Comprehensive Evaluation of Physical Activity and Physical Function for Canadian Aging Adults: A Cross-sectional Study

by

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Abstract

Background: Most physical activity (PA) recommendations exclude light and sedentary activities that have the potential to influence physical function for aging adults.

Purpose: 1) to test the association between a comprehensive approach to evaluate PA, and physical function, and 2) The second objective of this study was to evaluate how adults age 45-85 years old are report activities over a full week when using a questionnaire .

Methods: A total of 25,072 adults (aged 45-85) from the baseline data of the Canadian Longitudinal Study on Aging were included in this cross-sectional study. PA was self-reported via the Physical Activity Scale for the Elderly (PASE) and was used to make three comprehensive indexes based on MET-min per week: 1) Total Index (All Activities Performed), 2) RT Index (Aerobic/Resistance Exercises), and 3) SED Index (Sedentary/Activity Time). The physical function score was derived from five objective tests related to strength, agility, speed, balance, and power, using factor analysis. Logistic regression models were used, determined on the median by age group and sex, to determine the association between the comprehensive approach to evaluate PA and physical function.

Results: After adjusting for confounders, all three indexes were associated with the physical function score. When further adjusting for meeting the current PA guideline, the Total and the SED indexes remained significant [Total Index: OR =1.02, CI = (1.01-1.03), SED: OR = 0.94, CI = (0.92-0.97)]. Less than 1% of the sample was reporting between 24 ± 2 hours per day of any activities. In addition, 58% of the sample was overestimating the average intensity of their activities over 24 hours.

Conclusion: First, our results suggest that the combination of activities in the current guidelines and activities beyond the current recommendations should be considered important as they are associated with physical function of aging adults. Second, using the PASE, aging adults generally underestimate the total time spent performing activities but overestimate the intensity of the reported activities.

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Chapter 1: Introduction

Currently, Canada's fastest growing age group is people 65 years and older, and many of these people have complex conditions leading to a loss of independence. Many factors play a role in an aging adult's loss of independence; however, declines in physical function are a major contributor. Physical function can be defined as the ability to perform activities of living expected for one's age. A decline in physical function is often associated with increased caregiver burden, high resource needs, and premature death. Contrarily, preventing physical function decline, or alternatively, improving physical function for aging adults is associated with a reduced rate of hospitalization in terms of frequency and duration. This reduces the need for direct and indirect resources and cost. As one ages, there is a natural decline in physical function; fortunately, physical function can be improved or maintained by being physically active.

In Canada, as with most countries as well as the World Health Organization, there are physical activity guidelines for all age groups related to important health or functional outcomes. Specific to older Canadians, the suggested physical activity recommendation is a minimum of 150 minutes of aerobic activities spent at moderate-to-vigorous physical activity a week, in at least 10 min bouts, with at least two days of resistance training in addition to balance exercises if needed. Following this guideline would promote greater physical function. Currently, in Canada 87% of older adults are not reaching the guideline for aerobic activity when measured objectively, and the proportion meeting the guideline for the resistance training is unknown.

Measuring physical activity via questionnaires has been reported as a limitation in past literature. By having access to a large proportion of the Canadian population, it is possible to evaluate the validity of questionnaire that is often used by the scientific community and clinicians in regard to reported time and intensity. In addition, the maximum average intensity reported by elite older adults can be examined.

The first objective of this study was to evaluate how accurately aging adults are reporting activities over 24 hours using a valid questionnaire for older adults: The Physical Activity Scale for the Elderly (PASE) questionnaire. The current guidelines do not acknowledge the potential impact of low intensity activities that are performed regularly, such as house chores, or the influence of one type of activity compared to another. In addition, the current guidelines do not quantify the impact of accumulating sedentary behavior, such as sitting or lying down, on physical function in aging adults. Alternatively, a comprehensive approach for the guidelines would account for all the movements a person performs in a day, regardless of the intensity. As well, a comprehensive approach would take into account the knowledge that combining activities of different intensities, for varying lengths of time, may actually counteract the positive impacts on physical function (e.g., performing exercise but sitting all day). This approach is now recommended for children and accounts for screen time and potential health outcomes.

The second objective of this study was to test the association between a comprehensive approach to physical activity, including all intensities and forms of activities over a week, and physical function, a crucial outcome to remain independent.

Chapter 2: Literature Review

The average age of the Canadian population is increasing rapidly (Public Health Agency of Canada, 2014) and this is mainly due to the aging baby boomers (people born between 1946 and 1965), who are now aged 65 and above (Government of Canada, 2014b). More specifically, the number of older adults aged 65 years and over increased by 14.1% between 2006 and 2011, reaching nearly five million people (Statistics Canada, 2011b). With the population rapidly aging, it is becoming increasingly important to work towards maintaining their independence in order to increase quality of life (Borowiak & Kostka, 2004; Mitchell & Kemp, 2000), prevent increases of health care cost (Statistics Canada, 2011a), and decrease the high demand for nursing home admissions (Government of Canada, 2012). However, the reality is that approximately 80% Canadian older adults report having one or more chronic conditions (Canadian Institute for Health Information, 2011), and many of those lead to a loss of independence (Wolff, Starfield, & Anderson, 2002).

The current world life expectancy rate is increasing compared to previous generations (World Health Statistics, 2014). With longer lifespans, many older adults are struggling to maintain their physical function, which is defined as the ability to do daily activities that are required to remain independent; for example, climbing stairs or getting in and out of bed (Paterson & Warburton, 2010). These trends are concerning because of the limited capacity of nursing home facilities, and these trends impact the entire nation through healthcare cost (Paterson & Warburton, 2010). For example, the Conference Board of Canada has estimated that by 2026 there will be 2.4 million Canadians, 65 years and older, in need of continuous care, both paid and unpaid – a 71% increase since 2011 (The Conference Board of Canada, 2015). Therefore, it is important to develop strategies to help older adults remain independent for as long as possible. One strategy is exercise, which been shown to enhance overall health, and more specifically, physical function (Brach, FitzGerald, Newman, Kelsey, Kuller, VanSwearingen, & Kriska., 2003; Booth, Roberts, & Laye, 2012).

2.1 Benefits of Physical Activity

As defined by the World Health Organization, physical activity is any bodily movement produced by skeletal muscle that requires energy expenditure above resting value; simply put, any movement outside of sedentary behaviors and sleep is considered physical activity. The term 'exercise' is any movement that is structured, planned, and goal-orientated; therefore, exercise is a form of physical activity. It is well-known that physical activity can help improve many risk factors related to chronic conditions and mortality in several wellness dimensions across all ages: physical, psychological, and social (McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003; McAuley, Elavsky, Jerome, Konopack, & Marquez, 2005). Specific to the older population, physical activity can help protect against the development and progression of many disabling conditions; in fact, physical activity has been identified as being the primary prevention against 35 health conditions (Booth, Roberts, & Laye., 2012). Thus, clinical practice guidelines highlight the importance of physical activity when managing these conditions (Lau, Douketis, Morrison, Hramiak, Sharma, Ur, & Panel., 2007) across the adult lifespan (Paterson & Warburton, 2010). The physical benefits of physical activity in aging adults are substantial and vast, however, there several other areas that physical activity positively impacts.

2.2 Measuring Aerobic Physical Activity

There are several ways to measure the amount of aerobic activities; all with associated pros and cons. An objective measure is an impartial measurement that has minimal bias, as the score obtained is not subjected to an opinion or interpretation of the results. The most popular objective measures for aerobic physical activity are pedometers, accelerometers, and heart rate monitors. The benefits of using these measurement tools include the improved accuracy of the results (Kowalaki, Rhodes, Naylor, Tuokko, & MacDonald, 2012) and some of these devices allow for live feedback to the user. However, objective measures can be more expensive, and it can be more difficult to collect data for large populations. Contrarily, a subjective measure is influenced by personal judgement, and therefore, opened to interpretation or opinion. This form of testing is known to decrease the validity and reliability of the measure compared to a gold standard measure (Kriska & Capersen, 1997; Boisvert, Washburn, Montoye, & Leger, 1988; Laporte, Montoye, & Caspersen, 1985; Paffenbarger, Blair, Lee, & Hyde, 1993). A subjective measure is usually in the form of a questionnaire. Self-reported physical activity is one of the most popular forms of collecting information on physical activity obtained in large samples (Prince, Adamo, Hamel, Hardt, Gorber, & Tremblay, 2008). The benefits of using subjective measures are they are easy to administrate and they have low costs (Prince et al., 2008).

2.2.1 Objective measures

The gold standard method of physical activity data collection is the use of doubly labeled water. The doubly labeled water process involves partially or completely replacing the hydrogen and oxygen that make up water with an uncommon isotope for tracing purposes. This method is used to validate all other field tools aiming to quantify aerobic activities. However, this measure is not used often due to cost and practicality. A study performed by Corbett et al. evaluated the metabolic cost of daily activities in community dwelling adults across their lifespan. This cross-sectional study assessed the metabolic cost of daily living for 250 community dwelling adults across their lifespan with the use of a portable indirect calorimeter. With the data collected, researchers determined age-related differences in the metabolic costs for common lifestyle and exercise activities; and with these results, changes were made to improve the effectiveness by which physical activity is recommended for adults across the lifespan (Corbett, Wanigatunga, Valiani, Handberg, Buford, Brumback, & Manini., 2017).

Other objective measures for aerobic physical activity involve tools that estimate the quantity of movement performed at different intensities with the use of algorithms that take into considerations age and sex, as examples. The main benefit of these devices is the portability. These devices are further categorized as lab-based devices (e.g., accelerometer, pedometers) and commercial devices (e.g., Fitbit, cell phone apps). Although these commercial tools may motivate individuals to engage in physical activity, there has been little investigation into their validity and reliability (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014; Patel, Asch, & Volpp, 2015; Powell, Landman, & Bates, 2014).

Objective measures have their own individual disadvantages. For example, most tools cannot be used in water. In addition, most devices cannot to track physical activity such as cycling (Wilocx & Ainsworth, 2009; Dale & Welk, 2002). As well, pedometers are limited in monitoring acceleration and deceleration of movement in a vertical plane (Kowalski, Rhodes, Naylor, Tuokko, & MacDonald, 2012). Literature that has used these devices for data collection with an older population have shown mixed reviews. For example, a study performed by Cyarto et al. (2003) studied the accuracy of pedometers used by older adults in nursing homes with walking speed and gait disorders compared to community-dwelling older adults. The results of this study show that slow walking speeds and gait disorders decrease the effectiveness of pedometers measuring physical activity performed by frail older adults; however, they can be confidently used with older adults who have more mobility (Cyarto, Myers, & Tudor-Locke, 2003). In addition, a study by Resnick et al. (2001) tested the reliability and validity of a pedometer model called the Step Activity Monitor with older adults. The pedometer showed an overall step counting accuracy of 96% and concluded that the pedometer was easy to use, comfortable, and a valid and reliable measure of activity for older adults (Resnick, Nahm, Orwig, Zimmerman, & Magaziner, 2001). A study performed by Copeland et al. (2009) investigated the accelerometer cut-off point by tracking the physical activity of 38 healthy older adults with an average age of 70 years. Their findings revealed that accelerometers provide information about older adults' activity patterns and can be used to further understand the relationship between physical activity and healthy aging (Copeland & Esliger, 2009). Also, a study performed by Storti et al. (2007) supports the accuracy of an accelerometer as tool to measure physical activity. In this study, 34 community older adults, having an average age of 79.2 years, were tested at various gait speeds to investigate the accuracy of three accelerometers. The results show that all three accelerometers perform well at moderate and high walking speeds, but are less accurate at a slower walking pace (Storti, Pettee, Brach, Talkowski, Richardson, & Kriska., 2008). From the literature, the tools that were mentioned deem to be accurate forms of measuring physical activity; however, there are still limitations with these objective measures.

Heart rate monitors are also used as objective measurement tools for physical activity. Heart rate monitors record an individual's heart rate each minute, which gives detailed information on the frequency, the intensity, and the duration of physical activity (Schutz, Weinsier, & Hunter, 2001). Heart rate monitors have been used in both clinical and research settings to estimate energy expenditure during physical activity; this assumes a linear relationship between heart rate and oxygen consumption (Hills, Mokhtar, & Byma, 2014). Some of the advantages of this device are the ability to quantify the intensity of the physical activity, the capability to continuously estimate energy expenditure, and the device provides immediate feedback to the user (Hills, Mokhtar, & Byma, 2014). Heart rate monitoring is easy, quick, and it can be used in a laboratory setting or in free-living; however, many users report discomfort if worn over a long period.

Objective measures are valuable as they have been shown to be reliable and valid. There are several choices on which tool to use based on accuracy level, cost, or training. However, this form of testing can be extensive and may not be feasible for community or clinical settings (e.g., equipment, testing personnel). In this case, subjective measures may be more practical to use than objective measures.

