems less from the inefficacy of activity accumulated in shorter bouts rather than the lack of evidence for benefits derived from short bouts (Hardman, 2001).

There is an increasing body of evidence to suggest that the majority of physical activity in youth is accrued in sporadic (1-9 mins) or short (10-19 mins) bouts of activity, and the practices around averaging and minimum bout length can be the difference between 100% and 6% of the same set of youth activity data meeting >30min/day of MVPA (Esliger et al., 2005; Esliger & Tremblay, 2007).

However, less is known about the activity patterns and their associated consequences in older adults and in cancer survivors. Importantly, recent research has suggested that bouts of less than 10 minutes have similar effects on cardiovascular health independent of long bouts (Glazer et al., 2013; Macfarlane, Taylor, & Cuddihy, 2006). Glazer and colleagues (2013) found that MVPA accumulated in bouts of less than 10 minutes approached significance (p=0.08) at more effectively reducing risk of heart disease compared to MVPA accumulated in bouts of 10 minutes or more. This suggests that the concept of sporadic activity 'not counting' towards improved health outcomes may be erroneous.

There is limited consensus on how to classify a bout of LPA or SB, particularly because these two behaviours have only recently become of interest to PA and health scholars. As little as one minute of a sub-threshold count has been used as a bout (Saunders et al., 2013) all the way up to one-hour periods (Altenburg et al., 2013). While the fragmentation of sedentary time (e.g., the manner in which individuals accumulate sedentary time, or the number of separate periods of sustained sedentary counts per hour or day) has been noted as a variable of interest (Chastin et al., 2012), physiological data have shown favourable cardiometabolic profile outcomes when breaking up bouts into 20-minute chunks (Dunstan et al., 2012; Thorp et al., 2012). Similarly, there is no widely-agreed upon length of a LPA bout, although Nygaard and colleagues (2009) showed that as little as 15 minutes of slow walking was effective at reducing postprandial glycemia in middle-age women.

Therefore, due to the lack of consensus, LPA and SB bouts were defined as a minimum of 15 and 20 minutes, respectively. MVPA remained at standard 10-minute minimum, although correlations between total and bout-accumulated time will help elucidate the question surrounding the importance of minimum bout lengths. This provides us with a logical cut-off between bout lengths at different intensities, as it is reasoned that since less high-intensity activity is needed for health benefits, the same relationship holds inversely where more time at lower intensities is required for changes in health. These bouts will be used not only in our analysis of PA and QOL outcomes, but will also be used when pairing environments with activity bouts.

Participant accelerometer data were categorized into bouts using local *Activity Analyzer* software (Spatial Intelligence for Health Knowledge Laboratory, Halifax, NS). This program allows users to define bout criteria, with the addition of minimum bout duration and 'drop time' (time within a bout where the counts can be below a certain cut point threshold and still count as a part of a bout). For example, a bout of MVPA was defined as a minimum of 10 minutes with counts >1040; however, within that 10 minute window, up to 2 minutes of it is permitted to be <1041 (Spatial Intelligence for Health Knowledge Lab, 2014). This same ratio – 80% of the minutes within a bout needed to be above the cpm threshold for it to qualify as a bout – was applied to the "minimum sustained period" (minimum bout length) of the Activity Analyzer software for LPA and SB bouts as well.

Therefore, a 15-minute LPA bout allowed for up to 3 minutes to be below 51cpm or above 1040, while a 20-minute SB bout allowed up to 4 minutes to be above 50cpm.

3.3.2 Integrating Accelerometer and GPS Data

Prior to being given to participants, the accelerometer clock was synced to Windows LIVE atomic clock standard time, which ensured that time-matching the accelerometer and GPS devices would go smoothly (Oliver et al., 2010). Data was only considered valid for analysis if there was at least 10 hours of data in a day, and at least 4 valid days during the data collection period. This method is consistent with other population-level accelerometer studies (Colley et al., 2011; Troiano et al., 2007).

Accelerometer (bouts of MVPA, LPA, and SB) and GPS data were imported into the geographic visualization program ICU Workbench (G2 Technologies, Dartmouth, NS) and time-matched in order to provide the locations of activity bouts. Bout data were then coded minute-by-minute into specific locations (i.e., home, work, park, athletic facility). While this technique is still relatively new and there is no broadly accepted method for integrating GPS and accelerometer data, this method has shown previous success (Rainham et al., 2012; Troped et al., 2008).

While some automaticity for coding GPS data exists, most data are manually coded (Duncan et al., 2009). Matching activity bouts to locations was performed similar to how Rainham and colleagues (2012) paired activity levels with environmental locations in school-aged children, with the added step that some locations that were not visited frequently (~<2% of total locations time) were collapsed into general categories. In addition to simplifying presentation, this was done in part to relate the environment to the behaviours that predominantly occur there (e.g., grocery store, shopping mall, and strip mall were all collapsed into a "shopping" category). As such, these activity/location profiles attempt to pair environments and behaviours (although limitations of this approach will be discussed).

Initial location codes were adapted from Rainham et al. (2012), with new codes added as needed based on the environments participants visited. Home and workplace environments were identified based on program algorithms; other environments were identified using Google Maps Street View, web searches of addresses, and built-in GIS identification features. Once all files were coded once, they were re-checked to allow for the incorporation of new codes. Finally, all data were exported to SPSS v.20 (IBM Corp., Armonk, NY) for analysis, and codes were collapsed into more general location categories (see Table 3.1 for location category rationale).

Table 3.1

Description of Activity-Location Categories

Location categories	Definitions/Examples	Example Activity
Home	GIS-program calculated home	Watching TV, cooking
Nature Recreation	Parks, fields, general outdoors	Walking in a park, boating, gardening,
Shopping	Services (gas station), retail (stores, strip malls, malls), grocery stores	Grocery shopping, buying clothes
Neighbourhood/Other Residential	Surrounding neighbourhood, other residential areas	Walking around a neighbourhood, visiting a friend
Work	GIS-program calculated work	Sitting at desk
Other	Restaurant, Athletic Facility, Library, Medical Facilities, Religious, School/Education, Entertainment	Church, seeing a movie, having dinner
Urban	Points from dense urban centres and public spaces, parking lots	Walking downtown, running errands
Vehicle	Fixes are continuously >200m apart; GPS speed exceeds 20km/h.	Driving to work

3.3.3 Quality of Life and Activity Level

Accelerometer data were cleaned, and participant summaries were produced in *ActiLife v.6.7.3* software (ActiGraph, Pensacola, FL). Non-wear time was removed using a pre-determined algorithm built into the ActiLife software (Choi, Liu, Matthews, & Buchowski, 2011). This algorithm defines non-wear time by at least 90 minutes of consecutive zero (no movement) cpm, but uses a 'floating window' technique to account for artifacts by allowing for a short interval of up to 2 consecutive nonzero counts, provided no other nonzero counts are detected within 30 minutes preceding or following the nonzero counts. This algorithm produces less false non-wear times, and processes data continuously across days (e.g., continuously assess periods from 11:59PM to 12:00AM the following day) (Choi et al., 2011). It is better adapted to the sedentary patterns of older adults than the other built-in wear time validation algorithm (Troiano, 2007), which would more readily classify extended sedentary periods as 'non-wear.'

The SF36 questionnaire was scored with *QualityMetric Health Outcomes™ Scoring Software 4.5* proprietary software (QualityMetric Inc., Lincoln, RI). FACT-C subscale and total scores will be calculated in SPSS using the syntax scoring file provided by the FACIT group when registering a study with their system. Accelerometer and questionnaire data were visually inspected for normality using histograms, and the Shapiro-Wilk test of normality was used in cases where visual inspection was not conclusive at determining normal distribution. Boxplots were used to identify outliers (less or greater than 1.5 times the interquartile range (IQR) from the first or third quartile, respectively), which were subsequently filtered out of the analyses on a case-by-case basis. Due to the small sample size and non-parametric distribution of the physical activity and quality of life scores, Spearman's correlations were used to assess the strength of the relationship between time spent at different activity levels (including breaks in sedentary time) and QOL outcomes (SF36 PCS & MCS, FACT-G, and FACT-C). All analyses will be conducted with SPSS v.20.

3.3.4 Additional Data

Demographic and medical data are summarized and presented. These results (i.e., age, employment, disease stage, treatment type) were used for descriptive purposes only. The activity log data was used for descriptive purposes in order to improve our understanding of the types of activities that CRC survivors perform. While activity log data can be transformed into MET values from physical activity compendiums (see Ainsworth et al., 2000), and thereby be used to supplement the accelerometer data, Hall et al. (2013) found that the MET values from PA compendiums do not accurately reflect the energy expenditure of older adults. Additionally, as the activity log relies on participant memory and is completed at the end of the day, there would be a low likelihood of accurately combining these values with the accelerometer data and linking it to the GPS data.

CHAPTER FOUR: RESULTS

4.1 Participant Characteristics

Nineteen CRC survivors participated in this study between January and September, 2014. Of these, two participants were still undergoing treatment, one had a recurrent case of CRC, and eight were at least seven years post-treatment (see table 4.1). Participants were predominantly in their late 60s/early 70s, well-educated, and were equally represented by gender. Approximately two thirds were retired, while the majority lived with a partner. The majority of participants reported that their activity level was average compared to normal during the time of data collection. One participant had zero valid days of data, and was asked to re-wear the devices and complete the QOL questionnaires. Otherwise, no issues with wear time were experienced.

4.2 Time Spent at Different Activity Levels

All participants had at least 4 valid days (≥10 hours) of accelerometer data; the average number of valid days was 6.7 ± 0.93. The average daily wear time was 820 ± 58.5 minutes/day (13 hours, 40 minutes). Data were calculated both as total time at different intensity levels as well as only time spent within pre-determined 'bouts' (see section 3.4.1.2). Data were inspected visually using boxplots, and outliers were removed on a case-by-case basis. Data were also adjusted for the different amount of valid days, such that "daily" total time, number of bouts, and time in bouts was calculated by dividing the weekly totals by the number of valid days (see table 4.2).

Table 4.1.

Medical and Demographic Characteristics of Sample

Sample Characteristics		# (%)	Mean (SD)
Colon Cancer Diagnosis		13 (68.4)	
Rectal Cancer Diagnosis		6 (31.6)	
Cancer Stage			
	Stage 1-2	7 (36.8)	
	Stage 3-4	8 (42.1)	
	Don't know	4 (21.1)	
Cancer Treatment			
	Chemotherapy	14 (73.7)	
	Radiation	8 (42.1)	
	Surgery	17 (89.5)	
Months since diagnosis			103 (81.5)
Months since last treatment			101 (78.5)
>7 years post treatment		8 (42.1)	
2+ Comorbidities		8 (42.1)	
Age (years)			68.1 (9.5)
Female Gender		9 (47.4)	
BMI (kg/m^2)			26.8 (4.4)
Education			
	Did not Complete Post-Secondary	6 (31.6)	
	Completed Post-Secondary	13 (68.4)	
Income			
	<$70,000/year	8 (42.1)	
	>$70,000/year	9 (47.4)	
	Prefer not to say	2 (10.5)	
Employment Status			
	Paid Full or Part Time	7 (36.8)	
	Retired/Unpaid Volunteer Work	12 (63.2)	
Relationship Status			
	Married/Common-Law	16 (84.2)	
	Single/Divorced/Widowed	3 (15.8)	
Typical Transport to Work			
	Car	7 (87.5)	
	Public Transit	1 (12.5)	
Own Home Exercise Equipment		9 (47.4)	
	Use 0 times per week	5 (55.6)	
	Use 1-2 times per week	0	
	Use 3-4 times per week	4 (44.4)	
Use assisted walking device		3 (15.8)	
Average week of activity[a]			2.8 (0.8)

Note: Caucasian Ethnicity, regular access to a car, and car as the typical mode of transportation are not included as sample was completely homogenous. BMI, Body Mass Index.
[a]Assessed via 5-point Likert scale, with "3" denoting an average week.

Table 4.2

Average minutes spent in MVPA, LPA, SB, and Breaks in SB

	MVPA (M, SD)	LPA (M, SD)	SB (M, SD)	Breaks in SB (M, SD)
Daily Total Time	173 (87.3)	269 (45.5)	377 (105.0)	443 (110.9)
Daily # of bouts	4.6 (3.9)	2.7 (1.2)	5.3 (2.7)	5.2 (2.7)
Daily time in bouts	60 (47.7)[a]	52 (22.6)	192 (123.9)	-

Note: A dash ("-") denotes that no value is required, as minutes in sedentary breaks has no minimum time to be considered a bout. Minimum bout length for MVPA, LPA, and SB are 10, 15, and 20 minutes, respectively. MVPA, Moderate-to-Vigorous Physical Activity; LPA, Light Physical Activity; SB, Sedentary Behaviour.
[a]Adjusted for outliers (n = 17).

4.3 Location of Physical Activity and Sedentary Behaviour

4.3.1 GPS and Activity Data Cleaning and Management

All participants had at least four valid days of data of GPS and accelerometer data, with 74% having seven full days of data; reported information includes all valid days of data. There were a total of 46,031 instances of paired bout activity data and GPS information. Of these, 1,319 (2.9%) were duplicates. Duplicate fixes refer to instances where two data points with identical activity level information are created for a single minute of GPS data, which artificially inflates the number of data points for a given activity level. This can occur when the 'motion state' (e.g., stopped or moving) of a GPS unit changes.

There was an additional 3254 fixes (7.1%) that were classified as 'calculated' fixes. Calculated fixes occur when GPS satellites do not have a confirmed geographic location for the given minute of activity data. In some cases, calculated fixes were superfluous data that 'bookended' a bout that had clear reported fixes (e.g., no fix at 12:00:00, so coordinates are 'calculated', but confirmed, or 'reported', fixes at 12:00:02, 12:01:02, 12:02:02, etc.). In other cases, calculated fixes represented 'mystery' bouts where no GPS data was available during a given activity bout, making it impossible to accurately attribute a location to an activity bout. In both of these cases, the software would attempt to calculate the GPS coordinates based on other available data (e.g., last reported fix).

To better ascertain the influence of calculated and mystery fixes, a randomly selected sample of 10.5% of the participants (11.2% of data points) had their 'bookended' fixes manually removed. After removing these points, no difference in participant activity/location profiles (time in bouts spent at different locations) was found (data not shown). The resulting 'mystery' fixes accounted for 0.4% of the data points. Manually coding the location of these 'mystery' bouts by using the calculated fixes was deemed inappropriate, as there would be no way of telling if location had changed during the course of the bout, or if the calculated fixes were accurate.

Anecdotally, calculated fixes were typically removed from the 'reported' fix clusters when visually identifying activity bout locations, suggesting that using calculated fixes exclusively to identify location would greatly increase the chance of location misclassification. As removing calculated fixes did not seem to negatively impact the quality of the data, and manually coding them increased risk of error, 'calculated' fixes were completely removed. This left 41,458 paired activity bout and GPS data points for activity location profile analysis, which was 29% of total minutes that paired accelerometer and GPS data were available for, or an average of five hours and 12 minutes of bout data per participant per day. Figure 4.1 outlines the number of minutes of activity and GPS data at each subsequent step of processing during analysis.

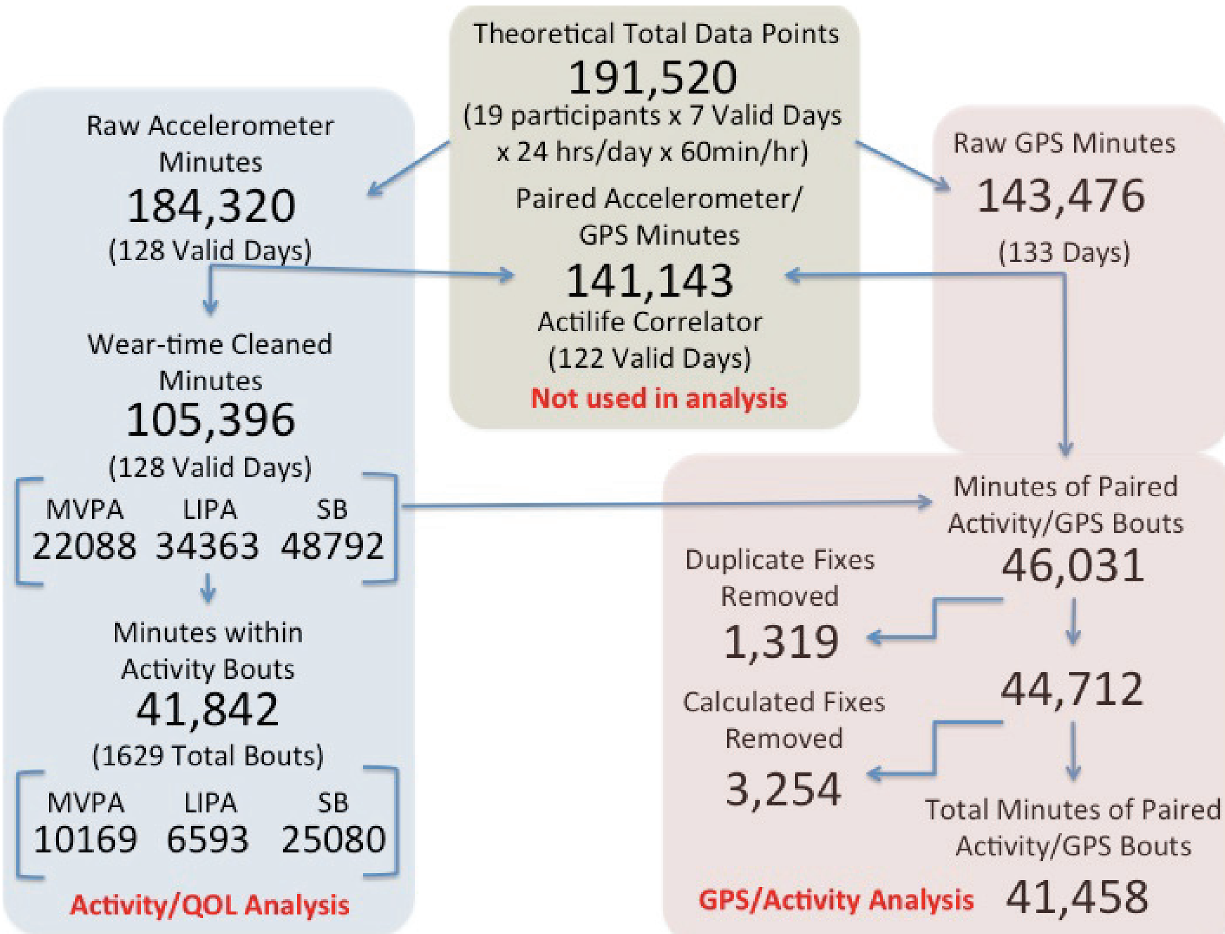


Figure 4.1. Refinement and path of data points throughout data cleaning at different analytical stages (one data point = one minute). GPS, Global Positioning System; QOL, Quality of Life.