2.2.2 Subjective measures

Questionnaires are a widely-used method in obtaining physical activity data in population studies, and this is mainly due to their easy administration at a low cost (Boisvert, Washburn, Montoye, & Leger, 1988; Kriska & Capersen, 1997; Laporte, Montoye, & Caspersen, 1985; Montoye, Kempers, Saris, & Washburn, 1996; Paffenbarger, Blair, Lee, & Hyde, 1993). There are many available questionnaires that measure physical activity, some of which have been tested for validity and reproducibility (Montoye, Kempers, Saris, & Washburn, 1996; Vuillemin, Denis, Guillemin, & Jeadnel, 1998). The goal is to select a questionnaire that was designed, and validated, specifically for the population of interest. For example, the Modifiable Activity Questionnaire assesses physical activity over a 12-month span during both work and leisure time. The validation and reliability for this questionnaire have been published (Helmerhorst, Brage, Warren, Besson, & Ekelund, 2012; Schulz, Harper, Smith, Kriska, & Ravussin, 1994). Questionnaires that seek to obtain physical activity data for participants can be useful for research, however, they may not be as accurate as objective measures (Helmerhorst et al., 2012). This may be due to the fact that questionnaires depend on the perception, encoding, storage, and retrieval of information about previous activity; answers depend on the participants' age and the context of the questioning (Baranowski, 1988; Durante & Ainsworth, 1996). The limitation of the human memory is a crucial component of an accurate questionnaire, and this may become a problem with an aging population as their ability to recall memories can decrease.

A study performed by Bonnefoy et al. (2001) compared 10 physical activity questionnaires to doubly labelled water measurements in a population of healthy elderly men. Of the 10 questionnaires, only three showed a reasonable degree of reliability (r= 0.54, 0.52, 0.54) and could be used to rank healthy older men and their physical activity. Bonnefoy concluded by stating that individual variability was high for all the questionnaires, suggesting that their use as a measure of individual energy expenditure may be limited (Bonnefoy, Normand, Pachiaudi, Lacour, Laville, & Kostka., 2001). Specific for older adults, an example of an accurate questionnaire used in the literature is the Physical Activity Scale of Elderly (PASE) questionnaire. The PASE is an easily scored, brief questionnaire for elderly individuals, and it is suitable for use in large epidemiological studies. For example, a study by Schuit et al. (1997) assessed the validity of the PASE questionnaire by comparing it to the estimated energy expenditure values obtained by the doubly labelled water method for 21 older men and women, aged 60 to 90 years old. It was found that the PASE questionnaire is a reasonably valid method to classify healthy men and women into physical activity categories with a correlation coefficient of 0.58 (Schuit, Schouten, Westerterp, & Saris, 1997). To summarize, physical activity questionnaires show limited reliability and validity (Helmerhorst et al., 2012). Subjective measurements can indicate situations where an increase in physical activity would be beneficial and they can monitor changes in population activity; however, they are limited in the interpretations that can be drawn in terms of exercise dosages and the resulting health benefits (Shephard, 2003).

Physical activity can be subjectively measured by the 7-day recall of physical activity. The 7-day recall is when you ask participants to think back to the physical activity they performed over the past seven days in as much detail as possible. Richardson et al. (2001) researched the validity of the Stanford 7-Day Recall, a well-known instrument for physical activity in epidemiological studies. This article included 77 participants who had their 7-day recall compared with accelerometer data, peak oxygen uptake, and percent body fat. The findings of this study show that the ability of the 7-day recall to assess physical activity was greater for more vigorous intensities than lower intensities (Richardson, Ainsworth, Jacobs, & Leon, 2001). Another study by Sloane et al. (2009) looked at the 7-day recall call method and compared it to the accelerometer data for accuracy. The results from this study support Richardson's study, as Sloane found a moderate agreement between the 7-day physical activity recall and the accelerometer data. Although he concluded there are correlations between the two methods of testing, there is limited accuracy as the measures capture somewhat different dimensions of physical activity and provide different estimates of change over time (Sloane, Snyder, Demark-Wahnefried, Lobach, & Kraus, 2009).

A popular method to assess a person's physical activity level after receiving his/her answers from a questionnaire is to translate intensity (e.g. moderate) into metabolic equivalent units (METs), and then combine intensity and duration per week (MET-min per Week). In simple terms, METs represent the amount of energy spent doing an activity compared to resting values. For example, an activity equivalent to 4 METs (such as bicycling) is equivalent to four times the energy burned by an individual at rest. If a person does 4 METS of an activity for 20 minutes, he or she has completed 4 X 20 = 80 MET-Minutes of physical activity. A person could reach the guideline by achieving a minimum of 500 MET-min per week by biking 150 minutes at that intensity (150 X 4 METs= 600). This is a valuable way to qualify activity as the current guidelines for aerobic and resistance activity can be expressed as METs, where the goal is to reach a minimum of 500 MET-min per week (Kaminsky & Montoye, 2014). Quantifying physical activities as MET-min per week is ideal because all activities of daily living have an associated estimated metabolic cost (Ainsworth et al., 2011).

Subjective physical activity assessments are valuable due to their low administering expenses and their ability to test large populations. The drawback is this form of testing is less accurate than objective measures. A study with 56 older adults compared the validity of physical activity measures using double labelled water, a pedometer, an accelerometer, an armband, as well as the Yale Physical Activity Survey, the Community Health Activities Model Program for Seniors (CHAMPS), and the Physical Activity Scale for the Elderly (PASE). The main outcome was total energy expenditure. The results showed that objective devices were more accurate than questionnaires when estimating total energy expenditure, and concluded that, at minimum, a pedometer should be used to assess physical activity level (Colbert, Matthews, Havighurst, Kim, & Scholler, 2011).

2.3 Measuring Resistance Training

The primary measurement tool used in the literature to collect information about an individual's resistance training behaviour is a questionnaire. Questionnaires are usually formatted to ask questions regarding intensity, duration, and frequency of the training, much like aerobic exercise questionnaires. Currently, there is not much literature available about theses questionnaires and the assessment of resistance exercise behaviours. For example, resistance training tends to be a single question in a questionnaire normally asked as, "Over the past 7 days, how often did you do any exercises specially to increase muscle strength or endurance, such as lifting weights or push-ups, etc.?" Information on resistance exercise is likely to be shown in questionnaires in the form of circuit training, however, not much else (Shephard, 2003). This can become a challenge for individuals taking the questionnaire as it is difficult to quantify resistance exercises performed during normal daily activities; for example, quantifying wood loading at home as a strength building exercise.

The same principles for reliability, variability, and sensibility for physical activity questionnaires still apply to resistance training questions. As an example, classifying exercise intensity is often an issue when administering a questionnaire. High, moderate, and low resistance is not well understood by participants, which can result in wrongful classification (Shephard, 2003). For example, Yore et al. (2007) assessed the reliability and validity of the Behavioural Risk Factor Surveillance System data that includes physical activity questions regarding leisure time activities, household activities, transportation-related activities, as well as walking and strengthening activities. These questions assessed physical activity levels based on the recommendations from the Centre of Disease Control and Prevention, and the American College of Sports Medicine. However, within this questionnaire only one question pertained to muscle-strengthening activities. The standard for strengthening was defined as any muscle-strengthening activity performed two or more days a week. The results of this study show the reliability for resistance training measure was excellent and fair for tests on validity. However, more research is required to investigate resistance training performed in a less gym-orientated way, and have questionnaires that are more in depth to resistance type exercises (Yore, Ham, Ainsworth, Kruger, Reis, Kohl, & Macera., 2007). Despite the problems associated with questionnaires, there is value for testing resistance training behaviour this way. For example, questionnaires can show where increased physical activity would be beneficial, and they can monitor changes in a population's activity level.

2.4 Physical Function and Physical Activity

Physical activity, specifically in aging adults, is associated with better physical functioning that leads to improved independence. A loss of independence is associated with caregiver burden, high resource needs, and premature death (Covinsky, Palmer, Fortinsky, Counsell, Stewart, Kresevic, & Landefeld., 2003). Being and remaining functional is critical for the health and well-being of older adults because declines in function are associated with social isolation and decreases in other health indicators such as strength, continence, mental health and cognitive function (Canadian Institute for Health Information, 2013). Last, but not least, many older adults consider the ability to carry out daily activities as an important priority (Paterson, Govindasamy, Vidmar, Cunningham, &

Koval., 2004; Warburton, Glendhill, and Quinney, 2001). Physical function declines with aging partly because of a reduction in muscle mass, which in turn causes a decrease in muscle strength and quality of life. For example, in a systematic review conducted by Paterson and Warburton (2010) that included 34 prospective cohort studies, they found that adhering to the Canadian Physical Activity Guidelines predicted greater physical function and about a 30% decrease in the relative risk of morbidity, mortality, as well loss of independence (Paterson & Warburton, 2010). Similarly, one study emphasized that doing physical activity at moderate intensity would be the ideal intensity to prevent functional limitations and disability (Paterson & Warburton, 2010). Another study by Wannamethee et al. (2005) stated that maintaining and adopting a healthy lifestyle in a population of individuals aged 40 years and above reduces the onset of mobility limitations in old age; in addition, staying physically activity may improve recovery (Wannamethee, Ebrahim, Papacosta, & Shaper, 2005).

Common factors affecting decreased physical function are diseases, lifestyles, and other physiological alterations that occur with aging (Fielding, Vellas, Evans, Bhasin, Morley, Newman, & Zamboni, 2011). Approximately half of the disabilities experienced by aging adults develop chronically and progressively due to underlying disease, comorbidity, and frailty. The other disabilities develop due to an acute, and often catastrophic, event such as a hip fracture or stroke (Ferrucci, Guralnik, Simonsick, Salive, Corti, & Langlios, 1996). Such outcomes can directly affect performance in activities of daily living (Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995) and increase the risk of future loss of independence (Gill, Robison, & Tinetti, 1998). Based on literature, regular exercise is a cornerstone method for improving or maintaining physical function in aging adults (Manini & Pahor, 2009).

The decrease in muscle size and muscle quality occurs naturally with age (Goldspink, 2012; Keller & Engelhardt, 2013). On average, the strength of people 80 years old is about 40% less than those 20 years of age (Lexell, Taylor, & Sjöström, 1988). This can become an issue because muscle strength is associated with independence and functional abilities (Puthoff & Nielsen, 2007). Sarcopenia is defined as the age-related loss of skeletal muscle mass (Fielding et al., 2011). In the literature, sarcopenia has been associated with a decline in physical function (Janssen, Shepard, Katzmarzyk, & Roubenoff., 2004; Morley 2001). Longitudinal studies have shown that there is a clear decline in muscle mass beginning at approximately 30 years of age (Keller & Engelhardt, 2013). The literature shows that sarcopenia can be reduced or avoided in the older population with a physically active lifestyle (Freiberger, Sieber, & Pfeifer, 2011; Ryu, Jo, Lee, Chung, Kim, & Baek., 2013).

Fortunately, muscles are still adaptable at older ages, and they can be trained to increase strength (Macaluso & De Vito, 2004). There are many benefits to resistance training, such as increased muscles mass and quality, in aging adults. Literature has shown that reduced muscle quality has negative impacts on an individual's quality of life and it increases the likelihood of age-related declines in health status (Hunter, McCarthy, & Bamman, 2004). More specifically, reduced lean mass with aging is associated with decreases in resting energy expenditure and whole body fat oxidation (Poehlman et al., 1995), as well as reductions in physical activity and energy expenditure (Hunter, Weinsier, Gower, & Wetzstein, 2001; Keys, Taylor, & Grande, 1973; Poehlman et al., 1993). Furthermore, bone mineral density is related to muscle mass and strength in aging adults (Dutta, 1997; Evans & Campbell, 1993). A study by Seguin & Nelson (2003) states that strength training in older adults can combat weakness, reduce frailty, build muscle strength and mass, preserve bone density, decrease the risk of osteoporosis, reduce depression symptoms, improve sleep, and reduce the signs and symptoms of numerous chronic diseases such as arthritis and type 2 diabetes (Seguin & Nelson, 2003).

There is literature to suggest that resistance training should be recommended to people having clinical conditions, functional limitations, a disability, or frailty with old age (Paterson & Warburton, 2010). A meta-analysis reflects the benefit of resistance training in older adults' functional capacity. Liu et al. (2009) assessed the effects of progressive resistance training on older adults. The findings show that doing resistance training two or three times a week can improve physical function by reducing physical disability, reducing some functional limitations (e.g., balance, gait speed, time walk, time 'up-and-go', chair rise and climbing stairs), and reducing muscle weakness in older adults who take part in the resistance training (Liu & Latham, 2009). According to the American College of Sports Medicine, to promote and maintain health and physical independence, aging adults should include a minimum of two days per week of muscle strength and muscle endurance exercises (Nelson et al., 2007). More specially, it is recommended that 8-10 exercises be performed on two or more non-consecutive days per week using major muscle groups. From previous literature, it can be concluded that resistance training is beneficial for the functional capacity and the well-being.

Physical function can be measured subjectively or objectively. Studies reported a negative relationship between obesity and both objective and subjective measures of physical function in older adults (Bouchard, Soucy, Sénéchal, Dionne, & Brochu, 2010; Jensen & Friedmann, 2002). Objectively, older adults were asked to perform physical tasks to assess their muscular strength, aerobic endurance, flexibility, and agility/dynamic balance — all of which are associated with outcomes such as the length of hospitalization (Cawthon et al., 2009; Guralnik et al., 1995), nursing home admission (Canadian Institute for Health Information, 2013; Statistics Canada, 2011a), and mortality (Guralnik et al., 1994). Examples of these tests are the Chair Stand Test, Arm Curls, the 6-Minute Walk Test, the 2-Minute Step Test, the Chair Sit-&-Reach, the Back Scratch, and the 8-Foot Time Up-&-Go Test (Jones & Rikli, 2002). Another way of assessing physical function is through the use of questionnaires. Questionnaires often ask aging adults to report their perceived ability to perform activities of daily living, such as the ability to walk a quarter of mile or climb a set of stairs. The answer bank is usually categorical (e.g. all the time, sometimes, not able). For example, the physical function questionnaire used in the Nation Health and Nutrition Examination Survey (NHANES) asked participants to rate their perceived exertion when performing daily activities (e.g. crouching, carrying a 10-pound bag) by either 1) no difficulty, 2) some difficulty, 3) much difficulty, 4) unable to do, etc.

In summary, it is extremely important for aging adults to maintain a desirable level of physical function as they age. Physical function can be impacted in many ways, however, no matter how fit or how old an individual is, physical activity can help increase or maintain someone's physical function. Furthermore, there are several ways physical function can be measured, both objectively and subjectively. Both methods have advantages and disadvantages.

Although physical activity influences physical function outcomes in aging adults, sedentary activities (e.g. watching television or reading) and sleep time have also been shown to have an association with physical function (Santos, Silva, Baptista, Santos, Vale, Mota, & Sardinha., 2012; Sardinha, Santos, Silva, Baptista, & Owen, 2015). Therefore, it is important that these activities are included in the guidelines to help aging adults improve or maintain positive physical function.

2.5 Sedentary Time

Sedentary time is characterized as any waking behavior that has an energy expenditure of less than, or equal to, 1.5 times the resting metabolic rate (1 MET) while in a sitting or reclining posture (Newton, Han, Zderic, & Hamilton, 2013). Common activities that are categorized as sedentary behavior include watching television, using the computer, reading, and driving. There has been emerging evidence showing that, in addition to physical activity, sedentary behaviors are associated with functional capacity (Craig, Sénéchal, McLellan, Slaght, & Bouchard., 2016; Guralnik et al., 1995; Santos et al., 2012). This is very important within the aging population as they have the highest levels of sedentary time (Baptista et al., 2012; Craig et al., 2016; Matthews et al., 2008). Santos et al. (2012) investigated the association between sedentary time and functional capacity. This study involved a total of 312 males and females, with ages between 65-103 years, whose physical activity and sedentary time were assessed with accelerometers, and their functional capacity assessed with the Senior Fitness Test. The findings reinforce the importance of not only promoting physical activity, but also reducing sedentary time, at older ages to preserve functional fitness and the performance of daily functioning tasks (Santos et al., 2012). Another study that demonstrates the importance of reducing sedentary time for aging adults was conducted by Sardinha et al (2015). This study assessed physical activity and sedentary behavior in 215 male and females, aged 65-94 years. The findings from this study conclude that breaking up sedentary time is associated with better physical function in older adults. This knowledge should be used in the future when creating guidelines for aging and older adults, as it preserves their physical functioning, and therefore, helps them continue to perform activities of daily living (Sardinha et al., 2015).

There is a significant amount of research that suggests that sedentary time must be considered when creating guidelines, and the importance of assessing physical activity and functional capacity for aging adults (Dunstan, Thorp, & Healy, 2011; Hamilton, Hamilton, & Zderic, 2007; Santos et al., 2012). For example, studies have shown a dose response, independent of exercise level, body mass index, sex, and smoking status, between sedentary behaviour and all-cause mortality (Seguin et al., 2014), diabetes (Proper, Singh, van Machelen, & Chinapaw, 2011), and cardiovascular disease (Katzmarzyk, Church, Craig, & Bouchard, 2009). In addition, recent studies involving over 150,000 people have shown that even if someone meets the Canadian Physical Activity Guidelines, his/her risk of mortality and risk of developing a cardiovascular disease increases if he/she sits more than six hours per day (Katzmarzyk et al., 2009). However, a recent paper that looked at a study including one million people stated that a high level of moderate intensity physical activity (>60 minutes per day) reduces the health risks associated with high sitting time (Ekelund et al., 2016).

2.6 Sleep

An important part of an individual's day is sleep, as it constitutes about one third of a person's day. Sleep can have a significant impact on someone's health and well-being as it influences cognitive performance, physiological processes, emotional regulation, physical development, and therefore, quality of life (Hirshkowitz et al., 2015). At a macro level, sleep can be broken down into two components: sleep duration and sleep quality. Both of which, if deprived, have been linked to the development of chronic conditions (Ali, Choe, Awab, Wagener, & Orr, 2013; Foley, Ancoli-Israel, Britz, & Walsh, 2004; Partinen, Putkonen, Kaprio, Koskenvuo, & Hilakivi., 2009). Literature shows that sleep lasting between 7 to 8 hours a night is positively associated with admirable self-reported health status and longevity (Frederick, Frerichs, & Clark, 1988; Hirshkowitz et al., 2015). Studies have found a positive relationship between good sleep quality and self-reported health (Hyyppä, Kronholm, & Mattlar, 1991; Lugaresi, Cirignotta, & Zucconi, 2018) and well-being (e.g. life satisfaction) (Eser, Khorshid, & Çinar, 2007; Schubert et al., 2002; Weller & Avinir, 1993).

The National Sleep Foundation recommends older adults receive between 7 and 8 hours of sleep a day. This recommendation is based off of associated health and well-being benefits, including cognitive, emotional, and physical benefits. Literature shows that older adults who sleep between 6 and 9 hours a day have better cognitive functioning, lower rates of mental and physical illness, and enhanced quality of life compared with shorter or longer sleep durations. In fact, there is evidence that suggests that long sleep durations (>9-10 hours) in older adults is associated with morbidity (e.g. hypertension, diabetes, poor general health) and mortality (Hirshkowitz et al., 2015). Reduced sleep duration and sleep fragmentation is common for the older age group (Hirshkowitz et al., 2015), and this may be because older adults often nap throughout the day, which disrupts their sleeping pattern.

Some literature has shown associations between sleep and physical function in older adults. For example, a study done by Ohayon & Vecchierini (2005) looked at normative data for sleep-wake characteristics for older adults (60 years and older), and then examined the risk factors associated with extreme values (e.g. lower and upper percentiles of the distribution). They found that obesity and the loss of autonomy for activities of daily living was associated with both early (9PM or earlier) and late (1 AM or later) bedtimes and early (before 5AM) and late (after 9AM) wake-up times (Ohayon & Vecchierini, 2005). Another relevant study looked at whether sleep quality is associated with physical function in 2,863 older men. This study looked at the total hours of night sleep, wake after sleep onset, sleep latency, and sleep efficiency measured by actigraphy, as well as physical function which included grip strength, walking speed, chair stand, and narrow walking. Results show that increased sleep fragmentation and hypoxia is associated with poorer physical function in older men (Dam, Ewing, Ancoli-Israel, Redline, & Stone, 2008). Similar results have been found in older women. A study by Goldman et al. (2007) examined the association between disturbed sleep and poor daytime physical function in 2889 women (mean age of 83.5 years). Actigraphs were used to measure participants' total sleep, time spent awake after sleep onset, and daytime nap patterns. Physical function was measured by gait speed, chair stand, and grip strength, while physical limitations were self-reported. The study concluded that individuals who spent less time asleep (<6 hours compared to 6.0-6.8 hours) or excessively long times asleep (≥ 7.5 compared to 6.8-7.5 hours) were associated with worse physical function (Goldman, Stone, Ancoli-Israel, Blackwell, Ewing, Boudreau, & Newman, 2007).

2.7 Physical Activity Recommendations

The amount of physical activity someone needs to optimize health is debatable as the answer depends on the expected outcome and the target population. An article from Powell, Paluch, & Blair (2011) investigated what volume, frequency, and intensity of physical activity is needed to see significant changes in health outcomes such as a reduction in the risk of a variety of diseases and improvements in functional ability (Powell, Paluch, & Blair, 2011). Based on this article, the type of physical activity required to produce positive outcomes is aerobic activities that use large muscle groups. These aerobic activities must be performed at a pace that can be maintained for more than a few minutes; this is often called moderate intensity. Another type of activity that produces positive outcomes is resistance training.

According to the American Guidelines, it seems as though a dose response exists for individuals expending between 500 and 1000 MET-min per week and significant health benefits. This means that individuals would significantly increase health benefits if they reached this exercise dose (U.S Department of Health and Human Services, 2008). For this recommendation, frequency and weekly time are not suggested, rather a combination of intensity, frequency, and time. The Canadian Physical Activity Guidelines, which were last updated in 2011, were created based on systematic reviews. The guidelines recommend that aging adults engage in a minimum of 150 minutes of moderate-to-vigorous aerobic activity, in 10-minute bouts of more, as well as at least two days of resistance training, and balance exercises if needed (Tremblay, Warburton, Janssen, Paterson, Latimer, Rhodes, & Duggan., 2011; Paterson & Warburton, 2010). This recommendation was created to maintain or improve physical function for aging adults, with the idea that more activity might give extra benefits. However, there is a new comprehensive approach for physical activity recommendations that is receiving more attention. A comprehensive approach has been created because of the new literature that highlights the importance of any type of physical activity, regardless of intensity or bout length, and its effect on health.

This approach may be beneficial for aging adults as many may not like, or may not be able to, engage in the typical forms of physical activity (i.e. moderate to vigorous physical activity or resistance training). Last time the physical activity levels of Canadians were objectively measured, only 13% of adults were meeting the guidelines for moderate-to-vigorous physical activity, and it was perceived that older adults had even lower rates (Colley et al., 2011). Since aging adults are currently not adhering to the guidelines, a novel approach, including activities they are already familiar with, may be helpful in engaging more of the population. Additionally, there seems to be a large disconnect between what an aging adult perceives their activity level to be and what their objectively measured physical activity engagement is. A study by Colley et al. (2011) found that older adults in Canada only get 17 minutes of moderate-to-vigorous physical activity a day – the lowest of all age categories (Colley et al., 2011). However, when asked to self-report their activity, the percentage of older adults who perceived to be in at least moderate intensity during their leisure time was 51% for males and 42% for females (Government of Canada, 2013b). Therefore, older adults have a hard time identifying what moderate-to-vigorous physical activity actually is, and they perceive themselves to be more active than they are.

2.8 Comprehensive Approach to Physical Activity

Exclusively promoting moderate-to-vigorous aerobic physical activity, which makes up less than 5% of a full day (Chaput, Carson, Gray, & Tremblay, 2014), limits our understanding of how physical activity is associated with physical function benefits. A full day includes activities of low intensity activity (e.g. sitting, sleep), light intensity activity (e.g. house chores), and moderate-to-vigorous activity (e.g. sports) (Chaput et al., 2014). There is a new method that is supported by research (Chastin et al., 2015; Thompson, Peacock, Western, & Batterham, 2015) that highlights the importance of movement, instead of solely exercise, affecting a variety of outcomes.

Most of the literature in the past has focused on children (Chaput et al., 2014; Tremblay, Carson, Chaput, Gorber, & et al., 2016; Saunders et al.,2016). Using a comprehensive approach to evaluate physical activity is important to use when investigating different combinations of varying activity modes and intensities, and their effect on physical function. For example, the comprehensive approach would be useful to evaluate the physical function outcomes for an individual who is regularly physically active, however, works at a desk for eight hours a day. Physical activity is any movement that expends energy above rest, and therefore, it can be evaluated. Specifically, in older adults, more studies are needed to understand if a comprehensive evaluation of physical activity is associated with further physical function benefits beyond what the current physical activity guidelines provide.

2.9 Objective/Hypothesis

This thesis had two main objectives: 1) to test the association between a comprehensive approach to evaluate physical activity and physical function, and 2) To evaluate how adults age 45-85 years old reporting activities over a full week using a questionnaire.

The hypothesis that the association between each physical activity index and physical function would be significant, even when adjusted for the current physical activity guidelines. The second objective of this study was to evaluate how adults age 45-85 years old are report activities over a full week when using a questionnaire.