4.3.2 Activity Location Profiles

Overall, the home environment was where the participants accrued the majority of minutes of activity bouts, including 70.4% of MVPA, 58.7% of LPA, and 86.4% of sedentary bouts. Other settings where MVPA occurred include nature/green space settings (7.4%), shopping (6.2%), vehicles (5.6%), and residential areas (4.9%). LPA predominantly occurred in vehicles (11.0%), shopping (7.3%), outdoor green space (5.3%), and in 'other' areas such as churches, schools/universities, and restaurants (7.3%). In addition to the home environment, sedentary bout time was mainly limited to vehicles (4.0%) and within other residential settings (2.3%). Table 4.3 describes the percent of time that participants spent at different kinds of locations for bouts of MVPA, LPA, and sedentary behaviour.

Table 4.3

Percent of Total Time of Activity Bouts Spent at Types of Geographic Locations

Environment	% MVPA bouts[a]	% LPA bouts[b]	% Sedentary bouts[c]
Home	70.6	58.7	86.4
Nature	7.4	5.3	1.4
Shopping	6.2	7.3	1.4
Vehicle	5.6	11.0	4.0
Neighbourhood/ Other Residential	4.9	2.8	2.3
Work	2.3	2.7	1.4
Other	1.8	7.3	1.3
Urban	1.5	4.8	1.8

Note. MVPA, Moderate-to-Vigorous Physical Activity; LPA, Light Physical Activity.
[a]Total minutes in MVPA bouts = 10,169. [b]Total minutes in LPA bouts = 6,593. [C]Total minutes in Sedentary bouts = 25,080.

Figures 4.2 and 4.3 display the proportion of total MVPA at each location for individuals currently working (n=7, figure 4.2) and those identified as retired (n=12, figure 4.3). For those currently working or volunteering, the workplace environment accounted for 6.2% of MVPA, 6.6% of LPA, and 6.1% of SB (data not shown). Retired individuals made up for this difference by being proportionally more active than their working counterparts in settings such as residential neighbourhoods (2% more time in MVPA bouts) and stores (3% more time in MVPA bouts).

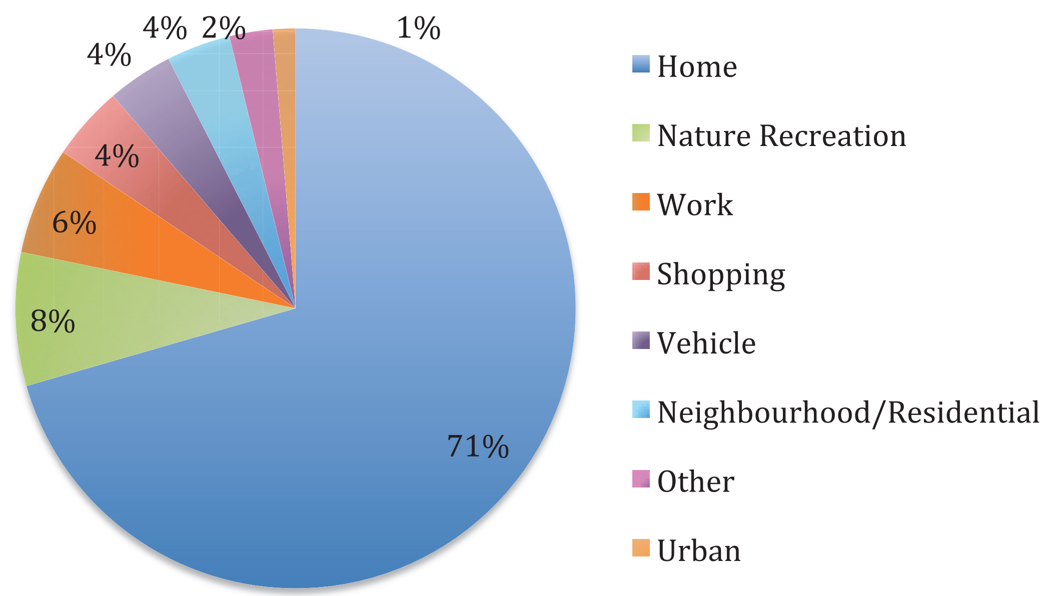


Figure 4.2. Location of MVPA for Participants Who are Currently Employed.

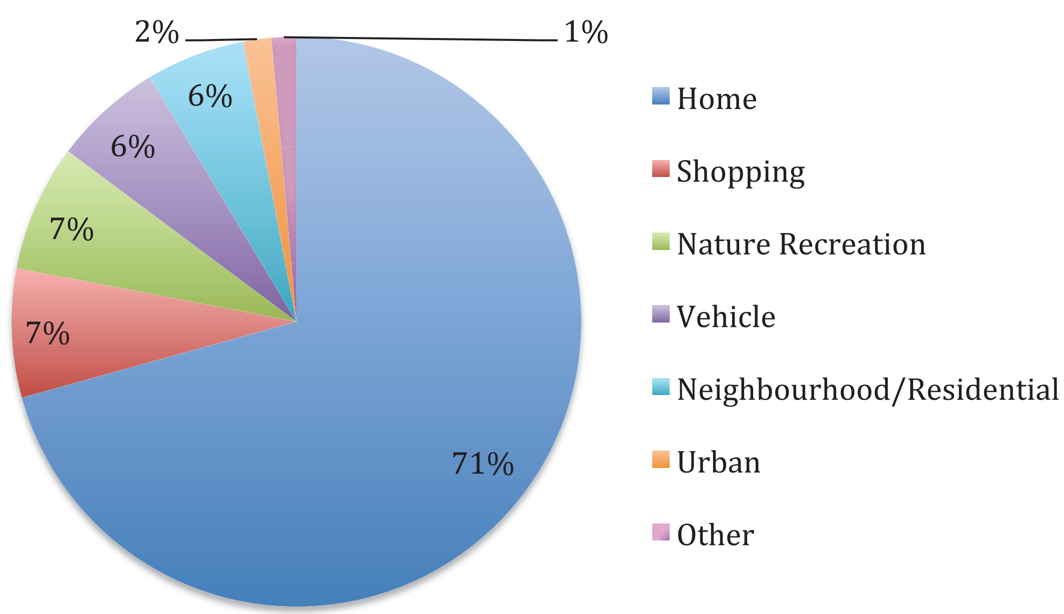


Figure 4.3. Location of MVPA for Participants Who are Retired.

4.4 Activity Level and QOL

The SF36 PCS and MCS subscales showed strong reliability (α = .89 and .95, respectively) (see table 4.4). The reliability of FACT-C (α = .87) and FACT-G (α = .86) were also acceptable, similar to those reported elsewhere (Courneya, Friendenreich, Arthur, & Bobick, 1999; Ward et al., 1999; Yoo, Kim, Eremenco, & Han, 2005). Both of these measures are well established in the QOL literature. Spearman's correlations were used to assess the strength of the relationship between time spent at different activity levels and QOL outcomes (see Table 4.5).

Both daily total MVPA and daily MVPA accumulated within 10-minute bouts was significantly and moderately correlated with SF36 PCS ($\boldsymbol{\rho}_S$=.51, p<.05, n=19 and $\boldsymbol{\rho}_S$=.59, *p*<.05, n=17, respectively). Average total sedentary time was significantly moderately negatively correlated with PCS scores ($\boldsymbol{\rho}_S$=-.50, p<.05, n=19). Time spent in sedentary breaks was trending towards a moderate correlation with SF36 PCS ($\boldsymbol{\rho}_S$=.42, *p*=.092. n=19). Both 'MVPA Bout' outliers (1.5 IQRs lower or higher than the first or third quartile, respectively) were removed as they greatly increased average time spent in MVPA bouts, one of which was an extreme outlier (>3 IQRs from the third quartile). SF36 MCS outliers were both removed because they had lower MCS scores than the rest of the sample (one of which was an extreme outlier).

Table 4.4.

Health-Related Quality of Life Outcome Scores and Reliability

Outcome Measure	Sample Score		Reference Value[a, b]	
	M (SD)	α	M (SD)	α
SF36 PCS	49.2 (7.6)	.89	47.2 (9.7)	-
Physical Functioning	73.7 (23.4)	.85	75.7 (22.2)	-
Role – Physical	77.3 (26.7)	.97	76.2 (36.5)	-
Bodily Pain	73.1 (16.0)	.60	74.0 (23.9)	-
General Health	77.5 (12.3)	.58	73.5 (18.4)	-
SF36 MCS	54.7 (9.5)	.95	53.7 (8.3)	-
Vitality	62.5 (20.9)	.89	67.7 (18.1)	-
Social Functioning	90.8 (14.3)	.92	87.0 (19.8)	-
Role – Emotional	86.8 (18.7)	.86	83.4 (32.8)	-
Mental Health	82.6 (16.5)	.90	79.3 (15.0)	-
FACT-G	94.4 (9.9)	.86	82.4 (14.1)	.84
Physical Well-Being	25.5 (2.2)	.51	20.1 (5.3)	.76
Social Well-Being	24.5 (3.3)	.54	22.3 (5.1)	.56
Emotional Well-Being	20.6 (3.2)	.60	20.0 (3.8)	.63
Functional Well-Being	23.8 (4.2)	.85	20.1 (6.5)	.82
FACT-C	116.4 (12.4)	.87	104.1 (17.2)	.87
Colorectal Cancer Subscale	22.0 (3.4)	.53	21.6 (4.9)	.63

Note. A dash ("-") denotes that the corresponding value was not reported in the original publication. SF36, Medical Outcome Survey Short Form 36-item; PCS, Physical Component Summary; MCS, Mental Component Summary; FACT-G, Functional Assessment of Cancer Therapy General; FACT-C, Functional Assessment of Cancer Therapy Colorectal.

[a]SF-36 reference values adapted from "Ages 65-74" (n=2910), reprinted with permission from "Canadian Normative Data from the SF-36 Health survey" by Hopman et al., 2000, p.266. [b]FACT-G and FACT-C reference values adapted from "Sample B-English" (n=63), reprinted with permission from "Reliability and Validity of the Functional Assessment of Cancer Therapy-Colorectal (FACT-C) Quality of Life Instrument", by Ward et al., 1999, p.185. Copies of permission letters can be found in *Appendix E*.

Table 4.5.

Spearman's Rho Correlations Between Health-Related Quality of Life Measures and Average Activity Levels Including Breaks in Sedentary Time

	MVPA Total	MVPA Bouts[a]	LPA Total	LPA Bouts	SB Total	SB Bouts	Breaks in SB
SF36 PCS	.51*	.59*	.01	.01	-.50*	-.36^	.44^
SF36 MCS[a]	-.23	-.02[b]	-.19	.07	.25	.29	-.27
FACT-G	.39	.14	.09	.05	-.07	-.08	.00
FACT-C	.37	.19	.18	.16	-.05	-.09	.00

Note. SF36, Medical Outcome Survey Short Form 36-item; PCS, Physical Component Summary; MCS, Mental Component Summary; FACT-G, Functional Assessment of Cancer Therapy General; FACT-C, Functional Assessment of Cancer Therapy Colorectal; MVPA, Moderate-to-Vigorous Physical Activity; LPA, Light Physical Activity; SB, Sedentary Behaviour.
[a]Adjusted for outliers (n=17). [b]Adjusted for outliers (n=15)
*$p < .05$. "^" denotes borderline significance ($.1 > p > .05$).

CHAPTER FIVE: DISCUSSION

The first objective of this study was to identify the kinds of locations that bouts of MVPA, LPA, and SB occurred in. It was expected that most MVPA would occur in green space and parks, while most SB would occur at home and at work. The second objective was to explore the relationship between MVPA, LPA, and SB with QOL. While the relationship between high MVPA and QOL is well-established, it was expected that high LPA and breaks in SB would also be related to QOL, while high SB would be negatively correlated with QOL.

5.1 Time Spent Active and Sedentary

Participants were very active, accumulating an average of 60 ± 47.7 minutes of MVPA in at least 10-minute bouts each day, spread over an average of 5 ± 3.9 separate bouts per day. Although this level of MVPA is substantially more than other CRC samples (Speed-Andrews et al., 2012; Vallance et al., 2014), this is likely due to the demographic characteristics of our sample, including the high number of years since cancer diagnosis. This surprisingly high level of activity may also be partially attributed to the age-specific cut points (SB = < 51cpm; LPA = 51-1040cpm; MVPA = >1040cpm) used to analyze the data (Copeland & Esliger, 2009). Based on these cut points, our participants exceeded the Canadian weekly PA guidelines (150 minutes of MVPA/week) in an average day, while in contrast only ~14% of Canadian older adults meet this criteria over the course of a week (Colley et al., 2011).

Most studies that assess population activity levels use a cut point that is almost double the MVPA cut point used in the current study (Colley et al., 2011; Troiano et al., 2007). More widely-used cut points offer more typical results; running the analyses using the MVPA cut point set by Troiano and colleagues (2007) (>2020cpm), three participants failed to accumulate *any* bouts of MVPA, with a group average of one bout of 22 ± 24.2 minutes of MVPA/day. However, even when using the Troiano cut points, the participants were more active than other age- and CRC-related samples (Vallance et al., 2014; Colley et al., 2011; Troiano et al., 2007).

While total LPA time was, as expected, greater than MVPA and less than SB, the number of bouts and time within bouts were the lowest of the 3 categories. This result was not expected, as it was reasoned that time in bouts would follow the same relative distribution as total LPA (e.g., there would be less time in LPA bouts than time in SB bouts, but more than MVPA bouts). This may be due to the narrow cpm range required to meet Copeland and Esliger's (2009) definition of LPA; the absolute range is less than 1000 cpm (51-1040 cpm), which is about half of the range used for other popular LPA cut points (Freedson et al., 1998; Troiano et al., 2007).

Another reason this may have occurred is because of the sustained nature of our bout criteria (15 minutes, with three minutes of potential 'drop time'), and the types of activities one typically performs at a light intensity (e.g., slow walking, washing the dishes, watering plants; Ainsworth et al., 2000). As some of these activities are isolated to the upper-body, they are unlikely to be captured by a waist-worn accelerometer. Furthermore, it may be that people are either intentionally active, or intentionally sedentary, and thus MVPA and sedentary bouts are more easily accumulated. With LPA, however, it is easier to dip down into SB cut points or up to MVPA cut points long enough to disrupt the successive number of epochs required to qualify as a bout. For measurement purposes, a shorter minimum bout time for LPA (e.g., ten minutes) is likely to result in more LPA bouts, and may reveal a relationship with physical health-related QOL.

Although we measured LPA in both bouts and total time in LPA, neither had significant relationship with QOL. This was unexpected, as Buman et al. (2010) found that total LPA was significantly correlated with better health and well-being. Interestingly, they also cite Copeland and Esliger's (2009) cut points (LPA: 51-1040; MVPA: >1040), although the definitions Buman and colleagues (2010) provide for LPA and MVPA are "low-light" and "high-light" intensity. In addition to not using these terms, Copeland and Esliger (2009) also argue higher greater cut points above their MVPA threshold are arbitrary as the relationship between MVPA and oxygen utilization decreases with age. Thus, it seems as if Buman and colleagues (2010) actually measured what Copeland and Esliger (2009) consider to be MVPA and labeled it as LPA, which may explain why we failed to find a relationship with any of our QOL measures while they were able to relate it to health outcomes.