Chapter 3: Article

Title: Comprehensive Evaluation of Physical Activity and Physical Function for Canadian Aging Adults: A Cross-sectional Study

Authors: Mayo A, Sénéchal M, Boudreau J, Bouchard DR

3.1 Abstract

Background: Most physical activity (PA) recommendations exclude light and sedentary activities that have the potential to influence physical function for aging adults. **Purpose:** 1) The second objective of this study was to evaluate how adults age 45-85 years old are report activities over a full week when using a questionnaire, and 2) to test the association between a comprehensive approach to evaluate PA, and physical function.

Methods: A total of 25,072 adults (aged 45-85) from the baseline data of the Canadian Longitudinal Study on Aging were included in this cross-sectional study. PA was self-reported via the Physical Activity Scale for the Elderly (PASE) and was used to make three comprehensive indexes based on MET-min per week: 1) Total Index (All Activities Performed), 2) RT Index (Aerobic/Resistance Exercises), and 3) SED Index (Sedentary/Activity Time). The physical function score was derived from five objective tests related to strength, agility, speed, balance, and power, using factor analysis. Logistic regression models were used, determined on the median by age group and sex, to determine the association between the comprehensive approach to evaluate PA and physical function.

Results: After adjusting for confounders, all three indexes were associated with the physical function score. When further adjusting for meeting the current PA guideline, the Total and the SED indexes remained significant [Total Index: OR =1.02, CI = (1.01-1.03), SED: OR = 0.94, CI = (0.92-0.97)]. Less than 1% of the sample was reporting between 24 ± 2 hours per day of any activities. In addition, 58% of the sample was overestimating the average intensity of their activities over 24 hours.

Conclusion: First, our results suggest that the combination of activities in the current guidelines and activities beyond the current recommendations should be considered

important as they are associated with physical function of aging adults. Second, using the PASE, aging adults generally underestimate the total time spent performing activities, but overestimate the intensity of the reported activities.

3.2 Introduction

Currently, Canada's population is growing older (Statistics Canada, 2011b), and as you age, many people have or develop chronic conditions that are associated with the loss of independence and reduced physical function (Wolff et al., 2002). Physical function is the ability to perform activities of daily living expected for one's age (Paterson & Warburton, 2010). The loss of physical function is associated with caregiver burden, high resource needs, and premature death (Government of Canada, 2012; Paterson & Warburton, 2010; Statistics Canada, 2011a). As one ages, there is a natural decline in physical function, but fortunately this can be reduced or maintained by being physically active (Booth et al., 2012; Brach et al., 2003).

The World Health Organization, as well as most countries, have developed physical activity guidelines for adults age 65 years and older which are related to health and functional outcomes (World Health Organization., 2017). Specific to older Canadians, it is recommended that they engage in a minimum of 150 minutes of moderate-to-vigorous physical activity a week, in at least 10 minute bouts, with at least two days of resistance training in addition to balance exercises if needed (Tremblay et al., 2011). In the United States, the physical activity guidelines recommend achieving 500-1000 MET-min per week, which is an evidence-based approach to achieving health benefits (Ferguson, 2014). A MET is a metabolic equivalent of a task, in other words, a way of quantifying the intensity of a task (Jetté, Sidney, & Blümchen, 1990). MET-min per week combines the intensity of a task and the length of time the task is performed over a week. Unfortunately, most older adults (65 and older) (85%) are not meeting these guidelines (Colley et al., 2011).

The guidelines do not acknowledge the potential impacts of low intensity activities (e.g. house chores) or sedentary behaviour (e.g. sitting or lying down) that are often performed by aging adults (Buman et al., 2010; Healy et al., 2007; Proper et al., 2011). It is possible that long exposure to these activities can significantly impact physical functions. A comprehensive approach to physical activity would account for all the movements performed during a day, regardless of the intensity. As well, it would enable further investigation into the effect of combining different activities and how they impact physical function (e.g. exercising for an hour but sitting for most of the day).

Measuring physical activity via questionnaires has several limitations according to previous literature (Colbert et al., 2011). Nonetheless, questionnaires continue to be extensively used because of the practicality and low cost. Having access to a large proportion of Canadians presents the ability to evaluate the validity of a questionnaire that is used by the scientific community and clinicians, such as the Physical Activity Scale for Elderly (PASE), to measure the time and the intensity of activity, compared to what is actually performed within 24-hours.

The main objectives of this study were to: 1) to test the association between a comprehensive approach to evaluate physical activity and physical function, and 2) to evaluate how adults age 45-85 years old report activities over a full week using a questionnaire.

3.3 Methods

3.3.1 Study design

This cross-sectional study used baseline data from the Canadian Longitudinal Study on Aging (CLSA) to test the association between a comprehensive approach to evaluate PA, and physical function.

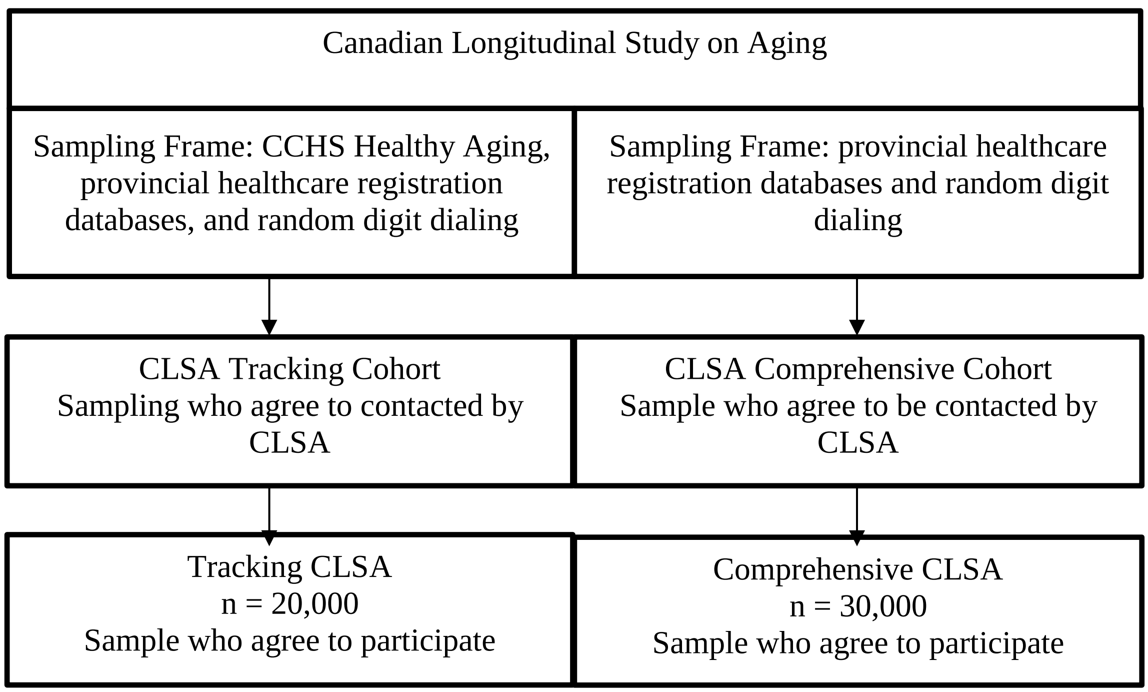

Figure 1. CLSA Study Design

3.3.2 Setting

CLSA is a Canadian-wide study with 51,332 people aged 45-85 years at baseline (2010-2015) who were followed for 20 years in three-year intervals. Individual were recruited to best sample the overall Canadian population. Data collected from self-reported information was done over the phone or via questionnaires, a sub-group of individuals were asked to have clinical measures (e.g. physical examinations, bio-specimens) performed at 11 collection sites across Canada: Victoria, Vancouver, Surrey, Calgary, Winnipeg, Hamilton, Ottawa, Montreal, Sherbrooke, Halifax, and St. John's. Follow-up of baseline data will be available in 2018.

3.3.3 Participants

A total of 51,332 were included in the CLSA database and sampled to represent the Canadian population. Figure 1 demonstrates CLSA study design in recruitment methods.

Excluded from the CLSA were residents in the three territories as well as other remote regions: persons living on First Nations reserves, full-time members of the Canadian Armed Forces, and individuals living in institutions. Individuals living in households and transitional housing arrangements in which only minimal care was provided were eligible. Individuals unable to correspond in English or French were excluded from the CLSA. Finally, individuals with cognitive impairment were excluded.

3.3.4 Exposure: Physical Activities

To meet the objective of the study, every activity performed in a day, for seven days, was combined to create different physical activity indexes. This was done by calculating MET-min per week for each activity. These activities include sleep, sitting, light, moderate, and vigorous activities which were self-reported via questionnaires. All activities except sleep were obtained from the PASE questionnaire (Appendix A). Every activity was translated into METs based on the intensity ranges and the Compendium of Physical Activities (Ainsworth et al., 2011) (Appendix B). The Compendium of Physical

Activity is an online index that gives predicted MET values to a variety of physical activities. A MET, or metabolic equivalent of a task, is defined as the energy it takes for an individual to sit at rest. The more intense a task, the more METs expended. For example, 3 METs is considered moderate intensity. In other words, energy expenditure for a moderate intensity activity is three times more for being at rest.

Physical activity was quantified by using the PASE questionnaire. This questionnaire assessed different types of activities typically performed by older adults (e.g. walking, housework). The questionnaire asks questions regarding the frequency, duration, and intensity of activity over the previous week. For this study, one of the 26 questions from the PASE questionnaire was excluded: "During the past seven days, did you engage in caring for another person, such as children, a dependent, or other adult?" It was excluded as there is no specific intensity or time allocated for this activity, and therefore, the estimation could be unrealistic or imprecise.

Sleep data was collected during a comprehensive interview in the participants' homes. The question used for this study to analyze energy expenditure during sleep was: "During the past month, on average, how many hours of actual sleep did you get a night?" The equivalent METs for sleep is 0.9 (Ainsworth et al., 2011), therefore, the number of hours asleep was converted into minutes, then multiplied by 0.9 to account for METs, and lastly multiplied by seven, to account for a full week, creating a MET-min per week measurement.

Seven groups of activities (e.g. sitting, walking for leisure or exercise, light, moderate, strenuous activities, strength activities, and work/volunteer work) from the PASE questionnaire were translated into MET-min per week using three different strategies depending of the available information.

The PASE questionnaire asks aging adults to recall their physical activities in a few different ways: 1) Report on the activity done, the frequency of that activity, and the duration of that activity (e.g. "Over the past seven days, how often did you take a walk outside your home or yard for any reason?"), 2) Report on the activities done and the frequency of that activity, but no duration (e.g. "Over the past seven days, how many hours did you volunteer?"), and 3) Report on the activity done, but no frequency or duration (e.g. "Did you participant in light house work?"). From these three types of questions, three strategies were made in order to obtain a MET-min per week evaluation (Appendix C). An example of an individual's calculation can be found in Appendix D.

3.3.5 Proposed Physical Activity Indexes

Three indexes were created to meet the two objectives of this study. These indexes were selected because they provide different ways of representing the comprehensive approach of physical activity. The Total Index represents the comprehensive approach in the literature and for youth recommendation. The RT index is based off the representation of the two forms of exercise within the CPAG. The RT Index regards both forms of activity, in terms of a ratio, to assess if there is a significance in regarding both separately. Lastly, literature shows that breaking up sedentary time is important; however, it is not in the guidelines. This index was selected to test the importance of reducing sedentary time, even if someone is physically active. This shows that sedentary time may be important to include in physical activity guidelines, even if an individual is already active. Explanation and further rationale can be seen below:

1) Total Index: This index represented the comprehensive approach. All activities, no matter the bout length, intensity, or duration, were included in this index. This index accounts for all intensities measured by the PASE questionnaire and the self-reported sleep. Currently, the physical activity guidelines only account for about 5% of a total day (Chaput et al., 2014), leaving 95% unaccounted for. Research has shown that behaviour choices for this 95% can impact physical function outcomes for aging adults.
2) RT Index: This index assessed the ratio at which someone does moderate-to-vigorous aerobic training in relation to resistance training and saw how it was associated with physical function. This is interesting especially for aging adults who state their favorite activity is walking/jogging (Szanton, Walker, Roberts, Thorpe, & Wolff., 2015). How physical activity is associated with physical function if an individual reached the MET-min per week requirement by doing only a cardio routine or only a resistance training routine. Neither person is reaching the CPAG guidelines; however, are reaching the recommended MET-min per week amount. For RT Index, those who did more resistance training were considered to have a ratio below 0.49 and those who did more activities

at moderate to vigorous intensity were considered above 1.6. Those who had an equal ratio were between 0.5-1.5.

3) SED Index: This index outlined the ratio between sedentary time and activity time for aging adults. Aging adults may be reaching, or very close to reaching the CPAG guidelines (Government of Canada, 2013a); however, they often also have a high amount of sedentary behaviour in their life. This index tested how increased sedentary behaviour is associated with physical function, even if an individual has an active lifestyle. To further describe the SED Index, categories were created for participants engaging in one behavior more than the other. For the SED Index, those engaging in more activity time than sedentary time had an index below 0.49, and those with an index above 1.6 had more sedentary time in their day. Those with a ratio between 0.5-1.5 were considered to have an equal ratio between the two activities. These ratios were chosen as a ratio of 1 would indicate a 1:1 ratio for each of the categories with a standard deviation of 0.5, which allowed for some variance. These cut-offs are for descriptive purposes to demonstrate where people spend more time in the given activities.