Even though our participants were considered to be very active, accumulating an average of 60 minutes of MVPA in bouts of at least 10 minutes per day, the majority of our participants spent their time sedentary, both in terms of total time (6.3 hours/day) as well as time spent in sedentary bouts of at least 20 minutes (3.2 hours/day). This is consistent with numerous other studies that have reported on the propensity towards SB in both cancer survivors (George et al., 2014; Lynch et al., 2011; Sabiston, Brunet, Vallance, & Meterissian, 2014; Vallance et al., 2014) and older adults (Colley et al., 2011; Evenson et al., 2012; Jefferis et al., 2014; Matthews et al., 2008). This paradox of both high SB and high MVPA may again be a direct product of the age-specific cut points we used. However, these results demonstrate how a sample can be both active and sedentary, and how increasing one and reducing the other are two separate and distinct health behaviours (Tremblay, 2012). Despite the fact that we omitted the postural element of sedentary behaviour (sitting or reclining *in addition to* very low energy expenditure) (Tremblay, 2012) and analyzed SB along the more classic activity 'continuum', this still demonstrates that one can be both very active and very sedentary. This concept is supported by national data from the United States, where cancer survivors were found to be simultaneously more active *and* more sedentary than individuals without a history of cancer (Kim et al., 2013).

It is unclear if this is some kind of compensatory behaviour in cancer survivors, or if concurrently high MVPA and SB is a general activity pattern. The 'ActivityStat Hypothesis' has been offered to explain this kind of behaviour: if PA increases one day, the next likely shows a decrease in activity level in order to maintain a consistent activity level, or energy expenditure (Gomersall, Rowlands, English, Maher, & Olds, 2013). Recent research in children lends support to this hypothesis, as every ten minutes spent at MVPA resulted in 25 minutes less LPA and 5 minutes less MVPA the following day (Ridgers, Timperio, Cerin, & Salmon, 2014). However, existing literature is split on the ability of this hypothesis to explain variation in activity levels, and remains to be well-studied in clinical populations (Gomersall et al., 2013).

Conversely, it could be argued that a cancer diagnosis presents a 'teachable moment' for health behaviours like PA, which could result in cancer survivors being more active than the general population (Demark-Wahnefried, Aziz, Rowland, & Pinto, 2005). This 'teachable moment' may be well-suited for SB interventions, as a recent study found that SB increases following a breast cancer diagnosis in middle-aged women with an unhealthy waist-to-hip ratio, while women with a healthy waist-to-hip ratio decreased SB (Sabiston et al., 2014). While more research needs to be done in various populations to test this concept, it may explain why our sample, among others, achieved a high level of both SB and MVPA.

A final point on PA measurement is the use of the activity logs, which has been noted as a potential addition to increase data collection comprehensiveness (Oliver et al., 2010; Rodriguez et al., 2005). While participants were asked to fill out an activity log only if they removed/forgot to wear the devices or performed aquatic activities (e.g., swimming), the vast majority of participants reported not removing the device at all. Only two participants recorded swimming as activities performed, one of whom swam daily. However, she was already an extreme outlier for MVPA, so it was deemed unnecessary to further increase her physical activity by adding self-reported data to her accelerometer-recorded data. Therefore, we feel that the data that was captured accurately reflects the PA patterns of this sample.

However, in greater sample sizes it may be beneficial to have recommended practices for integrating activity log data with GPS data. Factors such as identifying activity intensity based on pre-defined energy expenditure values (Ainsworth et al., 2000) and identifying a location based on the fixes corresponding to the noted time of device removal need to be considered. While it may be tempting to completely remove this information as it would likely not be a substantial portion of the data collected, not including this information – which likely would not be coded as 'non-wear' because it was for a short duration – would underestimate MVPA and LPA and overestimate SB.

5.2 Activity Level and Location

This study builds on past research activity and location research by providing information on the environments associated with are active and sedentary behaviours among CRC survivors. While some studies have used accelerometry and GPS data to determine if PA is occurring within an individual's neighbourhood (Prins et al., 2014) or identify the proportion of activity in specific environments, such as parks and playgrounds (Quigg et al., 2010), relatively few studies have sought to identify locations associated with different levels of activity (cf. Rainham et al., 2012).

This current work provides a comprehensive activity/location profile for older adults with CRC, which can be valuable for planning future activity interventions in environments where the target behaviour (e.g., MVPA, SB) is already likely to occur. To the authors knowledge, the only comparable study in cancer survivors explored group differences between non-small cell lung cancer and healthy controls relative to how much time they spent around and away from their home, including time spent outdoors (Granger, Denehy, McDonald, Irving, & Clark, 2014). While this study provided information on how far cancer survivors travel from their home relative to controls and the time they spent outdoors, it did not describe environments where different activity behaviours occurred. Another important difference was that we used accelerometer cut points to accurately measure activity level, while Granger and colleagues (2014) used steps per day as a measure of activity.

Interestingly, we found that the home environment was the predominant source for all three levels of activity (MVPA, LPA, and SB), rather than each activity level having a unique environment or two associated with it as expected. As such, our expected results were not found, other than in the case of most time in bouts of SB occurring at home. It is challenging to situate our findings, as while little research has explored what kinds of environments PA or SB occur in, recent research on a large sample of adults found that the majority of MVPA did not occur at home (Hurvitz, Moudon, Kang, Fesinmeyer, & Saelens, 2014). Furthermore, research on activity preferences suggests that walking is the preferred mode of activity for both CRC survivors (McGowan et al., 2013) and older adults (Chodzko-Zajko et al., 2009; Rosso et al., 2011). However, walking could occur in the home if participants owned a treadmill, which is possible considering approximately half of the participants reported having home exercise equipment.

The seemingly paradoxical finding that older CRC survivors both simultaneously report walking as their preferred form of activity *and* perform the majority of their MVPA in their home could be interpreted as this population being opportunistic about their activity choices. For example, while they may *prefer* walking, it appears that activities around the home account for the majority of activity bouts, such as household chores or gardening. This suggests that future PA-enhancing and SB-reducing interventions may be more sustainable and effective by targeting the home environment, rather than focusing on workplaces, community centres, or other public places. While this strategy may be a simplistic in that it does not factor in some of the co-benefits of activities in these settings (e.g., fresh air outdoors or a social environment at a community centre), it could be effective at increasing overall activity levels. Similar to population health interventions, it may be worthwhile to support a small change in an environment where one spends most of their time (e.g., a TV that has a timer to alert the viewer to stand up occasionally) rather than a dramatic change where an individual occasionally visits (e.g., increasing trails in a public park).

However, it is also worth noting that other types of environments contributed substantially to time spent in MVPA bouts. Outdoor nature-based environments (Nature Recreation – 7.4%; ~40mins/week), retail opportunities such as malls and grocery stores (Shopping – 6.1%; ~33mins/week), and residential areas (Neighbourhood/Other Residential – 4.8% ~26mins/week) accounted for an average of 18.3% of total minutes of bouts of MVPA. This supports other research suggesting the importance of having environments that facilitate PA, such as green space (Renalds et al., 2010; Rosso et al., 2011), shopping centres (Alberta Centre for Active Living, 2007), and the 'walkability' of neighbourhood features like land use mix (commercial and residential properties) and population and housing density (Berke et al., 2007; Cerin et al., 2006).

The vast majority of SB (86.5% of time in bouts) occurred in the home environment. This is an important contribution to the literature, as despite the growing evidence for the importance of reducing sedentary time, to the authors' knowledge there have been no studies that have identified the environments where SB occurs. While it can be expected that retired older adults will spend the majority of their time at home, both participants currently working and not working spend equivalent amounts of time in sedentary bouts at home (86.5% and 86.6%, respectively). Although occupational interventions aimed at reducing sedentary time may be effective in predominantly sitting occupations (Healy et al., 2012; Neuhaus et al., 2014), it appears that the home environment is a potentially important target for reducing overall sedentary bout time.

These findings provide preliminary evidence that future interventions to reduce SB should have a strong home-based component, with prompts/cues/considerations adapted to a domestic environment similar to other place-based SB-reducing interventions (Healy et al., 2012). This may be particularly relevant for older CRC survivors, as there are a number of factors that may make home-based activity more attractive. CRC survivors, particularly those with ostomies as a result of their treatment, may avoid leaving their home for fear of being unable to control their bladder/bowels, or to avoid embarrassment associated with their ostomy appliance (Sprangers et al., 1995). A home-based activity program may yield high adherence for this population. Moreover, evidence is lacking on the sustainability of activity interventions in cancer survivors, as studies commonly find that activity levels regress towards baseline once the intervention has completed (Mishra et al., 2012). Interventions that occur in a familiar context, such as the home, rather than an atypical context, such as a hospital or research fitness facility, may show better sustainability and thus benefit cancer survivors in the long term.

5.3. Relationship Between QOL and Activity

While the relationship between MVPA and physical QOL (as measured by PCS) was expected, other relationships were less well-defined. As such, the hypothesis that greater activity is associated with better physical QOL, and more sedentary time being associated with worse QOL, was only partially supported by these results. Although PA has been related to better mental health and well-being outcomes, even in older adults (Warburton et al., 2006a; Windle, Hughes, Linck, Russell, & Woods, 2010), there were no correlations between the SF36 MCS and any of our activity outcomes. However, this finding is concurrent with a similar sample of older CRC survivors that found PA was related to PCS, but not MCS (Thraen-Borowski, Trentham-Dietz, Edwards, Koltyn, & Colbert, 2013).

Likewise, FACT-C scores were not correlated with any of our outcomes. This may be because this measure was designed to be sensitive to populations currently receiving cancer therapy. While the Functional Assessment of Chronis Illness Therapies group of tools is designed for use in both chronic disease and general populations, it may be that it is not as sensitive to general health states; most participants had been finished treatment for some years at the time of data collection. In the initial incarnation of this project, the intended study population was exclusively CRC patients currently undergoing treatment, which was why the FACT-C was selected as an appropriate QOL measure.

There is a substantial body of evidence to suggest that greater MVPA is associated with better health-related QOL, even in older adults and cancer survivors (Fitzpatrick, Edgar, & Holcroft, 2012; Thompson et al., 2012). While the link between MVPA and physical QOL was apparent in our work, the link between SB and self-reported QOL is less clear in both the literature and our study. George et al. (2013) found that breast cancer survivors in the highest quartile of self-reported sedentary time did not report significantly different QOL than those in the lowest quartile. One reason why we found that total sedentary time was negatively correlated with physical QOL (SF36 PCS) ($\boldsymbol{\rho}_S$=-.496, p<.05, n=19) may have been that we were objectively measuring SB. A recent study of CRC survivors found that there was little correlation and agreement between self-reported and objectively measured SB in cancer survivors (Boyle et al., 2014). This may explain why another study by George and colleagues (2014) found that greater objectively-measured SB did in fact correlate with poorer physical QOL in cancer survivors, similar to our findings.

While the issue of self-reported and objectively-measured activity has been thoroughly discussed in the PA literature (cf., Ainsworth et al., 2000; Sallis & Saelens, 2000; Shephard, 2003) this issue is still being explored in the SB literature.

However, these factors do not explain why a recent study of CRC survivors also found no relationship between objectively-measured SB and FACT-C QOL scores (Vallance et al., 2014). One explanation may be that total sedentary time may be more indicative of current QOL than sedentary time accumulated in bouts, although Vallance and colleagues (2014) failed to find any relationship with either 30-minute minimum sedentary bouts or total sedentary time. We found that time spent in sedentary bouts (≥20 minutes) accounted for only approximately half of total sedentary time, which may suggest that SB accumulated in short continuous periods of time (<20 minutes), but over long periods of time, may in fact still be detrimental to one's health. At this point, there appears to be too little evidence to offer recommendations for what qualifies as a 'bout' of SB in order to relate it to health and QOL outcomes.

This idea that SB doesn't appear to be associated with current QOL, but is predictive of future health outcomes, may be supported by longitudinal work. Numerous studies have explored factors such as occupational SB history, and have concluded that long-term relationships between SB and health outcomes exist (Balboa-Castillo, León-Muñoz, Graciani, Rodríguez-Artalejo, & Guallar-Castillón, 2011; Brown, Miller, & Miller, 2003; Marshall & Gyi, 2010; van Uffelen et al., 2010; Warren et al., 2010). Since health changes associated with high SB are best supported in longitudinal research (e.g., the development of cardiovascular disease), they are likely reflective of current QOL in the same way that PA is. For example, the ability to be active is reflective of physical functioning, which comprises

27% of the items of the SF36. Additionally, it may take quite a bit of time – a lifetime – to accumulate the repercussions of a sedentary lifestyle, which would make any negative absolute health states seem more normal and less likely to be construed as low QOL. As such, QOL may not be a meaningful outcome to relate to current or short-term changes in SB. It may also be useful to look at some psychosocial variables in relation to SB and QOL in cancer survivors, as recent work in this area found that while greater SB was associated with worse depression, anxiety, and feelings of well-being (Lowe et al., 2014a), with more negative attitudes towards PA predicted greater SB (Lowe et al., 2014b)

Another explanation for the relationship between SB and QOL is the QOL tool itself. We found that significant correlations between activity level and QOL only emerged in one of our two QOL measures, the SF36, while no significant correlations emerged for the FACT-C, or any of its subscales (data not shown). While both tools are well-known measures of QOL, results from the concurrent use of the SF36 and other members of the FACT family have been varied. The FACT-G has been shown to have good correlations with SF36 subscales and component scores (Overcash, Extermann, Parr, Perry, & Balducci, 2001). Gill and colleagues (2004) found that both the SF36 and the FACT–Gynecological Cancer physical scales were closely correlated. Conversely, recent research on the SF36 and the FACT-Breast Cancer found that the SF36 had inadequate agreement and showed floor and ceiling effects, concluding that it should not be used in breast cancer research to assess QOL (Oliveira, Costa, Manzoni, & Cabral, 2014). Interestingly, as Vallance and colleagues (2014) also did not find a relationship between SB and QOL when using the FACT-C, it may be that it is not as sensitive to SB-related QOL outcomes as the SF36.

The finding that the FACT-C was not correlated with either MVPA or SB while the PCS was may speak to the constructs that the measures represent. The PCS specifically measures physical health-related QOL. Ten of the 21 items that comprise the PCS (48%) relate to physical functioning, while another two items (10%) refer to pain. Therefore, it is not surprising that this scale showed significant correlations with MVPA, as both physical function and pain have been related to activity level in past research (Penedo & Dahn, 2005; Thompson et al., 2012). By contrast, the FACT-C is a general measure of health-related QOL, and includes five different QOL subscales (physical, emotional, functional, social, and CRC-specific). Additionally, the items that PA has strong support for affecting (e.g., fatigue; Vallance et al., 2014) represent a smaller proportion of items on the FACT-C than they do on the PCS. When these two facts are taken into account, it is less surprising that the PCS was associated with activity level while the FACT-C was not.

5.4 Strengths and Limitations

5.4.1 Study Strengths

This use of objective activity level and built environment measurement addresses important limitations in past research, such as relying on GIS data that varies substantially in cost and quality across regions (Brownson & Hoehner, 2009). As both the accelerometer and GPS units have been shown to be valid and reliable ways to collect activity and personal location data, we were able to confidently describe where our sample was engaging in different levels of activity. This study used precise PA measurement parameters, included age-specific activity cut points (Copeland & Esliger, 2009), and minimum bout length (Hardman, 2001). While other measures less sensitive to activity intensity, such as steps per day, have been reported in similar research (Granger et al., 2014; Webber & Porter, 2009), our use of age-specific cut points allows for a better understanding of the relationship between activity level and QOL. The more precise PA measurements used within the current study results in activity/location profiles that are well-supported by research to be associated with favourable health outcomes, rather than total/sporadic activity levels (Chastin et al., 2012; Murphy, Blair, & Murtagh, 2009).

Another important aspect of this study is the use of activity logs to fill any potential gaps in accelerometer and GPS data, as this is not normally done in other studies and has been noted as a limitation (Brownson & Hoehner, 2009). This technique, in addition to following up with participants' post-data collection to clarify any gaps or disparities in accelerometer/GPS readings, enhanced the descriptive and explanatory portions of this study. While we did not analyze this data formally, it did allow us to capture activities that may have otherwise been missed if the devices were not being worn. Had we integrated this information into our results, we would have seen an increase in MVPA and LPA and a reduction in SB. In turn, this may have altered the activity/location profiles and affected the strength and significance of the correlations between activity level and QOL. However, as there was little information reported in the activity logs, it is doubtful that this information would have drastically changed our findings.