3.3.6 Outcome: Physical Function Score

Five objective tests were used to assess physical function. These tests include:

1) Grip Strength: Participants were asked to use their dominant hand while using a Tracker Freedom Wireless Grip dynamometer. Participants were asked to sit in a straight back chair with no armrest, have their feet flat on the floor with their arms

close to the body, have their shoulders relaxed with the working arm bent at a 90-degree angle at the elbow, and have their hands in a neutral position. In that position, the participants were asked to squeeze the dynamometer as hard as possible. This procedure was repeated three times with a 15-second rest between trails. Maximum and average trials were reported. For this study, average hand grip strength was used as it has been well documented to be reliable for age and gender stratified data in population-based studies (Massy-Westropp, Gill, Taylor, Bohannon, & Hill, 2011).

2) Timed up-and-go: This test asked participants to rise from a standard arm chair, walk to a marker on the floor placed three meters away, walk around the marker, return to the chair, and sit down. A participant could use a walking aid but had to be able to stand up, rise from the chair, and walk without the assistance of another person. The test was performed once after a practice trial.

3) Chair Rise: The chair rise test required participants to stand up and sit down from a standard chair as quickly as possible five times in a row, with their arms folded across their chest. The time was recorded from the initial sitting position to the final standing position. The test was performed after an initial practice trial. Although the test required the chair rise to be performed five times, some aging adults could not complete all five repetitions, and therefore, they completed as many as they could. The chair rise time was divided by the number of repetitions, providing a ratio. 83% of the total sample completed the required five repetitions.

4) One-Leg Stance Balance: The participants were positioned approximately one

meter from a wall and instructed to stand on one foot for as long as possible for a maximum of 60 seconds, while first lifting the dominant leg up to the calf. The test was repeated on the other leg. The best time that obtained was used for the analysis.

5) Four-Meter Walk: The participants walked to a marked, four-meter course at their usual walking pace while being timed. They could use a walking aid during the test but had to be able walk without the assistance of another person. The test was performed once after a practice trial.

Since each of the physical function tests have different units, and might have different implications on physical function, a factor analysis was performed to obtain a physical function score using the five objectively measured tests to create the physical function score. The analysis used KMO and Bartlett's test of Sphericity and Anti-Image Correlation to verify assumptions made by the analysis and Principal Components was used as the extraction method. An eigenvalue of 1 was used as a cut-off; however, one variable had a value of 0.9 and it was also accepted. Lastly, the rotation method used was varimax due to the dataset being orthogonal in nature. Figure 2 demonstrates the process of the individual physical function tests to the statistical analysis. After verification of the distribution of the factor score, it was clear that it was not linear. The factor score was then classified as a binary score arbitrary based on median value (0 – lower physical function, 1 – higher physical function) by sex (male and female), and by age groups (45-54, 55-64, 65-74, 75-85) both associated with physical function (Buttery et al., 2016; Silva, Menezes, Silva, & Menezes, 2014). As a result, the factor obtain from the factor analysis was treated as 0-1 in analysis.

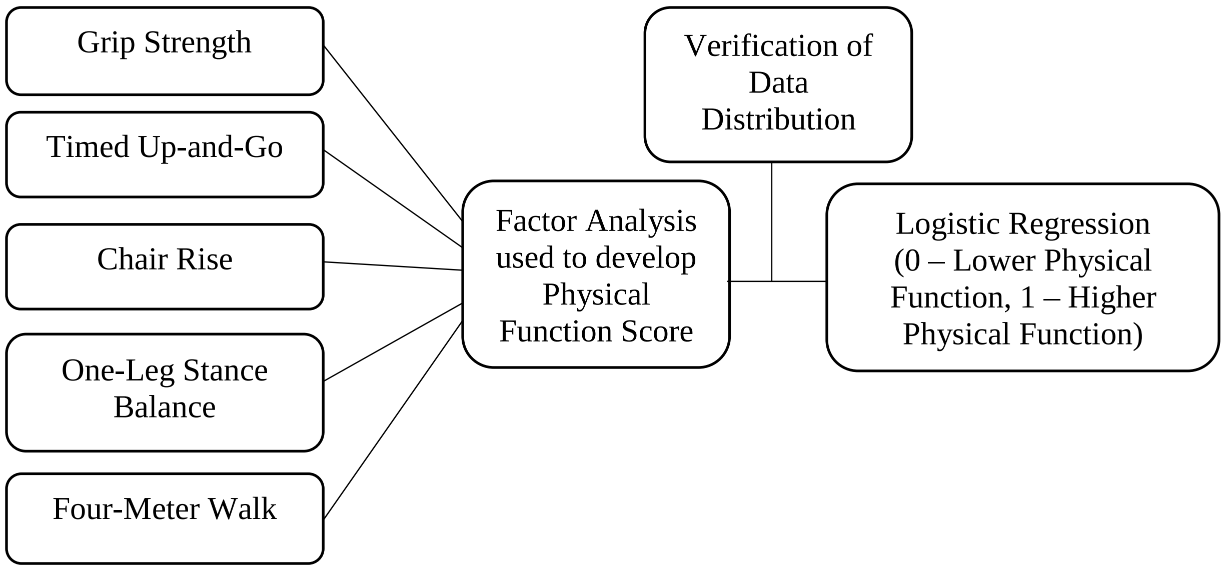

Figure 2. Factor Analysis Process

3.3.7 Confounders

Potential confounders that can potenially influence the association between physical function and physical activity indexes were considered in the analysis based on the literature and the availabilty within the CLSA dataset.

Personal characteristics such as age, sex (0-1), relationship status (single, married, widowed, divorced, separated, refused/I don't know), Body Mass Index (weight/height^2), education level (no post-secondary, trade certificate/diploma, non-university certificate/diploma, university certificate below bachelor's degree, bachelor's degree, university degree above a bachelor's degree, refused/I don't know), household incomes (less than $20,000; $20,000-$50,000; $50,000-$100,000; $100,000-$150,000, $150,000 or more, refused/I don't know), and ethnicity (caucasian/non-caucasian) were self-reported at a baseline home interview using a questionnaire, and then were objectively tested at the collection sites. Further coding was done for ethnicity because participants could code "yes" or "no" to a variety of ethicities; for example, account for being First Nations, Filipino, and Caucasian therefore making coding this variable difficult. In CLSA, 95.6% of individuals considered "white" as being part of their ethicity, therefore, they coded themselves as caucasian (1= Caucasian, 0 = Non-Caucasian) for simiplity.

Chronic conditions were self-reported through a baseline questionnaire during their home interview or over the telephone. For example, the questionnaire asked, "Has a doctor ever told you that you have an anxiety disorder such as phobia, obsessive-compulsive disorder or panic disorder?" and the participant could answer: Yes, No, Don't know/No Answer, or Refused. A total of 54 chronic conditions were accounted for in this study, and conditions that were not able to be coded were excluded. The 54 conditions included: Heart Disease, Peripheral Vascular Disease, High Blood Pressure, Heart Attack, Angina, Mood Problem, Dementia, Anxiety Disorder, Mood Disorder, Parkinson's Disease, Multiple Sclerosis, Epilepsy, Migraine, Breast Cancer, Colorectal Cancer, Bladder Cancer, Skin Cancer, Kidney Cancer, Lung Cancer, Thyroid Cancer, Prostate Cancer, Ovarian Cancer, Leukemina, Pancreatic Cancer, Non-Hodgkin Cancer, Melanoma, Osteoarthritis of the hip, Osteoarthritis of the knee, Rhumatiod Arthritis, Other Arthritis, Back Problems, Stroke, Mini Stroke, Mini Stroke Effects, Underactive Thyroid, Overactive Thyroid, Bowel Disorder, Bowel Incontinence, Urinary Incontinence, Ulcers, Urinary Tract Inflection, Kidney Disease, Dialysis, Pneumonia, Bronchitis, Allergies, Flu, Other Infection, Osteoporosis, Macular Degeneration, and Other Mental/Physical Conditions.

These chronic conditions were used as confounders in the logistic regression. If the individual had the chronic condition it was coded as a 1, if not, the individual was given a 0. The sum of all reported chronic conditions was used in the statistical analysis.

To describe the chronic conditions, a simplified list was developed:

1) Heart Condition (Heart Disease, Peripheral Vascular Disease, High Blood Pressure, Heart Attack, Angina),
2) Cognitive Condition (Mood Problem, Dementia, Anxiety Disorder, Mood Disorder, Parkinson's Disease, Multiple Sclerosis, Epilepsy, Migraine),
3) Cancer (Breast Cancer, Colorectal Cancer, Skin Cancer, Bladder Cancer, Kidney Cancer, Lung Cancer, Thyroid Cancer, Prostate Cancer, Ovarian Cancer, Leukemia, Pancreatic Cancer, Non-Hodgkin Cancer, Melanoma, Other Cancer),
4) Arthritis (Osteoarthritis of the Hip, Osteoarthritis of the Knee, Rheumatoid Arthritis, Other Arthritis, Back Problems, and Osteoporosis),
5) Stroke (Stroke, Mini Stroke, Mini Stroke Effects),
6) Thyroid Condition (Underactive Thyroid, Overactive Thyroid),
7) Digestive Condition (Bowel Disorder, Bowel Incontinence, Urinary, Incontinence, Ulcers, Urinary Tract Infection),
8) Lung Condition (Pneumonia, Bronchitis) and
9) Infection (Any other infection).

The physical activity guidelines was included as a confounders using three methods:

1) Those who reached over 500 MET-min per week (0 = less than 500, 1 = more than 500)
2) Those who reached over 500 MET-min per week in its raw data form (continuous variable including 500 MET-min per week and up)
3) Those who account doing RT and have over 150 minutes moderate-to-vigorous physical activity in a week (0= Not rearching guideline, 1=reaching guideline).

3.3.8 Statistical Analysis

Averages ± SD and frequencies (%) were used to describe the sample. To describe the functional score across the different PA indexes, a one-way ANOVA was run based on tertiles across the different indexes. These tertiles were then compared to each other for descriptives for age, sex, MVPA time, and sedentary time. To answer the first objective, logistic regression models were used to test the association between each physical activity indexes and the physical function score derived from the factor analysis. Linear regression models were not an option because the physical function score did not have a linear distribution when plotted with a scatter plot.

Five models were performed using logistic regressions:

1) Model 1: Each index predicted being above the median of physical function.
2) Model 2: Adjustment for relationship status, education level, BMI, household income, ethnicity, and the sum of chronic conditions.

3) Model 3: Those who reached over 500 MET-min per week (0 = less than 500, 1 = more than 500).
4) Model 4: Those who reached over 500 MET-min per week in its raw data form (continuous variable including 500 MET-min per week and up),
5) Model 5: Those who account doing RT and have over 150 moderate-to-vigorous MET-min per week (0= not rearching guideline, 1= reaching guideline).

Each model was weighted using CLSA's analytic weighting values. These are the weights used to relate the studies' sample to the total population; it is the CLSA's reccommended weighting for analytical analysis. For making the interpretation more practical, the Total Index was divided by 1000 MET-min per week, RT Index was divided by 100 MET-min per week, and SED Index remained the same. For Model 4 of the physical activity adjustments, the values were divided by 1000 to show clinically meaningful odds ratio and confidence intervals. However, for logistic regressions, values were left in their raw data form. In addition, all models were tested for collinearity using the variance inflation factor against the indexes, all factors were under the cut-off limit of 3 (Craney & Surles, 2002; Vatcheva, Lee, McCormick, & Rahbar, 2016); therefore, no multicollinearity was indicated.

To answer the second objective of the thesis, the time spent performing all the activities reported in the PASE was summed with the average time spent sleeping and compared to a 24-hour period. A standard deviation of ± 2 hour was used as the cut-off to be considered correctly reporting activities over 24 hours, this cut-off was used because within the PASE questionnaire hours was chosen with 2-hour increases; therefore, the same approach was used within this cut-off. To understand the total intensity and time reported by aging adults in a typical week, the Total Index was divided by minutes in a day and days in a week to obtain the average MET per minute, per day. From this, three categories were made: 1) Underestimated METs (<1 MET-min per day), 2) Accepted Range (1-1.5 MET-min per day), and 3) Overestimated METs (>1.5 MET-min per day). These categories were chosen based on Gerrior et al. (2006) reporting the average METs per day for a person considered sedentary, low active, active, or very active. The range of METs within each category is between 1-1.5 METs, which this studies' categories were based off of (Gerrior, Juan, & Peter, 2006).