A considerable strength of our work was the degree to which we had complete data to analyze. While best data management and cleaning practices are an ongoing topic of debate in this developing field (Kerr, Duncan, Schipperijn, & Schipperjin, 2011; Krenn, Titze, Oja, Jones, & Ogilvie, 2011), of the studies that report the amount of valid data, rates are as low as 55% acquiring >8 hours of valid data, particularly with older participants (Webber & Porter, 2009). In contrast, in the current study all participants had at least 4 valid days of data, with the majority (79%) having a full seven days worth of valid data (≥10 hours/day). Careful direction and encouraging participants to adhere to wearing the devices and ensuring the GPS was charged was no doubt helpful for this point. Furthermore, the clarity of the data collection and refinement process, as seen in figure 4.1, can help elucidate the often-opaque process of data integration and cleaning as suggested by Brownson and Hoehner (2009).

5.4.2 General Limitations

One of the main limitations to this study was the small sample size, which reduces the sensitivity of our statistical analysis and the subsequent generalizability of our results. For instance, we were unable to control for factors such as age, access to a vehicle, presence of an ostomy, time since diagnosis, and cancer stage, which have been noted to influence activity. However, given the paucity of related literature and the novelty of this methodology, other studies have argued that small sample sizes can still provide important insights necessary to advance this field (Webber & Porter, 2009). Therefore, we believe that this number of participants yielded important information on the methodological feasibility of associating environments with PA and SB in older adults with CRC. In turn, our results demonstrate the importance of the environment and activity level in CRC survivors, which can be used to support a larger-scale study.

The fact that our participants were self-identified may be another factor that limits the generalizability of our results. We did not have the ability to collect information from individuals who qualified to participate but decided not to. This may be important, as differences between CRC respondents and non-respondents have been noted on factors such as education (Ardnt et al., 2004). Our participants were aware of the nature of our study before participating, and thus may be more active or have an increased familiarity with technology than individuals who chose not to participate. Attitude towards and past familiarity with technology have been noted as factors predicting the use of technology (Czaja et al., 2006), and as such as our sample may not accurately reflect all older CRC survivors.

Another shortcoming of the proposed study is the cross-sectional design, as we are unable to account for any causal or long-term mechanisms related to active levels and the environments in which they occur. Little, if any, research has been conducted on the temporal nature of environments and activity levels, and if these vary substantially from week to week or over longer periods of time. A related confound is seasonality, and the effect that the weather can have on PA (particularly when examining what kinds of environments activities occur in) (Berke et al., 2007). Weather has been a noted barrier to PA (Tucker & Gilliland, 2007), specifically for both CRC (Courneya et al., 2005; Speed-Andrews et al., 2013) as well as older adults (Harris, Owen, Victor, Adams, & Cook, 2009; Rosenberg et al., 2012).

Due to difficulties in study recruitment, 6 participants had data collected during winter months (January – February), while the remaining participants had data collected during the summer months (June – September). While the winter group had significantly less MVPA and greater SB than the summer group ($p < .05$ for both MVPA and SB daily average and daily average in bouts), it cannot be determined that these differences were an artifact of small group size (6 in the winter, 13 in the summer) or due to other factors. For example, data collection difficulties resulted in the first group of participants being recruited from a local ostomy support group, which means that the presence of participants with an ostomy appliance occurred almost exclusively during winter months. As CRC survivors with ostomies have been known to experience additional complications, including disengagement from activities, this may explain the difference between activity levels independent of seasonality (Arndt et al., 2004; Sprangers et al., 1995). Regardless, longer time frames needed for more comprehensive study would need to control for data collected across different seasons and account for seasonal variations in activity patterns.

5.4.3. Activity Limitations

There is the potential that some activities, such as afternoon naps, may have been incorrectly coded as "non-wear" time. Participants were instructed to remove the accelerometer before going to bed at night, but it is uncertain if participants consistently removed the devices prior to taking a nap. If naps were greater than 90 minutes – the cut point of the ActiLife wear time validation software to consider it 'non-wear' time – then this would have accurately reflected their activity profile, as sleeping is distinct from sedentary time (Saunders & Chaput, 2012). However, if naps were shorter than this, there is a chance that these periods were erroneously coded as sedentary time. This would inflate total sedentary time, including the proportion of time spent in sedentary bouts accumulated at home, which may underestimate time spent in sedentary bouts at other locations. This may mean that other locations other than the home may be potentially important targets for sedentary behaviour reduction interventions. Additionally, this added sedentary time may have weakened the relationship between time spent sedentary and health-related QOL outcomes. While sedentary time was negatively associated with QOL in our research, sleep has been positively associated with QOL in CRC (Mormont et al., 2000), which suggests that naps coded as SB would blunt the correlation between SB and QOL.

Arguably the most contentious element of this study is the use of cut points specific to older adults. While these cut points were designed to provide a better representation of true energy costs for activities in older populations, there are some important limitations. These cut points were also developed based on walking on a treadmill, which means they likely underestimate the energy expenditure contribution of upper body activities and as such do not account for other free-living activities such as household chores. This suggests that some light-intensity activities common in older adults (i.e., folding laundry, doing dishes, light housework, preparing a meal) may have been overlooked in our analyses. As activity intensity typically decreases with age (Troiano et al., 2008), LPA presents an important activity domain to measure accurately, as at this time there is scant high-quality measurement research.

Additionally, as these cut points were also relatively recently developed and specific to older adults, it makes situating our findings within existing research difficult as they are not widely used, particularly in national data sets. For instance, while our analyses showed that our sample was exceeding the Canadian weekly PA recommendations in one day, using the more popular Troiano cut point (see section 5.1) showed that our sample was comparable to, if slightly more active than, similar samples (Vallance et al., 2014). However, the correlation between time spent in MVPA bouts and PCS was similar whether using Copeland and Esliger's (2009) age-appropriate cut points ($\boldsymbol{\rho}_S$=.588, p<.05) or the more widely-used Troiano cut points ($\boldsymbol{\rho}_S$=.554, p<.05). This suggests that, despite the absolute amount of MVPA varying between the two methods, the relationship between MVPA and physical QOL remains similar independent of the cut points used.

There is also the potential that we counted some activity data points twice (e.g., one minute of GPS/location data has 2 related activity data points) as they fall within the overlap of two bouts of different intensities. This occurred because the Activity Analyzer program we used to form bouts was configured to allow the 20% "drop time" of epochs outside of the desired bout intensity range. For example, the last two minutes of a ten-minute MVPA bout may be under the threshold for MVPA but still be included to accommodate the 20% drop time, but these minutes may also be the first minutes of a 15-minute LPA bout. As such, 23 minutes of actual activity is calculated as 25. This process occurs because the alternative is to prioritize MVPA points by removing them from the file being analyzed after the MVPA bouts are formed, then re-running the analysis to identify LPA bouts. This would leave 'holes' in the data, and likely underestimate the amount of LPA (and successively SB) that is actually being performed. Regardless, this is likely a small margin of error as a random sample of 11% of participants showed that these 'double counted' points only amounted to 67 ± 13 minutes per participant per week. However, future studies interested in exploring bout length of both MVPA and LPA may want to consider how to manage this issue.

While it is recognized that SB is distinct from the activity continuum (e.g., also involves postural elements), the methodology utilized to answer the primary research question did not take this into consideration. Therefore, while our measurement of SB is consistent with the greater PA literature, we did not factor in postural changes (measured via an inclinometer feature of most accelerometers) into our analysis; as such, time spent standing may have been interpreted as sedentary time (Saunders et al., 2013). This is due in part to the technology that was available, as the inclinometer function of the accelerometer has been noted to perform optimally when worn on the thigh (Boyle et al., 2014), while accelerometers for the purpose of measuring activity level are typically worn around on the hip (Colley et al., 2011).

Finally, the relationships between our outcome variables, and even the overall sedentary activity/environment profile, may have been different if we had used a different bout length. While the '10-minute bout' criteria for MVPA is well established, less is known about what length of continuous SB (or LPA, for that matter) is meaningful for health outcomes (Nygaard et al., 2009; Thorp et al., 2012). However, we believe we achieved a reasonable balance from both a health-related perspective as well as a logistical one, as counting and geographically pairing every minute of SB (too much data) or only those in 30-minute to 1-hour minimum bouts (not enough data) may not produce activity/environment profiles useful for activity behaviour interventions.

5.4.4 GPS/Activity Pairing Limitations

The proportion of GPS fixes we were able to use was a limitation of this work. Of the 44,712 instances of paired activity bout and GPS location data, 3254 (7.3%) were 'calculated' fixes. More sophisticated data-cleaning programs may have been able to parse out unwanted points and distinguish between 'bookended' and 'mystery' calculated fixes, as the decision to remove 'mystery' points altogether under-estimates how active individuals are. Including these 'mystery' fixes may sway the overall activity/environment profile towards indoor environments, as GPS fixes are better when the wearer is outdoors (Kerr et al., 2011). As such, this study may have underestimated the proportion of time that participants were active in settings like their home (e.g., if exercise equipment is in the basement) and high-density urban environments where satellite fixes can be scattered by tall buildings (Kerr et al., 2011).

One study element that is difficult to explain is that some minutes of both MVPA (5.6%) and LPA (11.0%) occurred while riding in motorized vehicles. This concern has been noted in previous research discussing the importance of reducing these 'false' activity bouts (Liden et al., 2002), but to date has only begun to be addressed in the GPS/activity research. For instance, Troped and colleagues (2008) noted that time spent in motor vehicles can be confused with other modes of transportation, such as cycling. Other studies using GPS and accelerometer to explore transport-related activity have also noted that MVPA can occur in cars, even when using MVPA cut points that were greater than those used in this study (Chaix et al., 2014; Oliver et al., 2010).

This finding may have been due to the 'window' technique we used to classify activity bouts, which allows for a few minutes to fall below the activity threshold. Another explanation may be driving on very bumpy roads, which could be a plausible explanation in rural settings; accelerometers pick up changes in accelerations in all three dimensions, and jarring driving could potentially inflate recorded counts. While there appears to be no simple answers for why this issue would occur to a large enough degree to account for 5-10% of time in non-sedentary bouts, it is important to note that with the aid of the GPS data (e.g., speed) we were able to code these bouts as occurring within a vehicle. While we did not remove this time from our activity analysis, future research could adapt protocols to manage this data as they see fit.

An unexpected classification issue that arose was coding for active transportation. Pairing GPS and accelerometer data has previously been hailed as an important method for better understanding this health behaviour (Duncan et al., 2009), which can account for up to one third of total MVPA (Chaix et al., 2014). While active transportation is seen as being supported by the built environment, this kind of *behaviour* is difficult to determine using solely observational data. As one of the research questions of this study was to identify the *environments* in which CRC survivors are being active and sedentary, it seemed incongruent with the goals of this study to attempt to manually code the behaviour of 'active transportation' based solely on the kind of environment the activity was occurring in. Collection of this kind of information is also confounded by satellite drift and in urban settings – the principal locale for this study – by the presence of tall buildings (Duncan et al., 2009), which suggests that advances in GPS technology may be necessary before high quality research of this kind can be performed. Therefore, this study was unable to determine if older CRC survivors are engaging in active transportation, and what kinds of environments this activity typically occurs within/between.

5.5 Future Research

One method of future inquiry is to identify the environments for all time at different activity levels, rather than just bouts. In our study, bouts accounted for less than half of the total activity time. As some research suggests that shorter periods of activity or SB may be important for health outcomes (Glazer et al., 2013; Jefferis et al., 2014; Macfarlane et al., 2006; Murphy et al., 2009), it may be worth exploring where all activity is occurring. Analysis for this question can be cumbersome, as location coding is performed manually, data point by data point, and the ease of coding bouts (which typically occur in one or two locations) is lost. However, as advancements in programming increase the automaticity of analyses, these types of questions will be answered more easily. For instance, advances in

GPS positioning and smart phone technology can automatically probe participants to elucidate on missing data points, providing us a more comprehensive understanding of where activity occurs (Chaix et al., 2014).

Similarly, while we were able to detail how much time in activity bouts occurred at different locations, we did not determine how much time was spent there in total, and therefore what proportion of time in different locations attributed to both bout and non-bout activity levels. By extension, we also did not examine the proportion of bouts that occurred in different environments. While presenting the proportion of *time* in bouts was useful for comparing environments, identifying environments where most bouts occur would provide further depth. For instance, if only 10% of bouts occur at home, but these bouts account for 70% of MVPA, it illustrates the importance of incorporating the home into activity strategies. This information would be used to describing which environments MVPA occurs in predominantly, and which environments provide opportunity to reduce SB and increase LPA and MVPA.

Another method of inquiry is to use GPS data to further our understanding of how built environment features influence PA. Different neighbourhood built environment characteristics result in significant differences in their residents' PA (Adams et al., 2012), and areas deemed 'highly walkable' are associated with more self-reported walking (Berke et al., 2007). However, to the authors' knowledge, no studies of these designs have employed both accelerometry and real-time location monitoring to determine if these differences in PA actually occur *within* these environments, or if other factors may explain this relationship (e.g., higher-SES neighbourhoods may be more walkable, but individuals have the means to pursue PA elsewhere). Additionally, factors such as residential self-selection bias (individuals selecting a neighbourhood that supports their already active lifestyle) have been noted (Boone-Heinonen et al., 2011). These are underlying assumptions that hold important implications for how we understand the relationship between the built environment and PA; applying activity/location methodology will allow us to question these assumptions for effectively.

Additional characterization of environments and activity levels may also be of use to health professionals when designing activity programs for CRC survivors. For instance, we did not explore the temporal nature of bout accumulation, such as whether participants consistently engaged in MVPA or SB at similar times of day. The potential of better understanding temporal patterns of activity has been noted in past research (Kerr et al., 2011). For example, proper application of temporal activity patterns at the programming level could increase attendance of and adherence to MVPA opportunities or interventions by scheduling them when older CRC survivors are already typically active. This information could also be used in conjunction with personalized messaging to influence behaviours that are likely to occur at a given time, such as SB (Dantzig, Geleijnse, & Halteren, 2012).

Time spent sedentary continues to be an elusive term, both for inclusion as a potential health factor as well as how it is defined and operationalized in research (Marshall & Ramirez, 2011; Tremblay, 2012; Yates et al., 2011). While the case for reducing SB as a health intervention is mounting in both occupational and recreational settings (Katzmarzyk et al., 2009; Neuhaus et al., 2014; van Uffelen et al., 2010), there is still the issue of defining SB as inactivity, despite calls for the contrary (Tremblay, 2012). An extension of this research would be to use postural analysis, as energy expenditure attributed to postural transitions has been noted as a potentially important factor for obesity (Levine et al., 2005). Examining posture in addition to accelerometer cut points would allow us to better understand how these two factors are related, which may validate or refute the concept of measuring SB on an activity continuum (e.g., <100cpm). As methodologies evolve to assess SB more accurately, it would follow suite to apply this rigour to identifying the environments that SB occurs in.

CHAPTER 6: CONCLUSION

This study was, to the authors' knowledge, the first to use both objectively measured activity levels and GPS data to create activity/environment profiles for not only older CRC survivors, but older adults and cancer survivors in general. The majority of time spent in bouts of MVPA, LPA, and SB occurred in the home environment, although other environments, such as retail stores, green spaces, and residential neighbourhoods accounted for almost one fifth of time spent in MVPA bouts. This corroborates existing research on the environmental influence of PA, and also provides novel evidence to suggest that the home environment is an important target for future activity interventions in older CRC survivors. Additionally, while this research supported the well-established relationship between MVPA and physical health-related QOL, there was less support for LPA and SB; only total time spent sedentary was significantly correlated with physical QOL. Moreover, no activity outcomes were significantly related to mental or CRC-specific QOL.

Several methodological considerations were discussed when using accelerometry and GPS technology to describe environments where CRC survivors are active and sedentary. When designing activity interventions, the locations presented in this research act as potential settings for place-based activity in CRC survivors. This study lends further support to the relationship between PA and QOL, and suggests that SB may affect QOL as well, although more sensitive tools and methods will further inform this. Future avenues of study are recommended, such as relating built environment neighbourhood characteristics to GPS and activity data to better understand how the environment affects activity levels. Health behaviours, such as increasing PA and reducing SB, are potentially important strategies for not only preventing CRC, but also for improving QOL in older CRC survivors.

REFERENCES

Adams, M. A., Sallis, J. F., Conway, T. L., Frank, L. D., Saelens, B. E., Kerr, J., … King, A. C. (2012). Neighborhood environment profiles for physical activity among older adults. *American Journal of Health Behavior*, *36*(6), 757–769. doi:10.5993/AJHB.36.6.4

Ainsworth, B. E., Bassett, D. R., Strath, S. J., Swartz, A. M., O'Brien, W. L., Thompson, R. W., … Kimsey, C. D. (2000). Comparison of three methods for measuring the time spent in physical activity. *Medicine and Science in Sports and Exercise*, *32*(Suppl. 9), 457–464.

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. N. N. M., Strath, S. J., … Leon, A. S. (2000). Compendium of Physical Activities : an update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise*, *32*(Suppl. 9), 498–516.

Alberta Centre for Active Living. (2007). Stepping Out : Mall Walking and Older Adults Mall Walking Programs in Alberta Mall Walking : A New Strategy for. *WellSpring*, *18*(1).

Alfano, C. M., & Rowland, J. H. (2006). Recovery issues in cancer survivorship: a new challenge for supportive care. *Cancer Journal*, *12*(5), 432–43.