3.4 Results

3.4.1 Study Sample Size

Of the total CLSA sample, only 25,072 of those individuals were included in this analysis after reductions for the following reasons as displayed in Figure 3. As shown in the Figure, 21,190 people did not have a site visit, 1,197 did not complete a full PASE questionnaire, 3,805 were missing one or more results from the five physical function tests, and 14 people had results that were considered outlier for sleep, resistance training, and physical activity responses.

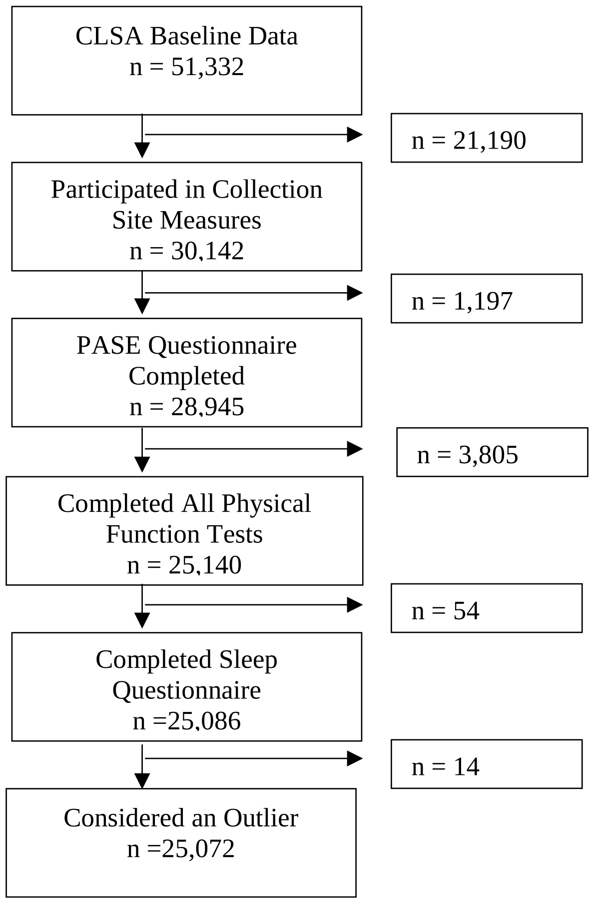

Figure 3. Sample Size Reduction

3.4.2 General Characteristics

Table 1 displays the general characteristics of the sample. The average age of the sample was 62 ± 10 years of age, half the sample was male (50.4%), and the majority of participants identifying themselves as Caucasian (92.0%). Based on the PASE questionnaire, 44.9% of participants self-reported reaching the minimum physical activity guideline (i.e. completing a minimum of 500 MET-min per week).

Table 1. General Characteristics of analytical sample (N=25,072)

Characteristics	Mean ± SD or N (%)	Missing Variable N (%)
Age (years)	62 ± 10	0 (0)
Sex (Male)	12,642 (50.4)	0 (0)
Ethnicity (Caucasian)	20,183 (92.0)	3,124 (12.5)
Marital Status (Married)	15,420 (70.3)	3,124 (12.5)
Education Level (Highest Level: Bachelor's Degree)	5,347 (28.3)	6, 208 (24.8)
Total Household Income ($50,000 to $150,000)	13,217 (52.8)	0 (0)
Body Mass Index (kg/m^2)	27.8 ± 5.2	20 (0.1)
Average Sleep Time (Hours)	6.8 ± 1.2	0 (0)
Physical Activity Guidelines (>500 MET-min per week)	11,253 (44.9)	0 (0)

Individuals self-reported having an average of 3.9 ± 2.8 chronic conditions, with the highest reported conditions including Musculoskeletal (50.0%), Other Mental/Physical Conditions (48.5%), and Heart Conditions (44.3%).

Table 2. Description of Self-Reported Categories

Self-Reported Chronic Condition	N (%)
≥ 1 Heart Condition	13,324 (44.3)
≥ 1 Cognitive/Mood Condition	9,164 (30.4)
≥ 1 Cancer	3987 (13.2)
≥ 1 Musculoskeletal	15,034 (50.0)
≥ 1 Stroke or Stroke Symptoms	1,048 (3.5)
≥ 1 Thyroid Condition	4,377 (14.5)
≥ 1 Digestive Condition	7,980 (26.5)
≥ 1 Kidney Condition	867 (2.9)
≥ 1 Lung Condition	2,353 (7.8)
≥ 1 Infection	3,685 (12.3)
Other Mental/Physical Condition	14,546 (48.5)
Allergies	11,498 (38.6)
Flu	1,989 (6.6)
Macular Degeneration	1,280 (4.3)
Average Self-Reported Conditions	3.9 ± 2.8

Data presented as: Mean ± SD or N (%)

3.4.3 Physical Activity and Physical Function

Self-reported physical activity through the PASE showed that most individuals during their wake time spent some time sitting (41.1%), and volunteering (31.5%) (Table 3). Additionally, when an individual's awake time was totaled, the average time an individual self-reported doing activities equaled 7.3 ± 5.2 hours per day.

Table 3. PASE Categories

	MET-min per week			Hours/Day		
Activity	Max	Min	Mean (SD)	Max	Min	Mean (SD)
Sitting	2,808	29	1,750 ± 868	5	0	3.0 ± 2.0
Walking	4,320	45	642 ± 649	5	0	0.7 ± 0.8
Light Intensity	4,320	45	569 ± 697	5	0	0.2 ± 0.5
Moderate Intensity	9,720	101	1,756 ± 1858	5	0	0.1 ± 0.5
Vigorous Intensity	17,280	180	2,164 ± 2323	5	0	0.2 ± 0.5
Strength Training	9,720	101	651 ± 703	5	0	0.1 ± 0.3
Volunteer	45,360	75	3,841 ± 3779	24	0	2.3 ± 3.0
Light Housework	776	8	202 ± 93	0.8	0	0.2 ± 0.1
Hard Housework	1,251	10	317 ± 148	0.7	0	0.2 ± 0.1
House Repair	365	2	83 ± 43	0.2	0	0.04 ± 0.02
Lawn Care	707	2	163 ± 83	0.4	0	0.09 ± 0.04
Outdoor Gardening	289	1	71 ± 35	0.3	0	0.07 ± 0.04
Total Activities	49,611	70	6701 ± 4228	0	31	7.3 ± 3.3
Activities + Sleep	52,257	1,582	9,281 ± 4,224	3.3	40.4	14.1 ± 4.5

Data are presented as: Mean ± SD

Figure 4 displays the number of individuals in each MET category based off the PASE questionnaire. The majority of individuals overestimate their MET intensity values (54%), followed by accepted values (45%), and lastly underestimated values (1%).

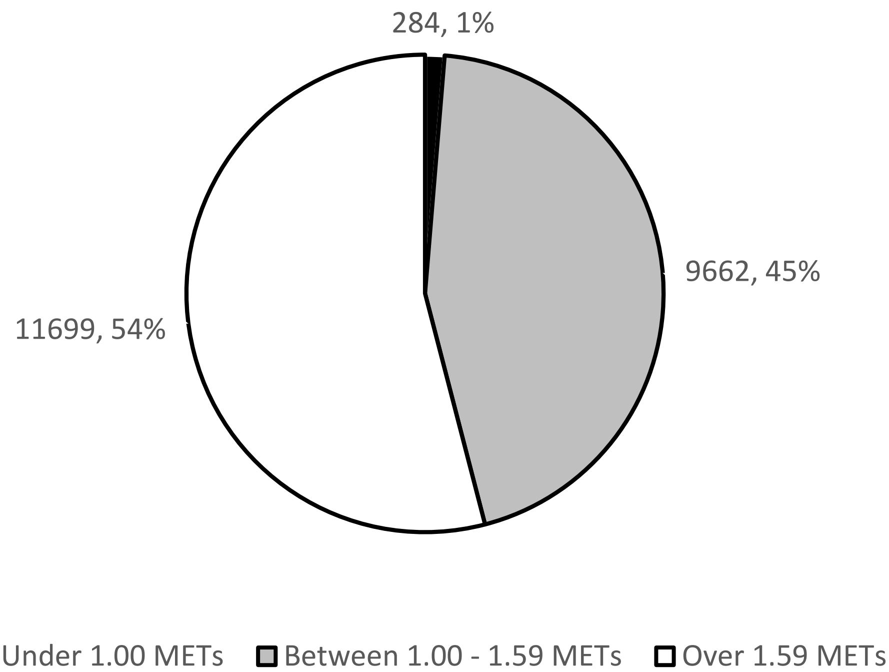

Figure 4. Perception of Average Intensity

Results for physical function are presented in Table 4. The last column is the normative values (Bohannon & Williams Andrews, 2011; Government of Canada, 2016; Ibrahim, Singh, & Shahar, 2017; Jones & Rikili, 2002; Springer, Marin, Cyhan, Roberts, & Gill, 2007) for individuals aged 62 years (the average age) for both men and women in the sample.

Table 4. Descriptive of Physical Function Test

Test	Minimum	Maximum	Mean ± SD	Norms
Average Grip Strength in Dominant Hand (Kg)				
Male	8.92	84.09	42.05 ± 9.38	43.8
Female	4.94	52.22	25.37 ± 5.74	26.2
8 ft Timed Get Up and Go (Seconds)				
Male	3.00	55.57	9.36 ± 1.82	10.4
Female	3.22	60.00	9.24 ± 1.87	10.4
Chair Rise (Seconds)				
Male	3.58	60.00	13.11 ± 3.50	11.4
Female	3.56	62.00	13.29 ± 3.70	11.4
Standing Balance (Seconds)				
Male	0.10	60.00	40.65 ± 23.10	33.8
Female	0.20	60.00	38.96 ± 23.36	30.4
Four Meter Walk Test (Seconds)				
Male	2.00	18.00	4.13 ± 0.84	5.36
Female	2.00	16.00	4.22 ± 0.91	4.96

Data are presented as: Mean ± SD

3.4.4 Physical Activity Indexes

Table 5 presents the PA indexes and the proportion of the sample that did more or less activities at moderate to vigorous intensity (MVPA) versus RT and more or less sedentary activities versus total activities. The Total Index has a range of 1,582-52,257 MET-min per week, with an average and standard deviation of 9281± 4224 MET-min per week. When looking at the RT Index, more individuals perform MVPA (86%) compared to equal amounts of each activity (3%) or doing resistance training (11%). The raw data from the SED Index displays that similar numbers of people are categorized as spending more of their time sedentary (40.6%), as the group that is categorized as spending equal amounts of time sedentary and active (41.9%). Compared to these groups, the number of people that are more active throughout the day is different (17.6%).

Table 5. Comprehensive Physical Activity Index Descriptives

Index	N (%)	Minimum	Maximum	Mean ± SD
Total Index (MET-min per week)		1,582	52,257	9281 ± 4224
RT Index (MVPA/RT)		0	22,950	577 ± 1601
More MVPA (≥1.5)	21,492 (85.7)	1.6	22,950	673 ± 1710
Equal (0.5-1.5)	628 (2.5)	0.5	1.5	0.9 ± 0.2
More RT (≤0.5)	2862 (11.4)	0	0.5	0.3 ± 0.1
SED Index (Sedentary/Activity)		0	80	2.0 ± 2.0
Activity Time (≤0.5)	4402 (17.6)	0	0.50	0.3 ± 0.1
Both (0.5-1.5)	10,495 (41.9)	0.50	1.60	1.0 ± 0.3
Sedentary Time (≥ 1.5)	10,175 (40.6)	1.6	79.58	4.0 ± 3.0

Data presented as: MET-min per week Mean ± SD or N (%)

3.4.5 Physical Activity Indexes and Physical Function Score

Table 6 demonstrates the general characteristics of those who have a higher and lower physical function score. A significant difference was observed between the two groups for body mass index and self-reported measures of meeting the physical activity guidelines ($p < 0.05$).

Table 6. Characteristics of Higher and Lower Physical Function Individuals

	Higher Physical Function	Lower Physical Function
Age (Years)	62±10	63±10
Sex (Female)	6321 (50%)	6321 (50%)
Ethnicity (Caucasian)	10,098 (92%)	10085 (92%)
Relationship Status (Married)	7765 (70%)	7655 (70%)
Highest Level of Education (Bachelors)	2698 (29%)	2649 (28%)
Household Income ($50-100,000)	4191 (33%)	4196 (34%)
Sum of Chronic Conditions (#)	4±3	4±3
Body Mass Index (kg/height^2)	27±4	29±6 *
Meeting guidelines (≥500 MET-min per week)	6480 (52 %)	4773 (38%) *

Data Presented as: Mean ± SD or N (%); * p value <0.05

Table 7 shows descriptive information and physical activity patterns for each index when split into tertiles. For the Total and SED indexes, differences were observed among the three tertiles for all variables. For RT index, all variables were significantly different except age differences between the lowest and the middle tertile.