Altenburg, T. M., Rotteveel, J., Dunstan, D. W., Salmon, J., & Chinapaw, M. J. M. (2013). The effect of interrupting prolonged sitting time with short, hourly, moderate-intensity cycling bouts on cardiometabolic risk factors in healthy, young adults. *Journal of Applied Physiology*, *115*(12), 1751–1756. doi:10.1152/japplphysiol.00662.2013

American Cancer Society. (2012). Physical side effects. Retrieved December 16, 2012, from http://www.cancer.org/treatment/treatmentsandsideeffects/physicalsideeffects/index

Arndt, V., Merx, H., Stegmaier, C., Ziegler, H., & Brenner, H. (2004). Quality of life in patients with colorectal cancer 1 year after diagnosis compared with the general population: a population-based study. *Journal of Clinical Oncology*, *22*(23), 4829–36. doi:10.1200/JCO.2004.02.018

Balboa-Castillo, T., León-Muñoz, L. M., Graciani, A., Rodríguez-Artalejo, F., & Guallar-Castillón, P. (2011). Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. *Health and Quality of Life Outcomes*, *9*(47). doi:10.1186/1477-7525-9-47

Benedict, C., Brooks, S. J., Kullberg, J., Nordenskjöld, R., Burgos, J., Le Grevès, M., … Schiöth, H. B. (2013). Association between physical activity and brain health in older adults. *Neurobiology of Aging*, *34*(1), 83–90. doi:10.1016/j.neurobiolaging.2012.04.013

Berke, E. M., Koepsell, T. D., Moudon, A. V., Hoskins, R. E., & Larson, E. B. (2007). Association of the built environment with physical activity and obesity in older persons. *American Journal of Public Health*, *97*(3), 486–492. doi:10.2105/AJPH.2006.085837

Boone-Heinonen, J., Gordon-Larsen, P., Guilkey, D. K., Jacobs, D. R., & Popkin, B. M. (2011). Environment and Physical Activity Dynamics: The Role of Residential Self-selection. *Psychology of Sport and Exercise*, *12*(1), 54–60. doi:10.1016/j.psychsport.2009.09.003

Boyle, T., Lynch, B. M., Courneya, K. S., & Vallance, J. K. (2014). Agreement between accelerometer-assessed and self-reported physical activity and sedentary time in colon cancer survivors. *Supportive Care in Cancer*. doi:10.1007/s00520-014-2453-3

Broderick, J. M., Hussey, J., & O'Donnell, D. M. (2014). Comment on "Interventions to improve exercise behaviour in sedentary people living with and beyond cancer: a systematic review". *British Journal of Cancer*, *111*(12), 2377–8. doi:10.1038/bjc.2014.248

Bronfenbrenner, U. (1977). Toward an Experimental Ecology of Human Development. *American Psychologist*, *32*, 513–531.

Brown, W. J., Miller, Y. D., & Miller, R. (2003). Sitting time and work patterns as indicators of overweight and obesity in Australian adults. *International Journal of Obesity and Related Metabolic Disorders*, *27*(11), 1340–6. doi:10.1038/sj.ijo.0802426

Brownson, R., & Hoehner, C. (2009). Measuring the Built Environment for Physical Activity: State of the Science. *American Journal of Preventive Medicine*, *36*(4 Suppl), S99–123. doi:10.1016/j.amepre.2009.01.005.

Buman, M. P., Hekler, E. B., Haskell, W. L., Pruitt, L., Conway, T. L., Cain, K. L., … King, A. C. (2010). Objective light-intensity physical activity associations with rated health in older adults. *American Journal of Epidemiology*, *172*(10), 1155–65. doi:10.1093/aje/kwq249

Butler-Jones, D. (2010). *The Cheif Public Health Officer's Report on the State of Public Health in Canada 2010: Growing Older - Adding Life to Years*. Ottawa, ON: Public Health Canada.

Campbell, P. T., Patel, A. V, Newton, C. C., Jacobs, E. J., & Gapstur, S. M. (2013). Associations of recreational physical activity and leisure time spent sitting with colorectal cancer survival. *Journal of Clinical Oncology*, *31*(7), 876–885. doi:10.1200/JCO.2012.45.9735

Canadian Cancer Society's Advisory Committee on Cancer Statistics. (2013). *Canadian Cancer Statistics 2013* (pp. 1–114). Toronto, ON.

Canadian Cancer Society's Steering Committee on Cancer Statistics. (2012). *Canadian Cancer Statistics 2012*. Toronto, ON.

Canadian Society for Exercise Physiology. (2004). *The Canadian Physical Activity, Fitness & Lifestyle Approach* (3rd ed.). Ottawa, ON: Author.

Canadian Society for Exercise Physiology. (2012). Canadian Physical Activity Guidelines Canadian Sedentary Behaviour Guidelines.

Carreca, I., Balducci, L., & Extermann, M. (2005). Cancer in the older person. *Cancer Treatment Reviews*, *31*(5), 380–402. doi:10.1016/j.ctrv.2005.04.012

Cerin, E., Saelens, B. E., Sallis, J. F., & Frank, L. D. (2006). Neighborhood Environment Walkability Scale: validity and development of a short form. *Medicine and Science in Sports and Exercise*, *38*(9), 1682–91. doi:10.1249/01.mss.0000227639.83607.4d

Chaix, B., Kestens, Y., Duncan, S., Merrien, C., Thierry, B., Pannier, B., … Méline, J. (2014). Active transportation and public transportation use to achieve physical activity recommendations? A combined GPS, accelerometer, and mobility survey study. *The International Journal of Behavioral Nutrition and Physical Activity*, *11*(1), 124. doi:10.1186/s12966-014-0124-x

Chastin, S. F. M., Ferriolli, E., Stephens, N. A., Fearon, K. C. H., & Greig, C. (2012). Relationship between sedentary behaviour, physical activity, muscle quality and body composition in healthy older adults. *Age and Ageing*, *41*(1), 111–114. doi:10.1093/ageing/afr075

Cheak-Zamora, N. C., Wyrwich, K. W., & McBride, T. D. (2009). Reliability and validity of the SF-12v2 in the medical expenditure panel survey. *Quality of Life Research*, *18*(6), 727–35. doi:10.1007/s11136-009-9483-1

Chodzko-Zajko, W. J., Proctor, D. N., Fiatarone Singh, M. a, Minson, C. T., Nigg, C. R., Salem, G. J., & Skinner, J. S. (2009). American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Medicine and Science in Sports and Exercise*, *41*(7), 1510–1530. doi:10.1249/MSS.0b013e3181a0c95c

Choi, L., Liu, Z., Matthews, C. E., & Buchowski, M. S. (2011). Validation of accelerometer wear and nonwear time classification algorithm. *Medicine and Science in Sport and Exercise*, *43*(2), 357–364. doi:10.1249/MSS.0b013e3181ed61a3.Validation

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports*, *22*(1), 1–8.

Copeland, J., & Esliger, D. (2009). Accelerometer assessment of physical activity in active, healthy older adults. *Journal of Aging and Physical Activity*, *17*, 17–30.

Courneya, K. S. (2003). Exercise in cancer survivors: an overview of research. *Medicine and Science in Sports and Exercise*, *35*(11), 1846–52. doi:10.1249/01.MSS.0000093622.41587.B6

Courneya, K. S., & Friedenreich, C. M. (1997). Relationship between exercise pattern across the cancer experience and current quality of life in colorectal cancer survivors. *Journal of Alternative and Complementary Medicine*, *3*(3), 215–26.

Courneya, K. S., Friedenreich, C. M., Quinney, H. A., Fields, A. L. a, Jones, L. W., & Fairey, A. S. (2004). Predictors of adherence and contamination in a randomized trial of exercise in colorectal cancer survivors. *Psycho-Oncology*, *13*(12), 857–66. doi:10.1002/pon.802

Courneya, K. S., Friedenreich, C. M., Quinney, H. A., Fields, A. L. A., Jones, L. W., Vallance, J. K. H., & Fairey, A. S. (2005). A longitudinal study of exercise barriers in colorectal cancer survivors participating in a randomized controlled trial. *Annals of Behavioral Medicine*, *29*(2), 147–53. doi:10.1207/s15324796abm2902_9

Courneya, K. S., Friendenreich, C. M., Arthur, K., & Bobick, T. M. (1999). Understanding exercise motivation in colorectal cancer patients: a prospective study using the theory of planned behavior. *Rehabilitation Psychology*, *44*(1), 68–84.

Cramp, F., & Byron-Daniel, J. (2012). Exercise for the management of cancer-related fatigue in adults (Review). *Cochrane Database of Systematic Reviews*, (11).

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Rogers, W. A., & Sharit, J. (2006). Factors Predicting the Use of Technology: Findings From the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging*, *21*(2), 333–352.

Dantzig, S., Geleijnse, G., & Halteren, A. T. (2012). Toward a persuasive mobile application to reduce sedentary behavior. *Personal and Ubiquitous Computing*, *17*(6), 1237–1246. doi:10.1007/s00779-012-0588-0

De Vreede, P. L., Samson, M. M., van Meeteren, N. L. U., Duursma, S. A., & Verhaar, H. J. J. (2005). Functional-task exercise versus resistance strength exercise to improve daily function in older women: A randomized controlled trial. *Journal of the American Geriatrics Society*, *53*(1), 2–10.

Demark-Wahnefried, W., Aziz, N. M., Rowland, J. H., & Pinto, B. M. (2005). Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. *Journal of Clinical Oncology*, *23*(24), 5814–30. doi:10.1200/JCO.2005.01.230

Denlinger, C., & Engstrom, P. (2011). Colorectal Cancer Survivorship: Movement Matters. *Cancer Prevention Research*, *4*(4), 502–511. doi:10.1158/1940-6207.CAPR-11-0098.Colorectal

DeSantis, C. E., Lin, C. C., Mariotto, A. B., Siegel, R. L., Stein, K. D., Kramer, J. L., … Jemal, A. (2014). Cancer treatment and survivorship statistics, 2014. *CA: A Cancer Journal for Clinicians*, *64*, 252–271. doi:10.3322/caac.21235

Ding, D., Sallis, J. F., Conway, T. L., Saelens, B. E., Frank, L. D., Cain, K. L., & Slymen, D. J. (2012). Interactive Effects of Built Environment and Psychosocial Attributes on Physical Activity: A Test of Ecological Models. *Annals of Behavioral Medicine*, *44*(3), 365–374. doi:10.1007/s12160-012-9394-1

Duncan, M. J., Badland, H. M., & Mummery, W. K. (2009). Applying GPS to enhance understanding of transport-related physical activity. *Journal of Science and Medicine in Sport*, *12*(5), 549–56. doi:10.1016/j.jsams.2008.10.010

Duncan, S., Stewart, T. I., Oliver, M., Mavoa, S., MacRae, D., Badland, H. M., & Duncan, M. J. (2013). Portable global positioning system receivers: static validity and environmental conditions. *American Journal of Preventive Medicine*, *44*(2), e19–29. doi:10.1016/j.amepre.2012.10.013

Dunstan, D., Kingwell, B., & Larsen, R. (2012). Breaking up prolonged sitting reduces postprandial glucose and insulin responses. *Diabetes Care*, *35*, 976–983. doi:10.2337/dc11-1931.

Esliger, D. W., Copeland, J. L., Barnes, J. D., & Tremblay, M. S. (2005). Standardizing and Optimizing the Use of Accelerometer Data for Free-Living Physical Activity Monitoring. *Journal of Physical Activity and Health*, *3*, 366–383.

Esliger, D. W., & Tremblay, M. S. (2007). Physical activity and inactivity profiling : the next generation. *Applied Physiology, Nutrition, and Metabolism*, *32*, S195–S207.

Evenson, K. R., Buchner, D. M., & Morland, K. B. (2012). Objective Measurement of Physical Activity and Sedentary Behavior Among US Adults Aged 60 Years or Older. *CDC - Preventing Chronic Disease*, *9*(2), 1–10.

Ferrer, R. a, Huedo-Medina, T. B., Johnson, B. T., Ryan, S., & Pescatello, L. S. (2011). Exercise interventions for cancer survivors: a meta-analysis of quality of life outcomes. *Annals of Behavioral Medicine*, *41*(1), 32–47. doi:10.1007/s12160-010-9225-1

Fitzpatrick, T. R., Edgar, L., & Holcroft, C. (2012). Assessing the relationship between physical fitness activities, cognitive health, and quality of life among older cancer survivors. *Journal of Psychosocial Oncology*, *30*(5), 556–72. doi:10.1080/07347332.2012.703768

Fong, D. Y. T., Ho, J. W. C., Hui, B. P. H., Lee, A. M., Macfarlane, D. J., Leung, S. S. K., … Cheng, K. (2012). Physical activity for cancer survivors: meta-analysis of randomised controlled trials. *British Medical Journal*, *344*, e70. doi:10.1136/bmj.e70

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine and Science in Sport and Exercise*, *30*(5), 777–81.

Gardiner, P. A., Eakin, E. G., Healy, G. N., & Owen, N. (2011). Feasibility of reducing older adults' sedentary time. *American Journal of Preventive Medicine*, *41*(2), 174–177. doi:10.1016/j.amepre.2011.03.020

Gay, J. L., Saunders, R. P., & Dowda, M. (2011). The relationship of physical activity and the built environment within the context of self-determination theory. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *42*(2), 188–96. doi:10.1007/s12160-011-9292-y

George, S., Alfano, C., Wilder, S., Irwin, M., McTiernan, A., Bernstein, L., … Ballard-Barbash, R. (2013). Sedentary Behavior, Health-Related Quality of Life and Fatigue among Breast Cancer Survivors. *Journal of Physical Activity and Health*, *10*, 350–358.

George, S. M., Alfano, C. M., Groves, J., Karabulut, Z., Haman, K. L., Murphy, B. a, & Matthews, C. E. (2014). Objectively measured sedentary time is related to quality of life among cancer survivors. *PloS One*, *9*(2), e87937. doi:10.1371/journal.pone.0087937

Gill, K., Von Gruenigen, V., Frasure, H., Grandon, M., Hopkins, M., & Jenison, E. (2004). Simultaneous measurement of cancer specific quality of life and general health status in genecologic malignancies. *Journal of Clinical Oncology*, *22*(14S), 8253.

Glazer, N. L., Lyass, A., Esliger, D. W., Blease, S. J., Freedson, P. S., Massaro, J. M., … Vasan, R. S. (2013). Sustained and shorter bouts of physical activity are related to cardiovascular health. *Medicine and Science in Sports and Exercise*, *45*(1), 109–15. doi:10.1249/MSS.0b013e31826beae5

Gomersall, S. R., Rowlands, A. V, English, C., Maher, C., & Olds, T. S. (2013). The ActivityStat hypothesis: the concept, the evidence and the methodologies. *Sports Medicine (Auckland, N.Z.)*, *43*(2), 135–49. doi:10.1007/s40279-012-0008-7

Gorman, E., Yang, P., Khan, K., Liu-Ambrose, T., & Ashe, M. (2011). Accelerometry cutpoints and older adults: A systematic review. In *International Conference on Ambulatory Monitoring of Physical Activity and Movement (ICAMPAM)*. Glasgow, Scotland.

Granger, C. L., Denehy, L., McDonald, C. F., Irving, L., & Clark, R. A. (2014). Physical Activity Measured Using Global Positioning System Tracking in Non-Small Cell Lung Cancer: An Observational Study. *Integrative Cancer Therapies*, *E-pub ahea*. doi:10.1177/1534735414542484

Green, J., & Edwards, P. (2008). The limitations of targeting to address inequalities in health: a case study of road traffic injury prevention from the UK. *Critical Public Health*, *18*(2), 175–187. doi:10.1080/09581590701697300

Hall, K. S., Howe, C. A., Rana, S. R., Martin, C. L., & Morey, M. C. (2013). METs and Accelerometry of Walking in Older Adults: Standard versus Measured Energy Cost. *Medicine and Science in Sports and Exercise*, *45*(3), 574–82. doi:10.1249/MSS.0b013e318276c73c

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2007). Role of Low Energy Expenditure and Sitting in Obesity, Metabolic Syndrome, Type 2 Diabetes, and Cardiovascular Disease. *Diabetes*, *56*(November 2007), 2655–2667. doi:10.2337/db07-0882.CVD

Hamilton, M. T., Healy, G. N., Dunstan, D. W., Zderic, T. W., & Owen, N. (2008). Too Little Exercise and Too Much Sitting: Inactivity Physiology and the Need for New Recommendations on Sedentary Behavior. *Current Cardiovascular Risk Reports*, *2*(4), 292–298. doi:10.1007/s12170-008-0054-8

Hardman, A. (2001). Issues of fractionization of exercise (short vs long bouts). *Medicine and Science in Sports and Exercise*, *33*(Suppl. 6), 421–427.