Table 7. Descriptive and PA patterns Across Tertiles Indexes

	Lowest Tertile	Middle Tertile	Highest Tertile
Total Index			
Age (Years)	67 ± 10	63 ± 10	58 ± 8
Sex (Female)	4628 (55)	4307 (52)	3495 (42)
MVPA (mins/week)	27 ± 67	99 ± 151	330 ± 442
RT time (mins/week)	19 ± 54	41 ± 89	70 ± 150
Sedentary Time (mins/week)	1187 ± 619	1478 ± 678	1349 ± 689
RT Index (MVPA/RT)			
Age (Years)	63 ± 10	63 ± 10	61 ± 10
Sex (Female)	2182 (49)	6347 (52)	3901 (47)
MVPA (mins/week)	59 ± 109	25 ± 108	389 ± 407
RT time (mins/week)	174 ± 181	12 ± 54	19 ± 44
Sedentary Time (mins/week)	1330 ± 672	1398 ± 674	1254 ± 665
SED Index (SED/Activity time)*			
Age (Years)	57 ± 8	62 ± 10	68 ± 9
Sex (Female)	3538 (42)	4322 (52)	4569 (55)
MVPA (mins/week)	324 (443)	119 ± 160	13 ± 88
RT time (mins/week)	56 ± 128	44 ± 98	29 ± 92
Sedentary Time (mins/week)	1038 ± 610	1436 ± 653	1540 ± 650

Data presented as: Mean ± SD or N (%);

* Note that the lower the SED Index (lower tertile) = less sedentary

Tables 8 presents the main analysis of the study. A logistic regression between the three indexes and the physical function score was performed with various models. All three indexes are shown to be significantly associated with a positive physical function score in Model 2 (Total Index OR = 1.04, CI = (1.03-1.05); RT Index OR = 1.01, CI = (1.00-1.02); SED Index OR = 0.91, CI = (0.89-0.94)) when adjusting for general characteristics. However, when adjusting for the physical activity guidelines some indexes lose their significance. For the Total Index, no matter how the physical activity guidelines were adjusted for, the index was shown to be significant in Model 3, Model 4, and Model 5 (Model 3 OR = 1.02, CI = (1.01-1.03), Model 4 OR = 1.02, CI = (1.00-1.05), Model 5 OR = 1.03, CI = (1.02-1.04)). The RT Index was only significant in Model 3 (OR=1.00, CI = (1.00-1.01)) and Model 5 (OR = 1.02, CI = 1.01-1.02). SED Index was significant in Model 3, Model 4, and Model 5 (Model 3 OR= 0.94, CI = (0.92-0.97), Model 4 OR = 0.93, CI = (0.91-0.96), Model 5 OR= 0.92, CI = (0.90-0.95)). The indexes were also performed with the average of the chronic conditions as well as for the individual chronic conditions that may directly affect physical function (macular degeneration, cancer, arthritis and hearing aid), as opposed to the sum of the chronic conditions, and no differences were found. Other confounders that were found to be sigificant in the logistic regression include: body mass index (OR = 0.91, CI = 0.90-0.92)), household income (OR = 1.10, CI = 1.07-1.12)), and each model of reaching the physical activity guides (Model 3: OR = 1.38, CI = 1.33-1.42; Model 4: OR = 1.12, CI = 1.10-1.15; Model 5: OR = 1.65, CI = 1.47-1.85).

Table 8. Comprehensive Indexes Predicting the Odds of Performing Above the Median for Physical Function

N=25,072	Total Index (ALL ACTIVITIES)	RT Index (MVPA/RT)	SED Index (SED/ACTIVE)
Model 1	1.04 (1.04-1.05)	1.02 (1.02-1.02)	0.90 (0.88-0.92)
Model 2	1.04 (1.03-1.05)	1.01 (1.01-1.02)	0.91 (0.89-0.84)
Model 3	1.02 (1.01-1.03)	1.00 (1.00-1.01)	0.94 (0.92-0.97)
Model 4	1.02 (1.00-1.05)	1.00 (0.99-1.02)	0.93 (0.91-0.96)
Model 5	1.03 (1.02-1.04)	1.02 (1.01-1.02)	0.92 (0.90-0.95)

Data presented as OR (95% CI)
Model 1 – Index
- Total Index for every increase of 1000 MET-min per week
- RT Index for every increase 100 in the ratio
- SED Index for every decrease in 1 in the ratio

Model 2 – Futher adjusted for Relationship Status, Education Level, BMI, Household Income, Ethnicity, Sum of Chronic of Conditions
Model 3 – Additionaly adjusted ≥ 500 MET-min per week (Yes/No), OR,
Model 4 – Additionaly adjusted RT + 150 mins of MVPA (Yes/No), OR
Model 5- Additionaly adjusted ≥ 500 MET-min per week (Continuous)

3.5 Discussion

The first objective of this study was to test the association between a comprehensive approach to evaluate physical activity, and physical function. It was hypothesized that the association between each physical activity index and physical function was going to be significant even when adjusted for the current guidelines. This hypothesis is accepted for the Total Index and the SED Index. Our results suggest that the sum of all activities, including different intensities and the combination of different types of activities, must be considered along with the traditional moderate-to-vigorous intensity exercise and resistance training when promoting physical activity to maintain and improve physical function.

The second objective of this study was to evaluate how adults age 45-85 years old are report activities over a full week when using a questionnaire. It was hypothesized that aging adults would fail to self-report activities completed in 24 hours or over a full week, and our study supports this hypothesis. When evaluating physical activity in aging adults it was found that self-reported time was vastly underestimated, however, the intensity was overestimated. This makes drawing conclusions from physical activity estimations and analyses challenging.

In the current study, the Total Index was significantly associated with the physical function score even when adjusted for meeting the current physical activity guidelines. *This means that every activity, regardless of the intensity, contributes to physical function even if someone reaches the current physical activity guidelines.* For the Total Index, when adjusted for all confounders except for if they met the guidelines, every increase of 1000

MET-min per week showed an increased likelihood of being above the median in the physical function score of 2-3% (OR=1.04, 95% CI= 1.03-1.05) that an individual would have a functional capacity above the median for age and sex. This finding is important as it demonstrates that no matter what age, sex, race, or how many chronic conditions an individual may have, if he/she moves more in a day (regardless of the type and intensity of the activity) he/she will have a physical function score above the median for his/her allocated sex and age. Since this index was significant it suggests that there might be other activities, rather than traditional exercises, that can contribute to greater physical function. This is good news for people age above 45 years that have little desire to perform traditional exercise. Similar 24-hour guidelines have been made in relation to youth in Canada and have shown health associations (Chaput et al, 2014).

Similar to the Total Index, the SED Index was shown to be significant when adjusted for general characteristics and whether the individuals reached the physical activity guidelines. However, this index was even more strongly associated with the outcome. For each reduction of 1 in the SED Index, a person age between 45 and 85 years old would increase the likelihood of having a physical function above the median for his/her sex and age by 6 to 8%. The fact that this index is significant, even when adjusting for meeting the current physical activity guidelines, demonstrates that the combination of sitting less and moving more can impact the physical function of an adult age 45 to 85 years old. These findings support previous literature showing that sedentary time is an important element of someone's health (Craig et al., 2016; Guralnik et al., 1995; Santos et al., 2012). Therefore, including sedentary time in physical activity recommendations may be beneficial.

In this study, participants reported activity for an average of 14.1 hours out of a 24-hour day. Within this study, the activities performed over 24 hours, every day of the week, were assessed by the use of a single question related to sleep, as well as the Physical Activity Scale for the Elderly (PASE) which assessed activities performed. Despite the fact that the PASE has been assessed for validity and reliability in a few studies in the past (Hagiwara Akiko, Ito Naomi, Sawai Kazuhiko, & Kazuma Keiko, 2008; Loland, 2002; Washburn, Smith, Jette, & Janney, 1993) some studies have shown limitations with this questionnaire (Campbell, 2012; Krol-Zielinake & Ciekot, 2015; Logan, Gottlieb, Maitland, Meegan, & Spriet, 2013; Siordia, 2012). For example, a study done with aging adults recommends using a pedometer instead of a questionnaire to estimate energy expenditure, even though the pedometer still has limitations (Colbert et al., 2011). Our study shows that the average time aging adults report for physical activity is 7.3 hours and for sleep is 6.8 hours, representing only 59% of a day. Interestingly, even if most people underestimate the time of activities performed over a 24-hour period, they generally overestimate the intensity they performed these activities. In a given day, people will have an average MET of between 1.10 and 1.59 (Gerrior, Juan, & Peter, 2006) which represents 11,088 to 15,120 MET-min per week; however, 56% of the sample studied had a MET-min per week outside this range. Although the PASE questionnaire has its place, such questionnaires may not be best suited to report and track activity accurately enough for national epidemiological studies.

Although there are limitations, this study does have many strengths. The current findings could impact how physical activity is recommended to Canadian aging adults and contribute to the development of comprehensive exercise guidelines for aging adults. As stated earlier, many aging adults do not participate in enough physical activity as defined by current physical activity guidelines, however, they may engage in other activities that are associated with positive functional outcomes. Lastly, although the proposed study is cross-sectional in nature, it will be possible to use the comprehensive physical activity indexes as predictors for health outcomes in later cycles of the CLSA.

In summary, our results suggest that both the activities currently outlined in the guidelines as well as activities not mentioned in the current guidelines should be considered important as they are all associated with the physical function of aging adults. The results of this study, combined with the knowledge that most aging adults do not reach the current guidelines, suggest that it is worth developing a 24-hour comprehensive approach to physical activity that may be associated with physical function. This is important because physical function predicts independence, which is a crucial outcome for aging adults. Second, his study suggests that the PASE questionnaire does not seems to be suited to quantify the total time spent performing activities over 24-hour.

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Chapter 4: General Discussion

4.0 Discussion

The first objective of this study was to test the association between a comprehensive approach to evaluate physical activity, and physical function. It was hypothesized was that the association between each physical activity index and physical function was going to be significant even when adjusted for the current guidelines. This hypothesis is accepted for the Total Index and the SED Index. Our results suggest that the sum of all activities, including different intensities and the combination of different types of activities, must be considered along with the traditional moderate-to-vigorous intensity exercise and resistance training when promoting physical activity to maintain and improve physical function.

The second objective of this study was to evaluate how adults age 45-85 years old are report activities over a full week when using a questionnaire. It was hypothesized that older adults would fail to self-report activities completed in 24 hours or over a full week, and our study supports this hypothesis. When evaluating physical activity in older adults it was found that self-reported time was vastly underestimated, however, the intensity was overestimated. This makes drawing conclusions from physical activity estimations and analyses challenging.

4.0.1 Test the association between a comprehensive approach to evaluate physical function.

Logistic regression analysis was used to test the association between each physical activity index and the likelihood of having a score above the median for physical function. Aside from the physical activity indexes, confounders were also assessed to see if there were associations with the physical function score. Of the confounders adjusted for only body mass index, household income, and the three physical activity guideline models were found to be associated.

Body mass index (BMI) has been shown to be associated with physical function in older adults (Galanos, Pieper, Cornoni-Huntley, Bales, & Fillenbaum, 1994; LaCroix, Guralnik, Berkman, Wallace, & Satterfield, 1993). Although mechanisms have yet to be identified, it is believed that BMI influences physical function outcomes because of its negative association with chronic disease, the decreased ability to perform endurance exercise, the decreased energy demands on ventilation, and the alteration of pulmonary function (Babb, Korzick, Meador, Hodgson, & Buskirk, 1991; Sakamoto, Ishikawa, Senda, Nakajima, & Matsuo, 1993). Additionally, high BMI also impedes mobility and flexibility (LaCroix et al., 1993). Secondly, in the literature low household income has been associated with physical function. For example, one longitudinal study followed adults aged 55-85 over 9 years and found that low income was related to poorer levels of physical function (Koster et al., 2006). This outcome may be because low income is also related to an increased risk of negative health conditions (Brunner et al., 1997; Everson, Maty, Lynch, & Kaplan, 2002), negative health behaviors (e.g. smoking, alcohol consumption, low physical activity) (Martikainen, Stansfeld, Hemingway, & Marmot, 1999; Stafford, Hemingway, Stansfeld, Brunner, & Marmot, 1998), and limited available resources (e.g. social support, community support) (Siegrist & Marmot, 2004). Lastly, reaching and adhering to the physical activity guidelines has been shown to improve physical function (Tremblay et al., 2011). For instance, physical activity in middle-aged and older adults has shown a reduced risk of poor physical function for 30-50% of adults (Paterson & Warburton, 2010). Physical activity maintains muscle mass, muscle quality, and cardiovascular health, while also reducing the risk of chronic conditions that may impact an older adult's physical function (Nelson et al., 2007; Warburton et al., 2001; Warburton, Nicol, & Bredin, 2006).