Harris, T. J., Owen, C. G., Victor, C. R., Adams, R., & Cook, D. G. (2009). What factors are associated with physical activity in older people, assessed objectively by accelerometry? *British Journal of Sports Medicine*, *43*(6), 442–50. doi:10.1136/bjsm.2008.048033

Harriss, D. J., Cable, N. T., George, K., Reilly, T., Renehan, A. G., & Haboubi, N. (2007). Physical activity before and after diagnosis of colorectal cancer: disease risk, clinical outcomes, response pathways and biomarkers. *Sports Medicine*, *37*(11), 947–60.

Health Canada. (2002). *Healthy Aging: Physical Activity and Older Adults* (pp. 1–17). Ottawa, ON.

Healy, G., Lawler, S., Thorp, A., Neuhaus, M., Robson, E., Owen, N., & Dunstan, D. (2012). *Reducing prolonged sitting in the workplace (An evidence review: Full report)*. Melbourne, Australia: Victorian Health Promotion Foundation.

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2008). Breaks in Sedentary Time: Beneficial associations with metabolic risk. *Diabetes Care*, *31*(4), 661–666. doi:10.2337/dc07-2046

Hewitt, M., Rowland, J. H., & Yancik, R. (2003). Cancer Survivors in the United States: Age, Health, and Disability. *Journal of Gerontology*, *58*(1), 82–91.

Hurst, M. (2009). *Who participates in active leisure?* (pp. 25–31). Ottawa, ON.

Hurvitz, P. M., Moudon, A. V, Kang, B., Fesinmeyer, M. D., & Saelens, B. E. (2014). How far from home? The locations of physical activity in an urban U.S. setting. *Preventive Medicine*, *69*, 181–186. doi:10.1016/j.ypmed.2014.08.034

Jefferis, B. J., Sartini, C., Shiroma, E., Whincup, P. H., Wannamethee, S. G., & Lee, I.-M. (2014). Duration and breaks in sedentary behaviour: accelerometer data from 1566 community-dwelling older men (British Regional Heart Study). *British Journal of Sports Medicine*, epub ahead of print. doi:10.1136/bjsports-2014-093514

Katzmarzyk, P. T., Church, T. S., Craig, C. L., & Bouchard, C. (2009). Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Medicine and Science in Sports and Exercise*, *41*(5), 998–1005. doi:10.1249/MSS.0b013e3181930355

Keats, M. R., Blanchard, C., Tyrrell, A., Rainham, D. G., & Younis, T. (2012). Environmental Influences on Physical Activity Behaviours in Breast Cancer Survivors: A Pilot Study [Poster]. In *Canadian Society for Psychomotor Learning and Sport Psychology*. Halifax, NS.

Kerr, J., Duncan, S., Schipperijn, J., & Schipperjin, J. (2011). Using global positioning systems in health research: a practical approach to data collection and processing. *American Journal of Preventive Medicine*, *41*(5), 532–40. doi:10.1016/j.amepre.2011.07.017

Kerr, J., Rosenberg, D. E., Nathan, A., Millstein, R. a, Carlson, J. a, Crist, K., … Marshall, S. J. (2012). Applying the ecological model of behavior change to a physical activity trial in retirement communities: description of the study protocol. *Contemporary Clinical Trials*, *33*(6), 1180–8. doi:10.1016/j.cct.2012.08.005

Kesse-Guyot, E., Charreire, H., Andreeva, V. a, Touvier, M., Hercberg, S., Galan, P., & Oppert, J.-M. (2012). Cross-sectional and longitudinal associations of different sedentary behaviors with cognitive performance in older adults. *PloS One*, *7*(10), e47831. doi:10.1371/journal.pone.0047831

Khakoo, A. Y., Liu, P. P., Force, T., Lopez-Berestein, G., Jones, L. W., Schneider, J., & Hill, J. (2011). Cardiotoxicity due to cancer therapy. *Texas Heart Institute Journal*, *38*(3), 253–6.

Kim, R. B., Phillips, A., Herrick, K., Helou, M., Rafie, C., Anscher, M. S., … Ning, Y. (2013). Physical activity and sedentary behavior of cancer survivors and non-cancer individuals: results from a national survey. *PloS One*, *8*(3), e57598. doi:10.1371/journal.pone.0057598

Kintzel, P. E., Pharm, D., Chase, S. L., Schultz, L. M., & Rourke, T. J. O. (2008). Increased Risk of Metabolic Syndrome, Diabetes Mellitus, and Cardiovascular Disease in Men Receiving Androgen Deprivation Therapy for Prostate Cancer. *Pharmacotherapy*, *28*(12), 1511–1522.

Koroukian, S. M., Xu, F., Bakaki, P. M., Diaz-Insua, M., Towe, T. P., & Owusu, C. (2010). Comorbidities, functional limitations, and geriatric syndromes in relation to treatment and survival patterns among elders with colorectal cancer. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *65*(3), 322–9. doi:10.1093/gerona/glp180

Krenn, P. J., Titze, S., Oja, P., Jones, A., & Ogilvie, D. (2011). Use of global positioning systems to study physical activity and the environment: a systematic review. *American Journal of Preventive Medicine*, *41*(5), 508–15. doi:10.1016/j.amepre.2011.06.046

Kreuter, M. W., De Rosa, C., Howze, E. H., & Baldwin, G. T. (2004). Understanding wicked problems: a key to advancing environmental health promotion. *Health Education & Behavior*, *31*(4), 441–54. doi:10.1177/1090198104265597

Kuiper, J. G., Phipps, A. I., Neuhouser, M. L., Chlebowski, R. T., Thomson, C. a, Irwin, M. L., … Newcomb, P. a. (2012). Recreational physical activity, body mass index, and survival in women with colorectal cancer. *Cancer Causes Control*, *23*(12), 1939–48. doi:10.1007/s10552-012-0071-2

Lee, I.-M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., & Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*, *380*(9838), 219–229. doi:10.1016/S0140-6736(12)61031-9

Levine, J. a, Lanningham-Foster, L. M., McCrady, S. K., Krizan, A. C., Olson, L. R., Kane, P. H., … Clark, M. M. (2005). Interindividual variation in posture allocation: possible role in human obesity. *Science*, *307*(5709), 584–586. doi:10.1126/science.1106561

Liden, C. B., Wolowicz, M., Stivoric, J., Teller, A., Vishnubhatla, S., Pelletier, R., & Farringdon, J. (2002). *Accuracy and Reliability of the SenseWear TM Armband as an Energy Expenditure Assessment Device* (pp. 1–15).

Loprinzi, P. D., Lee, H., Cardinal, B. J., Crespo, C. J., Andersen, R. E., & Smit, E. (2013). The Relationship of Actigraph Accelerometer Cut-Points for Estimating Physical Activity with Selected Health Outcomes. *Research Quarterly for Exercise and Sport*, *83*(3), 422–430.

Lowe, S. S., Danielson, B., Beaumont, C., Watanabe, S. M., Baracos, V. E., & Courneya, K. S. (2014a). Associations between objectively measured physical activity and quality of life in cancer patients with brain metastases. *Journal of Pain and Symptom Management*, *48*(3), 322–32. doi:10.1016/j.jpainsymman.2013.10.012

Lowe, S. S., Danielson, B., Beaumont, C., Watanabe, S. M., Baracos, V. E., & Courneya, K. S. (2014b). Correlates of objectively measured sedentary behavior in cancer patients with brain metastases: an application of the theory of planned behavior. *Psycho-Oncology*. doi:10.1002/pon.3641

Lynch, B. M., Dunstan, D. W., Healy, G. N., Winkler, E., Eakin, E., & Owen, N. (2010). Objectively measured physical activity and sedentary time of breast cancer survivors, and associations with adiposity: findings from NHANES (2003-2006). *Cancer Causes & Control : CCC*, *21*(2), 283–288. doi:10.1007/s10552-009-9460-6

Lynch, B. M., Dunstan, D. W., Vallance, J. K., & Owen, N. (2013). Don't take cancer sitting down: A new survivorship research agenda. *Cancer*, *119*(11), 1928–1135. doi:10.1002/cncr.28028

Lynch, B. M., Dunstan, D. W., Winkler, E., Healy, G. N., Eakin, E., & Owen, N. (2011). Objectively assessed physical activity, sedentary time and waist circumference among prostate cancer survivors: findings from the National Health and Nutrition Examination Survey (2003-2006). *European Journal of Cancer Care*, *20*(4), 514–519. doi:10.1111/j.1365-2354.2010.01205.x

Lynch, B. M., Owen, N., Hawkes, A. L., & Aitken, J. F. (2010). Perceived barriers to physical activity for colorectal cancer survivors. *Supportive Care in Cancer*, *18*(6), 729–34. doi:10.1007/s00520-009-0705-4

Macfarlane, D. J., Taylor, L. H., & Cuddihy, T. F. (2006). Very short intermittent vs continuous bouts of activity in sedentary adults. *Preventive Medicine*, *43*(4), 332–6. doi:10.1016/j.ypmed.2006.06.002

Maddison, R., Hoorn, S. Vander, Jiang, Y., Mhurchu, C. N., Exeter, D., Dorey, E., … Turley, M. (2009). The environment and physical activity: The influence of psychosocial, perceived and built environmental factors. *The International Journal of Behavioral Nutrition and Physical Activity*, *6*, 19. doi:10.1186/1479-5868-6-19

Marshall, S., & Gyi, D. (2010). Evidence of health risks from occupational sitting: where do we stand? *American Journal of Preventive Medicine*, *39*(4), 389–91. doi:10.1016/j.amepre.2010.07.001

Marshall, S. J., & Ramirez, E. (2011). Reducing Sedentary Behavior: A New Paradigm in Physical Activity Promotion. *American Journal of Lifestyle Medicine*, *5*(6), 518–530. doi:10.1177/1559827610395487

Matthews, C., Chen, K., Freedson, P. S., Buchowski, M., Beech, B., Pate, R. R., & Troiano, R. P. (2008). Amount of time spent in sedentary behaviors in the United States, 2003–2004. *American Journal of Epidemiology*, *167*(7), 875–881. doi:10.1093/aje/kwm390.Amount

Mazzeo, R. S., Cavanagh, P., Evans, W. J., Fiatarone, M., Hagberg, J., Mcauley, E., & Startzell, J. (1998). Exercise and physical activity for older adults. *Medicine and Science in Sports and Exercise*, *30*(6), 1–28.

McGowan, E., Speed-Andrews, A. E., Blanchard, C. M., Rhodes, R. E., Friedenreich, C. M., Culos-Reed, S. N., & Courneya, K. S. (2013). Physical Activity Preferences Among a Population-Based Sample of Colorectal Cancer Survivors. *Oncology Nursing Forum*, *40*(1), 44–52.

Meisner, B. A., Dogra, S., Logan, A. J., Baker, J., & Weir, P. L. (2010). Do or decline?: comparing the effects of physical inactivity on biopsychosocial components of successful aging. *Journal of Health Psychology*, *15*(5), 688–696. doi:10.1177/1359105310368184

Meyerhardt, J. A., Giovannucci, E. L., Holmes, M. D., Chan, A. T., Chan, J. A., Colditz, G. A., & Fuchs, C. S. (2006). Physical activity and survival after colorectal cancer diagnosis. *Journal of Clinical Oncology*, *24*(22), 3527–34. doi:10.1200/JCO.2006.06.0855

Mishra, S. I., Scherer, R. W., Geigle, P. M., Berlanstein, D. R., Topaloglu, O., Gotay, C. C., & Snyder, C. (2012). Exercise interventions on health-related quality of life for cancer survivors. *Cochrane Database of Systematic Reviews*, (Issue 8). doi:10.1002/14651858.CD007566.pub2

Moradi, T., Gridley, G., Björk, J., Dosemeci, M., Ji, B.-T., Berkei, H. J., & Lemeshow, S. (2008). Occupational physical activity and risk for cancer of the colon and rectum in Sweden among men and women by anatomic subsite. *European Journal of Cancer Prevention*, *17*(3), 201–208.

Mormont, M., Waterhouse, J., Bleuzen, P., Giacchetti, S., Jami, A., Misset, J., … Le, F. (2000). Marked 24-h Rest / Activity Rhythms Are Associated with Better Quality of Life , Better Response , and Longer Survival in Patients with Metastatic Colorectal Cancer and Good Performance Status Marked 24-h Rest / Activity Rhythms Are Associated with Better.

Murphy, M. H., Blair, S. N., & Murtagh, E. M. (2009). Accumulated versus continuous exercise for health benefit: a review of empirical studies. *Sports Medicine*, *39*(1), 29–43.

National Cancer Institute. (n.d.). NCI dictionary of cancer terms. Retrieved December 15, 2012, from http://www.cancer.gov/dictionary?CdrID=450125

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., … Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Circulation*, *116*(9), 1094–1105. doi:10.1161/CIRCULATIONAHA.107.185650

Netz, Y., Dunsky, A., Zach, S., Goldsmith, R., Shimony, T., Goldbourt, U., & Zeev, A. (2012). Psychological functioning and adherence to the recommended dose of physical activity in later life: results from a national health survey. *International Psychogeriatrics*, *24*(12), 2027–2036. doi:10.1017/S1041610212001299

Neuhaus, M., Healy, G. N., Fjeldsoe, B. S., Lawler, S., Owen, N., Dunstan, D. W., … Eakin, E. G. (2014). Iterative development of Stand Up Australia: a multi-component intervention to reduce workplace sitting. *The International Journal of Behavioral Nutrition and Physical Activity*, *11*(1), 21. doi:10.1186/1479-5868-11-21

NIH Consensus Development Panel on Physical Activity and Cardiovascular Health. (1996). Physical Activity and Cardiovascular Health. *The Journal of the American Medical Association*, *276*(3), 241–246.

Nygaard, H., Tomten, S. E., & Høstmark, A. T. (2009). Slow postmeal walking reduces postprandial glycemia in middle-aged women. *Applied Physiology, Nutrition, and Metabolism*, *34*(6), 1087–92. doi:10.1139/H09-110

Oliveira, I. S., Costa, L. C. M., Manzoni, A. C. T., & Cabral, C. M. N. (2014). Assessment of the measurement properties of quality of life questionnaires in Brazilian women with breast cancer. *Brazilian Journal of Physical Therapy*, *18*(4), 372–383. doi:10.1590/bjpt-rbf.2014.0045

Oliver, M., Badland, H., Mavoa, S., Duncan, M. J., & Duncan, S. (2010). Combining GPS, GIS, and Accelerometry: Methodological Issues in the Assessment of Location and Intensity of Travel Behaviors. *Journal of Physical Activity and Health*, *7*, 102–108.

Overcash, J., Extermann, M., Parr, J., Perry, J., & Balducci, L. (2001). Validity and Reliability of the FACT-G Scale for Use in the Older Person With Cancer. *American Journal of Clinical Oncology*, *24*(6), 591–596. doi:10.1097/00000421-200112000-00013

Peddle, C. J., Plotnikoff, R. C., Wild, T. C., Au, H.-J., & Courneya, K. S. (2008). Medical, demographic, and psychosocial correlates of exercise in colorectal cancer survivors: an application of self-determination theory. *Supportive Care in Cancer*, *16*(1), 9–17. doi:10.1007/s00520-007-0272-5

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, *18*(2), 189–193.

Powell, K. E., Paluch, A. E., & Blair, S. N. (2011). Physical activity for health: What kind? How much? How intense? On top of what? *Annual Review of Public Health*, *32*, 349–365. doi:10.1146/annurev-publhealth-031210-101151

Prins, R. G., Pierik, F., Etman, a, Sterkenburg, R. P., Kamphuis, C. B. M., & van Lenthe, F. J. (2014). How many walking and cycling trips made by elderly are beyond commonly used buffer sizes: results from a GPS study. *Health & Place*, *27*, 127–33. doi:10.1016/j.healthplace.2014.01.012

Public Health Agency of Canada. (2011). Physical Activity Guidelines. Retrieved February 21, 2014, from http://www.phac-aspc.gc.ca/hp-ps/hl-mvs/pa-ap/03paap-eng.php

Puts, M. T. E., Papoutsis, A., Springall, E., & Tourangeau, a E. (2012). A systematic review of unmet needs of newly diagnosed older cancer patients undergoing active cancer treatment. *Supportive Care in Cancer*, *20*(7), 1377–94. doi:10.1007/s00520-012-1450-7

Qstarz International Co., L. (2012). BT-Q1000XT. *GPS Travel Recorder*. Retrieved November 17, 2012, from http://www.qstarz.com/Products/GPS Products/BT-Q1000XT-F.htm#

Quigg, R., Gray, A., Reeder, A. I., Holt, A., & Waters, D. L. (2010). Using accelerometers and GPS units to identify the proportion of daily physical activity located in parks with playgrounds in New Zealand children. *Preventive Medicine*, *50*(5-6), 235–40. doi:10.1016/j.ypmed.2010.02.002

Rainham, D. G., Bates, C. J., Blanchard, C. M., Dummer, T. J., Kirk, S. F., & Shearer, C. L. (2012). Spatial classification of youth physical activity patterns. *American Journal of Preventive Medicine*, *42*(5), e87–96. doi:10.1016/j.amepre.2012.02.011

Renalds, A., Smith, T. H., & Hale, P. J. (2010). A Systematic Review of Built Environment and Health. *Family and Community Health*, *33*(1), 68–78.

Rhodes, R. E., Brown, S. G., & McIntyre, C. a. (2006). Integrating the perceived neighborhood environment and the theory of planned behavior when predicting walking in a Canadian adult sample. *American Journal of Health Promotion*, *21*(2), 110–118.

Rhodes, R. E., Mark, R. S., & Temmel, C. P. (2012). Adult sedentary behavior: a systematic review. *American Journal of Preventive Medicine*, *42*(3), e3–28. doi:10.1016/j.amepre.2011.10.020

Richard, L., Gauvin, L., & Raine, K. (2011). Ecological models revisited: Their uses and evolution in health promotion over two decades. *Annual Review of Public Health*, *32*, 307–26. doi:10.1146/annurev-publhealth-031210-101141

Ridgers, N. D., Timperio, A., Cerin, E., & Salmon, J. (2014). Compensation of physical activity and sedentary time in primary school children. *Medicine and Science in Sports and Exercise*, *46*(8), 1564–9. doi:10.1249/MSS.0000000000000275

Rodriguez, D. A., Brown, A. L., & Troped, P. J. (2005). Portable Global Positioning Units to Complement Accelerometry-Based Physical Activity Monitors. *Medicine & Science in Sports & Exercise*, *37*(Supplement), S572–S581. doi:10.1249/01.mss.0000185297.72328.ce

Rosenberg, D. E., Huang, D. L., Simonovich, S. D., & Belza, B. (2012). Outdoor Built Environment Barriers and Facilitators to Activity among Midlife and Older Adults with Mobility Disabilities. *The Gerontologist*, (The Gerontologist Advance Access published September 25, 2012). doi:10.1093/geront/gns119

Rosso, A. L., Auchincloss, A. H., & Michael, Y. L. (2011). The urban built environment and mobility in older adults: a comprehensive review. *Journal of Aging Research*. doi:10.4061/2011/816106

Sabiston, C. M., Brunet, J., Vallance, J. K., & Meterissian, S. (2014). Prospective examination of objectively assessed physical activity and sedentary time after breast cancer treatment: sitting on the crest of the teachable moment. *Cancer Epidemiology, Biomarkers & Prevention*, *23*(7), 1324–30. doi:10.1158/1055-9965.EPI-13-1179

Saelens, B., & Handy, S. (2008). Built Environment Correlates of Walking: A Review. *Medicine and Science in Sports and …*, *40*(206). doi:10.1249/MSS.0b013e31817c67a4.Built

Sallis, J. F. (2012). Big issues for preventive medicine. *Preventive Medicine*, *55*(6), 531–2. doi:10.1016/j.ypmed.2012.07.004

Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K. A., Kraft, M. K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health*, *27*, 297–322. doi:10.1146/annurev.publhealth.27.021405.102100

Sallis, J. F., Owen, N., & Fisher, E. B. (2008). Ecological Models of Health Behavior. In K. Glanz, B. Rimer, & K. Viswanath (Eds.), *Health Behaviour and Health Education: Theory, Research, and Practice* (4th ed., pp. 465–485). San Francisco, CA: Jossey-Bass.

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: status, limitations, and future directions. *Research Quarterly for Exercise and Sport*, *71*(2), 1–14.

Santos-lozano, A., Marín, P. J., Torres-luque, G., Ruiz, J. R., Lucía, A., & Garatachea, N. (2012). Technical variability of the GT3X accelerometer. *Medical Engineering and Physics*, *34*(6), 787–790. doi:10.1016/j.medengphy.2012.02.005

Sasaki, J. E., John, D., & Freedson, P. S. (2011). Validation and comparison of ActiGraph activity monitors. *Journal of Science and Medicine in Sport*, *14*(5), 411–416. doi:10.1016/j.jsams.2011.04.003

Saunders, T. J., & Chaput, J.-P. (2012). Is obesity prevention as simple as turning off the television and having a nap? *The British Journal of Nutrition*, *108*(5), 946–7. doi:10.1017/S0007114512002644

Saunders, T. J., Tremblay, M. S., Mathieu, M.-È., Henderson, M., O'Loughlin, J., Tremblay, A., & Chaput, J.-P. (2013). Associations of sedentary behavior, sedentary bouts and breaks in sedentary time with cardiometabolic risk in children with a family history of obesity. *PloS One*, *8*(11), e79143. doi:10.1371/journal.pone.0079143

Schipperijn, J., Kerr, J., Duncan, S., Madsen, T., Klinker, C. D., & Troelsen, J. (2014). Dynamic Accuracy of GPS Receivers for Use in Health Research: A Novel Method to Assess GPS Accuracy in Real-World Settings. *Frontiers in Public Health*, *2*(March), 21. doi:10.3389/fpubh.2014.00021

SF-36. (1998). U.S. Population Norms. QualityMetric Incorporated.

Shephard, R. J. (2003). Limits to the measurement of habitual physical activity by questionnaires. *British Journal of Sports Medicine*, *37*(3), 197–206.

Shibata, A., Oka, K., Harada, K., Nakamura, Y., & Muraoka, I. (2009). Psychological, social, and environmental factors to meeting physical activity recommendations among Japanese adults. *The International Journal of Behavioral Nutrition and Physical Activity*, *6*, 60. doi:10.1186/1479-5868-6-60

Smith, B. D., Smith, G. L., Hurria, A., Hortobagyi, G. N., & Buchholz, T. a. (2009). Future of cancer incidence in the United States: burdens upon an aging, changing nation. *Journal of Clinical Oncology : Official Journal of the American Society of Clinical Oncology*, *27*(17), 2758–65. doi:10.1200/JCO.2008.20.8983

Spatial Intelligence for Health Knowledge Lab. (2014). *Analysis of Accelerometry-Linked GPS Data Activity Analyzer and ICU-H (GAP): Protocol*. Halifax, NS.

Speed-Andrews, A. E., McGowan, E. L., Rhodes, R. E., Blanchard, C. M., Culos-Reed, S. N., Friedenreich, C. M., & Courneya, K. S. (2013). Identification and Evaluation of the Salient Physical Activity Beliefs of Colorectal Cancer Survivors. *Cancer Nursing*, *00*(0), 1–9. doi:10.1097/NCC.0b013e3182813972

Speed-Andrews, A. E., Rhodes, R. E., Blanchard, C. M., Culos-Reed, S. N., Friedenreich, C. M., Belanger, L. J., & Courneya, K. S. (2012). Medical, demographic and social cognitive correlates of physical activity in a population-based sample of colorectal cancer survivors. *European Journal of Cancer Care*, *21*(2), 187–96. doi:10.1111/j.1365-2354.2011.01290.x

Sprangers, M. A. G., Taal, B. G., Aaronson, N. K., & te Velde, A. (1995). Quality of life in colorectal cancer. *Diseases of the Colon & Rectum*, *38*(4), 361–369. doi:10.1007/BF02054222

Statistics Canada. (2009). *Physical Activity During Leisure Time, 2009*. Ottawa, ON.

Statistics Canada. (2010). *Population Projections for Canada, Provinces and Territories*. Ottawa, ON.

Steinherz, L. J., Steinherz, P. G., Tan, C. T., Heller, G., & Murphy, M. L. (1991). Cardiac toxicity 4 to 20 years after completing anthracycline therapy. *Journal of the American Medical Association*, *266*(12), 1672–7.

Thompson, W. W., Zack, M. M., Krahn, G. L., Andresen, E. M., & Barile, J. P. (2012). Health-related quality of life among older adults with and without functional limitations. *American Journal of Public Health*, *102*(3), 496–502. doi:10.2105/AJPH.2011.300500

Thorp, A. A., Healy, G. N., Winkler, E., Clark, B. K., Gardiner, P. A., Owen, N., & Dunstan, D. W. (2012). Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study of office, customer service and call centre employees. *The International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 128. doi:10.1186/1479-5868-9-128

Thraen-Borowski, K. M., Trentham-Dietz, A., Edwards, D. F., Koltyn, K. F., & Colbert, L. H. (2013). Dose-response relationships between physical activity, social participation, and health-related quality of life in colorectal cancer survivors. *Journal of Cancer Survivorship*, *7*(3), 369–78. doi:10.1007/s11764-013-0277-7

Tremblay, M. S. (2012). Letter to the editor : Standardized use of the terms "sedentary" and "sedentary behaviours." *Applied Physiology, Nutrition, and Metabolism*, *37*, 540–542. doi:10.1139/H2012-024

Troiano, R. (2007). Wear Time Validation Parameters. *ActiGraph Support*. Retrieved October 21, 2014, from https://help.theactigraph.com/entries/21703957

Troiano, R. P. (2005). A Timely Meeting: Objective Measurement of Physical Activity. *Medicine & Science in Sports & Exercise*, *37*(Supplement), S487–S489. doi:10.1249/01.mss.0000185473.32846.c3

Troiano, R. P., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T., & McDowell, M. (2007). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise*, *40*(1), 181–8. doi:10.1249/mss.0b013e31815a51b3

Troped, P. J., Oliveira, M. S., Matthews, C. E., Cromley, E. K., Melly, S. J., & Craig, B. a. (2008). Prediction of activity mode with global positioning system and accelerometer data. *Medicine and Science in Sports and Exercise*, *40*(5), 972–8. doi:10.1249/MSS.0b013e318164c407

Troped, P. J., Wilson, J. S., Matthews, C. E., Cromley, E. K., & Melly, S. J. (2010). The built environment and location-based physical activity. *American Journal of Preventive Medicine*, *38*(4), 429–38. doi:10.1016/j.amepre.2009.12.032

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909–22. doi:10.1016/j.puhe.2007.04.009

Vallance, J. K., Boyle, T., Courneya, K. S., & Lynch, B. M. (2014). Associations of objectively assessed physical activity and sedentary time with health-related quality of life among colon cancer survivors. *Cancer*, *120*(18), 2919–26. doi:10.1002/cncr.28779

Van Uffelen, J. G. Z., Wong, J., Chau, J. Y., van der Ploeg, H. P., Riphagen, I., Gilson, N. D., … Brown, W. J. (2010). Occupational sitting and health risks: a systematic review. *American Journal of Preventive Medicine*, *39*(4), 379–388. doi:10.1016/j.amepre.2010.05.024

Warburton, D. E. R., Nicol, C. W., & Bredin, S. S. D. (2006a). Health benefits of physical activity: the evidence. *Canadian Medical Association Journal*, *174*(6), 801–809. doi:10.1503/cmaj.051351

Warburton, D. E. R., Nicol, C. W., & Bredin, S. S. D. (2006b). Prescribing exercise as preventive therapy. *Canadian Medical Association Journal*, *174*(7), 961–974.

Ward, W., Hahn, E., Mo, F., Hernandez, L., Tulsky, D. S., & Cella, D. (1999). Reliability and validity of the Functional Assessment of Cancer Therapy-Colorectal (FACT-C) quality of life instrument. *Quality of Life Research*, *8*(3), 181–195.

Warren, T., Barry, V., Hooker, S., Sui, X., Church, T. S., & Blair, S. N. (2010). Sedentary behaviors increase risk of cardiovascular disease mortality in men. *Medicine and Science in Sports and Exercise*, *42*(5), 879–885. doi:10.1249/MSS.0b013e3181c3aa7e.Sedentary

Watson, A. J. M., & Collins, P. D. (2011). Colon cancer: a civilization disorder. *Digestive Diseases (Basel, Switzerland)*, *29*(2), 222–8. doi:10.1159/000323926

Webber, S., & Porter, M. (2009). Monitoring mobility in older adults using global positioning system (GPS) watches and accelerometers: a feasibility study. *Journal of Aging and Physical Activity*, *17*, 455–467.

Westerterp, K. R., & Meijer, E. P. (2001). Physical activity and parameters of aging: a physiological perspective. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *56 Spec No*(Ii), 7–12.

Windle, G., Hughes, D., Linck, P., Russell, I., & Woods, B. (2010). Is exercise effective in promoting mental well-being in older age? A systematic review. *Aging & Mental Health*, *14*(6), 652–69. doi:10.1080/13607861003713232

Yates, T., Wilmot, E. G., Davies, M. J., Gorely, T., Edwardson, C., Biddle, S., & Khunti, K. (2011). Sedentary behavior: what's in a definition? *American Journal of Preventive Medicine*, *40*(6), e33–4; author reply e34. doi:10.1016/j.amepre.2011.02.017

Yoo, H. J., Kim, J. C., Eremenco, S., & Han, O. S. (2005). Quality of life in colorectal cancer patients with colectomy and the validation of the Functional Assessment of Cancer Therapy-Colorectal (FACT-C), Version 4. *Journal of Pain and Symptom Management*, *30*(1), 24–32. doi:10.1016/j.jpainsymman.2004.12.009

APPENDIX A: QUESTIONNAIRE

Thank you for agreeing to participate in this research study. The first part of the survey is needed to help us understand more about you. For this reason, it is very important information. All of the information is held in strict trust and your name will **NOT** appear on any public documents. Please answer the following questions based on your **present status**. For further information or if you have any questions about completing the questionnaire, please contact Logan Lawrence (Principal Investigator) by e-mail at logan.lawrence@dal.ca or phone at (902) 266-8978.

MEDICAL INFORMATION

If you have had more than one cancer diagnosis, based on your most recent **COLORECTAL CANCER DIAGNOSIS**, please answer the following questions:

1. What type of colorectal cancer diagnosis was/is it? (check all that apply):

   ☐ colon ☐ rectal ☐ other (specify): ______________________

2. In what month and year were you diagnosed? ______________________

3. What stage of Colorectal cancer were you diagnosed with? (please mark)

   ☐ Stage 1 ☐ Stage 2 ☐ Stage 3 ☐ Stage 4 ☐ Do not know

4. What grade of Colorectal cancer were you diagnosed with? (please mark)

   ☐ Grade 1 ☐ Grade 2 ☐ Grade 3 ☐ Grade 4 ☐ Do not know

5. Are you currently being treated for this cancer? ☐ Yes ☐ No

   5b. If **No**, when was the month and year of your last treatment? ____________

6. What type(s) of treatment(s) have you received? (please check <u>ALL</u> that apply)

   ☐ Chemotherapy ☐ Radiation therapy ☐Surgery

   ☐ Other (specify): ______________________________

7. Have you / had you experienced this cancer before? ☐ Yes ☐ No

   7b. If **<u>Yes</u>**, please specify type of recurrence, and month/year of recurrence:

   ____

   7c. If **<u>Yes,</u>** What type of treatment did you receive? (please check <u>ALL</u> that apply)

   ☐ Chemotherapy ☐ Radiation therapy ☐Surgery

   ☐ Other (specify): ______________________________

<u>Your Health and Well-Being</u>

This survey asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities. ***Thank you for completing this survey!***

For each of the following questions, please mark an ☒ in the one box that best describes your answer.

1. In general, would you say your health is:

Excellent	Very good	Good	Fair	Poor
▼	▼	▼	▼	▼
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

2. <u>Compared to one year ago</u>, how would you rate your health in general <u>now</u>?

Much better now than one year ago	Somewhat better now than one year ago	About the same as one year ago	Somewhat worse than one year ago	Much worse now than one year ago
▼	▼	▼	▼	▼
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

3. The following questions are about activities you might do during a typical day. Does <u>your health now limit you</u> in these activities? If so, how much?

	Yes, limited a lot	Yes, limited a little	No, not limited at all
a Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	☐ 1	☐ 2	☐ 3
b Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	☐ 1	☐ 2	☐ 3
c Lifting or carrying groceries	☐ 1	☐ 2	☐ 3
d Climbing several flights of stairs	☐ 1	☐ 2	☐ 3
e Climbing one flight of stairs	☐ 1	☐ 2	☐ 3
f Bending, kneeling, or stooping	☐ 1	☐ 2	☐ 3
g Walking more than a kilometre	☐ 1	☐ 2	☐ 3
h Walking several hundred metres	☐ 1	☐ 2	☐ 3
i Walking one hundred metres	☐ 1	☐ 2	☐ 3
j Bathing or dressing yourself	☐ 1	☐ 2	☐ 3

4. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Cut down on the amount of time you spent on work or other activities	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b Accomplished less than you would like	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c Were limited in the kind of work or other activities	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d Had difficulty performing the work or other activities (for example, it took extra effort)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

5. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Cut down on the amount of time you spent on work or other activities	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b Accomplished less than you would like	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c Did work or other activities less carefully than usual	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?

Not at all	Slightly	Moderately	Quite a bit	Extremely
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

7. How much bodily pain have you had during the past 4 weeks?

None	Very mild	Mild	Moderate	Severe	Very severe
▼	▼	▼	▼	▼	▼
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all	A little bit	Moderately	Quite a bit	Extremely
▼	▼	▼	▼	▼
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

9. These questions are about how you feel and how things have been with you <u>during the past 4 weeks</u>. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the <u>past 4 weeks</u>…

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Did you feel full of life?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b Have you been very nervous?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c Have you felt so down in the dumps that nothing could cheer you up?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d Have you felt calm and peaceful?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
e Did you have a lot of energy?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
f Have you felt downhearted and depressed?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
g Did you feel worn out?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
h Have you been happy?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
i Did you feel tired?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

10. During the <u>past 4 weeks</u>, how much of the time has your <u>physical health or emotional problems</u> interfered with your social activities (like visiting with friends, relatives, etc.)?

All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

11. How TRUE or FALSE is <u>each</u> of the following statements for you?

	Definitely true	Mostly true	Don't know	Mostly false	Definitely false
a I seem to get sick a little easier than other people	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b I am as healthy as anybody I know	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c I expect my health to get worse	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d My health is excellent	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Thank you for completing these questions!

Functional Assessment for Cancer Therapy

Below is a list of statements that other people with your illness have said are important.

	PHYSICAL WELL-BEING	Not at all	A little bit	Some -what	Quite a bit	Very much
GP1	I have a lack of energy	0	1	2	3	4
GP2	I have nausea	0	1	2	3	4
GP3	Because of my physical condition, I have trouble meeting the needs of my family	0	1	2	3	4
GP4	I have pain	0	1	2	3	4
GP5	I am bothered by side effects of treatment	0	1	2	3	4
GP6	I feel ill	0	1	2	3	4
GP7	I am forced to spend time in bed	0	1	2	3	4

	SOCIAL/FAMILY WELL-BEING	Not at all	A little bit	Some -what	Quite a bit	Very much
GS1	I feel close to my friends	0	1	2	3	4
GS2	I get emotional support from my family	0	1	2	3	4
GS3	I get support from my friends	0	1	2	3	4
GS4	My family has accepted my illness	0	1	2	3	4
GS5	I am satisfied with family communication about my illness	0	1	2	3	4
GS6	I feel close to my partner (or the person who is my main support)	0	1	2	3	4
Q1	*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.*					
GS7	I am satisfied with my sex life	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.

FACT-C 2

	EMOTIONAL WELL-BEING	Not at all	A little bit	Some -what	Quite a bit	Very much
GE1	I feel sad	0	1	2	3	4
GE2	I am satisfied with how I am coping with my illness	0	1	2	3	4
GE3	I am losing hope in the fight against my illness	0	1	2	3	4
GE4	I feel nervous	0	1	2	3	4
GE5	I worry about dying	0	1	2	3	4
GE6	I worry that my condition will get worse	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.

	FUNCTIONAL WELL-BEING	Not at all	A little bit	Some -what	Quite a bit	Very much
GF1	I am able to work (include work at home)	0	1	2	3	4
GF2	My work (include work at home) is fulfilling	0	1	2	3	4
GF3	I am able to enjoy life	0	1	2	3	4
GF4	I have accepted my illness	0	1	2	3	4
GF5	I am sleeping well	0	1	2	3	4
GF6	I am enjoying the things I usually do for fun	0	1	2	3	4
GF7	I am content with the quality of my life right now	0	1	2	3	4

FACT-C 3

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

	ADDITIONAL CONCERNS	Not at all	A little bit	Some -what	Quite a bit	Very much
C1	I have swelling or cramps in my stomach area	0	1	2	3	4
C2	I am losing weight	0	1	2	3	4
C3	I have control of my bowels	0	1	2	3	4
C4	I can digest my food well	0	1	2	3	4
C5	I have diarrhea (diarrhoea)	0	1	2	3	4
C6	I have a good appetite	0	1	2	3	4
C7	I like the appearance of my body	0	1	2	3	4
Q2	Do you have an ostomy appliance? (Mark one box)	☐ No		or	☐ Yes	
	If yes, please answer the next two items:					
C8	I am embarrassed by my ostomy appliance	0	1	2	3	4
C9	Caring for my ostomy appliance is difficult	0	1	2	3	4

DEMOGRAPHIC INFORMATION

1. Please indicate your age: ______________

2. How would you describe your gender: ☐ Male ☐ Female ☐ Other: ________

3. Please provide your height and weight (circle unit): _____ cm / in _____ kg / lbs

4. How would you describe yourself: (please check **one**)

☐ Aboriginal	☐ Japanese
☐ Arab/West Asian	☐ Korean
☐ Black	☐ Latin America
☐ Caucasian	☐ South Asian
☐ Chinese	☐ Southeast Asian
☐ Filipino	☐ Other: __________________

☐ Some high school	☐ Completed high school	☐ Some technical school
☐ Some university/college	☐ Completed technical school	☐ Completed university/college
☐ Some graduate school	☐ Completed graduate school	

5.Please indicate the highest level of education that you have completed: (check **one**)

6. Please indicate your current level of household income: (please check one)

- ☐ Less than $19,999
- ☐ $20,000-$39,999
- ☐ $40,000-69,999
- ☐ $70,000 or more
- ☐ Do not wish to say

7. What is your current employment status? Please choose the **one** that best describes your current situation. If you are self-employed, choose full-time or part-time as appropriate.

- ☐ Working in paid job full-time (30 or more hours per week)
- ☐ Working in a paid job part-time (Less than 30 hours per week)
- ☐ Unemployed
- ☐ Unable to work because of sickness or disability

- ☐ Looking after home and/or family
- ☐ Student
- ☐ Retired
- ☐ Doing unpaid or voluntary work
- ☐ On sick leave but expecting to return to work

8. Please indicate your current relationship status: (please check **one**)

☐ Single/never married ☐ Married/common law/living with partner
☐ Divorced/separated ☐ Widowed

9. What is your typical mode of transportation?

☐ Walk ☐ Bike ☐ Public Transit ☐ Car ☐ Other:

9. b) How do you typically get to work?

☐ N/A ☐ Walk ☐ Bike ☐ Public Transit ☐ Car ☐ Other:

9. c) Do you have regular access to a vehicle? ☐ Yes ☐ No

10. Do you have exercise equipment at home? ☐ Yes ☐ No
(e.g. Bowflex, weights, exercise bike)

10. b) If **Yes,** how often do you use your equipment every week?

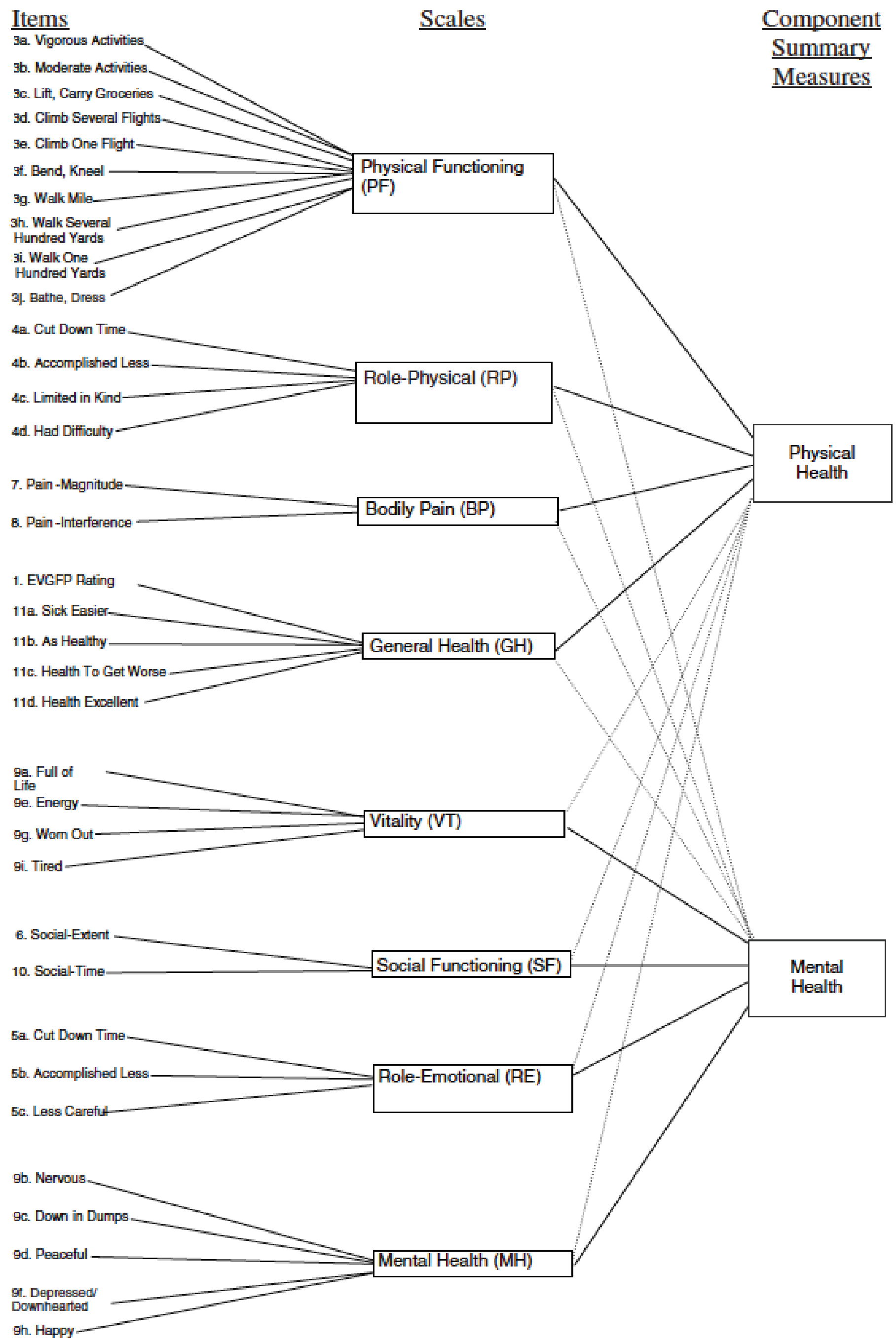
☐ 0 times/week ☐ 1-2 ☐ 3-4 ☐ 5+

11. Do you typically use any kind of assistive walking device? ☐ Yes ☐ No
(e.g. cane, walker)

12. Please indicate any health problems (other than cancer) that you have:

☐ Heart disease ☐ Diabetes ☐ Arthritis
☐ Osteoporosis ☐ Kidney/liver disease ☐ Depression
☐ High blood pressure ☐ Other: ______________

APPENDIX B: SF36 CONSTRUCTION AND SCORING



Note. All health domain scales contribute to the scoring of both the Physical and Mental Component Summary measures. Scales contributing most to scoring of the summary measures are indicated by a connecting solid line (—). Scales contributing to the scoring of the summary measures to a lesser degree are indicated by a dotted line (……).

Figure 1A. A diagram of how the SF36 PCS and MCS component scores are constructed. Adapted from Ware et al. SF-36v2 ® Health Survey: Administrative guide for clinical trial investigators. Lincoln, RI: QualityMetric Incorporated; 2008, p. 4.

APPENDIX C: EXAMPLES OF DIFFERENT CUT POINTS FROM THE LITERATURE

Activity Intensity (counts/min)	Matthew[A] (2005)	Freedson[B,C] Adult (1998)	Freedson[D] Adult VM3 (2011)	Troiano[E] (2008)	Esliger & Copeland[F] (2009)*	Colley[G] (2011)	Hall[H] (2013)*	Hendelman[C] (2000)	Swartz[C] (2000)
Sedentary	< 260	<100		<100	<50[A]	<100			
Mild/Light	261-759	100-759	<2690	100-2019	51-1040	101-1535		<190.7	<573
'Lifestyle'		760-1951					<809		
Moderate	760-5924	1952-5724	2690-6166	2020-5998	1041+	1535-3961	810+	190.7–7525.7	574–4944
Hard/Vigorous	>5925	5725-9498	6167-9642	5999+		3962+		7525.8–14860.5	4945–9318
Very Hard/Vigorous		9499+	9643+					14860.6+	9317+

Note. An asterisk ("*") denotes that the measure was designed specifically for older adults.
[A]Parker SJ, Strath SJ, Swartz AM. Physical activity measurement in older adults: relationships with mental health. J Aging Phys Act 2008;16:369–80. [B]Freedson, PS; Melanson, E; Sirard, J; Calibration of the Computer Science and Applications, Inc. Accelerometer (1997, Medicine & Science in Sports Exercise. [C]Ainsworth BE, Bassett DR, Strath SJ, Swartz AM, O'Brien WL, Thompson RW, et al. Comparison of three methods for measuring the time spent in physical activity. Medicine and Science in Sports and Exercise. 2000 Sep;32(9 Suppl):S457–64. [D]Sasaki, JE; John, D; Freedson, PS. Validation and Comparison of ActiGraph Activity Monitors. [E]Troiano, RP; Berrigan, D; Dodd, KW; Masse, LC; Tilert, T; McDowell, M; Physical Activity in the United States Measured by Accelerometer. Medicine & Science in Sports & Exercise, August, 2007. [F]Gardiner PA, Eakin EG, Healy GN, Owen N. Feasibility of reducing older adults' sedentary time. American journal of preventive medicine. Elsevier Inc.; 2011 Aug;41(2):174–7. Authors note lack of consensus for 'sedentary' cut point. [G]Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. Health Reports. 2011 Mar;22(1):1–8. [H]Hall KS, Howe CA, Rana SR, Martin CL, Morey MC. METs and Accelerometry of Walking in Older Adults: Standard versus Measured Energy Cost. Medicine and science in sports and exercise. 2013 Mar;45(3):574–82.

APPENDIX D: COMPARISON OF TESTING PARAMETERS IN CREATION OF ACTIVITY INTENSITY CUT POINTS

Reference	Age Range	Stage One Speed	Stage Two Speed	Stage Three Speed	Moderate intensity walking speed	Mean counts per minute at a VO_2 of 13 ml/kg/min	METs considered moderate activity
Esliger & Copeland, 2009	64-77	2.4 km/h	3.6 km/h	4.8 km/h	3.2 km/h	1041	3.7
Freedson et al., 1998	18-30[A]	4.8 km/h	6.4 km/h	9.7 km/h	Not stated	3003	3.0

Note. Cut points were extrapolated from data of oxygen consumption (VO_2) at three treadmill stages. A MET is a common unit of energy expenditure, where 1 MET is equal to 3.5 milliliter of oxygen per kilogram of body weight per minute. 3 METs is commonly used to define moderate-to-vigorous intensity physical activity.

Km/h, Kilometers per hour; METs, Metabolic Equivalent of a Task; VO_2; Volume of Oxygen consumed

[A]Sample age range is approximated as only mean and SD of groups was provided.

APPENDIX E: PERMISSION TO REPRODUCE DATA

From: **Jason Bredle** jbredle@facit.org
Subject: RE: Copyright permission for FACT-C (Ward et al., 1999)
Date: October 30, 2014 at 12:51 PM
To: Logan Lawrence loganlawren@gmail.com

Hi Logan,

Sure, that's fine. You have our permission. Do you need a specific document saying this or does email suffice?

Kind regards,
Jason

Jason Bredle
Manager, Business Operations
jbredle@facit.org
+1-773-807-9094

FACIT .org • FACIT trans

PROVIDING A VOICE FOR PATIENTS WORLDWIDE
www.facit.org

From: Logan Lawrence [mailto:loganlawren@gmail.com]
Sent: Wednesday, October 29, 2014 4:24 PM
To: Information
Subject: Copyright permission for FACT-C (Ward et al., 1999)

I am completing my masters thesis and wanted to include FACT-C values from a past publication ("Reliability and validity of the Functional Assessment of Cancer Therapy-Colorectal (FACT-C) quality of life instrument", Ward et al., 1999) to compare with the results from my research. APA formatting requires that I have a copyright release to reproduce this information; can you please direct as to how I can receive this permission?

Kind regards,

Logan Lawrence, MSc Kin (c)
Dalhousie University, Halifax
loganlawren@gmail.com

Hello Logan,

Yes, of course, I would be happy to have you reprint these values. I believe that I can speak for all of the authors – hopefully you don't need to email each one of them as it is quite a large team. Do you need a separate email (e.g. more formal) or is this sufficient?

Wilma

Wilma M. Hopman, BAH, MA
Research Methodologist, Clinical Research Centre, Kingston General Hospital
Faculty, Department of Public Health Sciences, Faculty of Medicine, Queen's University
Empire 2, Room 3-235
76 Stuart Street, Kingston, Ontario
K7L 2V7

Phone 613 549 6666, ext. 4941
Fax 613 548 6042
Email hopmanw@kgh.kari.net

From: Logan Lawrence [mailto:loganlawren@gmail.com]
Sent: November-17-14 2:52 PM
To: Hopman, Wilma M
Subject: Permission to reprint SF36 norms

Good afternoon Ms. Hopman,

I am using the SF36 for my masters research on physical activity and colorectal cancer survivors, and was hoping to reprint some age-specific values in my thesis to compare my sample to the Canadian normative data you published in 2000. (Particularly, the mean and SD of the sub scales and component summary scores for the 65-74 age range).
In order to reprint these values in my thesis, Dalhousie University requires that I have the permission of the authors of the original material in addition to properly referencing the material. Please let me know if you would be okay with me reprinting these values (a simple email will suffice).

Please do not hesitate to contact me if you have any questions - I can be reached at (902) 266-8978.

Kind regards,

Logan Lawrence, MSc Kin (c)
Dalhousie University, Halifax
logan.lawrence@dal.ca