4.0.2 Adults age 45-85 years old are accurately reporting activities using a questionnaire

In this study, participants were only reporting activity for an average of 14.1 hours of the possible 24 hours in a day. Several reasons can be used to explain this result. One reason is the tool that is currently being used in the CLSA to quantify activities. Within this study, the activities performed over 24 hours, every day of the week, were assessed by the use of a single question related to sleep, as well as the Physical Activity Scale for the Elderly (PASE) which assessed activities performed. Despite the fact that the PASE has been assessed for validity and reliability in a few studies in the past (Hagiwara Akiko, Ito Naomi, Sawai Kazuhiko, & Kazuma Keiko, 2008; Loland, 2002; Washburn, Smith, Jette, & Janney, 1993) some studies have shown limitations with this questionnaire (Campbell, 2012; Krol-Zielinake & Ciekot, 2015; Logan, Gottlieb, Maitland, Meegan, & Spriet, 2013;

Siordia, 2012). For example, a study done by Innerd et al. (2015) found that physical activity questionnaires were significantly associated with the objective measures of daily sedentary time, low intensity physical activity and activities classified as sedentary, activities of daily living, and walking; however, when objective measures were compared with moderate and high intensity activities, they were significantly different (Innerd et al., 2015). This shows that older adults might be better at reporting light intensity activities, compared to moderate and vigorous intensity activities. Furthermore, a study by Harris et al. (2009) compared a physical activity questionnaire, an accelerometer, and a pedometer used by older adults. Results showed that validity was strong between the accelerometers and the pedometers, but weaker for self-reported measures. Objective measures had better construct validity as they were more strongly associated with physical activity determinants and type, and thus objective measures had greater value for researchers compared to (Harris et al., 2009). Similarly, a study done with older adults recommends using a pedometer instead of a questionnaire to estimate energy expenditure, even though the pedometer still has limitations (Colbert et al., 2011). Our study shows that the average time older adults report for physical activity is 7.3 hours and for sleep is 6.8 hours, representing only 59% of a day. This means that in general adults age 45 to 85 years old did not accurately report 24 hours of activities. In fact, less than 1% of the sample reported between 22 and 26 hours per day (range: 3-54 hours). Although, cognitive impairment could lead to older adults not being able to recall the activities done over the past seven days, this variable was included as a confounder in the analyses. Secondary analyses confirmed that cognitive impairment and age cannot explain the poor ability to report physical activity over the past seven days, since no significant difference was observed in the self-reported average time over 24 hours when comparing older adults (45-64 years of age) and younger adults (65-85 years of age) (12±4 hours vs. 12±3 hours; $p < 0.05$). Thus, using objective measures to quantify physical activity would be of value at every age despite cognitive impairment. Interestingly, even if most people underestimate the time of activities performed over a 24-hour period, they generally overestimate the intensity they performed these activities. In a given day, people will have an average MET of between 1.10 and 1.59 (Gerrior et al., 2006) which represents 11,088 to 15,120 MET/Min/Week; however, 56% of the sample studied had a MET/Min/Week outside this range. Secondary analysis revealed that younger adults reported more MET/Min/Week compared to older adults, although, not significantly different (10,292 ± 4,533 vs. 7,727 ± 3116, $p <0.05$). These sub-analysis between older and younger adults show that when reporting physical activity on a questionnaire, there are no significant differences in the time or intensity reported. This contradicts the literature as it states that when younger adults are objectively measured they tend to be more active than older adults (Colley et al., 2011; Government of Canada, 2013a).

The result that the PASE questionnaire is unable to precisely quantify activities performed by older adults is supported by many studies performed in the past. These studies demonstrate the limitations of using questionnaires to quantify physical activity (Colbert et al., 2011; Shephard, 2003; Sylvia, Bernstein, Hubbard, Keating, & Anderson, 2014). Questionnaires might be more problematic when data is collected over time and across different sites, as was done for the CLSA. For example, the interpretation of what is considered as light, moderate and vigorous can vary depending on the interviewer's perception (Krol-Zielinake & Ciekot, 2015). In this study, even though the sample underestimated the time spent doing activities and sedentary behaviour in a day, the average METs reported was still greater than what is possible (>1.59 METs (Gerrior et al., 2006)). One of the reasons for this is because of the inability to properly identify different intensities (Bouchard et al., 2013; Prince et al., 2008; Scotto, Waechter, & Rosneck, 2009; Slaght, Sénéchal, Hrubeniuk, Mayo, & Bouchard, 2017). For example, a study in 2015 by Bouchard et al. showed that older inactive adults (65+) were unable to identify what would be considered as moderate intensity, and no improvements were noticed even when they received education and a tool to help them improve the identification of moderate intensity (Bouchard et al., 2013; McLellan et al., 2018; Bouchard et al., 2015). Similar findings were observed for active adults (Prokop, Hrubeniuk, Sénéchal, & Bouchard, 2014), showing that the identification of moderate intensity is complex.

Expense and the need for qualified professionals to perform objective measurements are barriers for their use in large studies, however, given that physical activity is one of the strongest predictors of adverse health events and mortality (Sylvia et al., 2014), objective measures of physical activity are crucial for public health surveillance. In addition, other national studies already use objective measures for physical activity. For example, the National Health and Nutrition Examination Survey from the United States (NHANES, 2017) and the Canadian Health Measures Survey in Canada (Government of Canada, 2014a) use accelerometers to assess physical activity. Using objective measures would improve the precision of the measurements which would allow for the discovery of more meaningful outcomes. More policies would then be created which would encourage physical activity at a population level. With continued use of subjective measures to quantify physical activity underestimations regarding physical activity for older adults will occur, which will result in error and will impact how policies are created.

Sitting time was reported to be 3.0 ± 2.0 hours per day, which consists of 17% of a day. Comparatively, the Canadian Health Measures Survey (CHMS) (Government of Canada, 2013a), which measured physical activity using accelerometers (an objective measure), determined that individuals performed sedentary behaviour for 680 minutes per day, 74% lower when objectively measured! This comparison shows that time spent doing sedentary activities is largely underestimated and would have affected our indexes if objectively measured. Because CLSA is a study which will influence public health decisions and policies over the next 20 years, it is important to reevaluate the possibility of using objective measures of physical activity for all intensities, especially since sedentary behavior seems to be an independent predictor of many health outcomes (Chastin et al., 2015; Proper et al., 2011).

4.1 Indexes

4.1.1 Total Index

In the current study, the Total Index and the SED Index were significantly associated with the physical function score even when adjusted for meeting the current physical activity guidelines. *This means that every activity, regardless of the intensity, contributes to physical function even if someone reaches the current physical activity guidelines.* For the Total Index, when adjusted for all confounders except for if they met the guidelines, every increase of 1000 MET/Min/Week showed an increased likelihood of being above the median in the physical function score of 2-3% (OR=1.04, 95% CI= 1.03-1.05) that an individual would have a functional capacity above the median for age and sex. This means that if an individual adds 60 minutes a day of light activity, for every day of the week, he/she would have an increase of 1050 MET/Min/Week for his/her Total Index. This would increase the odds of having a functional capacity above the median for their age and sex. Obviously, there are many possibilities for how to increase MET/Min/Week. It is important to note that even if someone does not increase his/her MET/Min//Week by 1000, any increase could still have possible associated benefits.

This finding is important as it demonstrates that no matter what age, sex, race, or how many chronic conditions an individual may have, if he/she moves more in a day (regardless of the type and intensity of the activity) he/she will have a physical function score above the median for his/her allocated sex and age. Since this index was significant it suggests that there might be other activities, rather than traditional exercises, that can contribute to greater physical function. This is good news for people age above 45 years that have little desire to perform traditional exercise.

In terms of a comprehensive approach to physical activity, a similar approach has been used to promote physical activity to children in Canada (Tremblay et al., 2016). As stated by Chaput et al. (2014), even if someone reaches the current physical activity guidelines, it only accounts for about 5% of the day (Chaput et al., 2014). Most of the literature currently available that uses a comprehensive approach for movements performed in 24 hours has focused on children (Chaput et al., 2014; Tremblay et al., 2016).

These findings resulted in the publication of the 24-hour guidelines for youth in Canada. It is now recommended that children accumulate: 60 minutes of moderate-to-vigorous aerobic activity a day, including 3 days a week of vigorous activity and bone strengthening activities; several hours a day of structured and unstructured light physical activity; uninterrupted 9 to 11 hours of sleep per night, with constant bed and wake times; a maximum of 2 hours per day of recreational screen time; and limited sitting for extended periods of time (Tremblay et al., 2016). Similar guidelines are currently being developed for Canadian adults.

4.1.2 SED Index

Similar to the Total Index, the SED Index was shown to be significant when adjusted for general characteristics and whether the individuals reached the physical activity guidelines. However, this index was even more strongly associated with the outcome. For each reduction of 1 in the SED Index, a person age between 45 and 85 years old would increase the likelihood of having a physical function above the median for his/her sex and age by 6 to 8%. To improve the SED Index, individuals must move more, sit less, or both. For example, an individual who sits for 300 minutes per day, each day of the week, would have 2,520 MET/Min/Week. If this individual also performed 60 minutes of walking per day, each day of the week, he/she would have an additional 840 MET/Min/Week. This individual's SED Index ratio would be 3. To decrease this ratio, this individual could sit for 40 minutes less in a day and perform light activity, such as walking, instead. This would make his/her ratio 1.8.

The fact that this index is significant, even when adjusting for meeting the current physical activity guidelines, demonstrates that the combination of sitting less and moving more can impact the physical function of an adult age 45 to 85 years old. These findings support previous literature showing that sedentary time is an important element of someone's health (Craig et al., 2016; Guralnik et al., 1995; Santos et al., 2012). Therefore, including sedentary time in physical activity recommendations may be beneficial.

4.1.3 RT Index

Contrary to the Total and the SED Index, the RT Index was found significant depending on how the current physical activity guidelines were introduced in the model. This index displays the amount of aerobic activities that are performed compared to resistance training activities. Our result shows that only 2.5% of the sample does an equal amount of both activity, with 85.7% of the sample doing more aerobic activities. The index shows that doing both types of activity is important, because meeting the guidelines was significant for Models 3, 4, 5 despite if the RT was significant. The ratio between the two types of activities does not seem to matter, as it depends on how you adjust for the current physical activity guidelines. Even if performing more RT or aerobic activity does not seem to give older adults an advantage in terms of physical function, it is still important to note that only 30% of individuals in this study reported doing any kind of RT. This index might not come out as significant in all models of CPAG adjustments as the current physical activity guidelines are similar to the index, therefore, the ratio of the two types of activities may not be as important as simply meeting the guideline and does not offer any new information.

Strengths and Limitations/Bias

One of the limitations of this study is that it is cross-sectional. From this design only an association can be inferred, and not a causal relationship. However, it will be possible to follow these people over time as more data will be collected soon, and then available for analysis. All measures in this study were taken from a single time point, and therefore, physical activity and physical function variations throughout different weeks are unknown (Raina, Wolfson, & Kirkland, 2009). Furthermore, the data collected is not a representation of the whole country, as collection sites were only in 11 Canadian cities. These locations are all urban based, therefore, there is no representation of rural locations. In addition, not all the provinces are represented. For example, Maritime provinces such as Prince Edward Island and New Brunswick were not involved in the study. Lastly, none of the Territories were included in the CLSA data collection. Other limitations associated with CLSA data collection include the fact that a subjective measure was used to quantify physical activity, this may introduce procedural and/or response bias as there may have been pressure on the participants to answer until a time restraint or in a certain way. Additionally, only a limited number of tests were performed to assess functional outcomes. Lastly, the indexes used to quantify physical activities in a comprehensive manner all use estimated intensities to calculate MET/Min/Week. Another limitation is that the sleep time question does not account for napping throughout the day. Although napping does not show negative effects on alertness or performance measures for older adults without insomnia (Monk, Buysse, Carrier, Billy, & Rose, 2001), it does have negative effects for older adults who suffer from insomnia (Ancoli-Israel & Martin, 2006). Day napping is common among older adults (Foley et al., 2007; Picarsic et al., 2008); therefore, this may have impacted their reported amount of sleep time in the CLSA questionnaire. Lastly, although controlled for in the chronic conditions confounder, excluding all individuals with cognitive impairment may have been beneficial as those individuals may find it harder to recall the activity they engaged in over the past seven days.

Although there are limitations, the research does have many strengths. The current findings could impact how physical activity is recommended to Canadian older adults and contribute to the development of comprehensive exercise guidelines for older adults. As stated earlier, many older adults do not participate in enough physical activity to reach the current physical activity guidelines to reap functional health outcomes, however, they may engage in other activities that are associated with positive functional outcomes. Lastly, although the proposed study is cross-sectional in nature, the goal is to use the comprehensive physical activity indexes as predictors for health outcomes in later cycles of the CLSA.

Conclusion

In summary, our results suggest that both the activities currently outlined in the guidelines as well as activities not mentioned in the current guidelines should be considered important as they are all associated with the physical function of older adults. The results of this study, combined with the knowledge that most older adults do not reach the current guidelines, suggest that it is worth developing a 24-hour comprehensive approach to physical activity that may be associated with physical function. This is important because physical function predicts independence, which is a crucial outcome for older adults. Second, this study suggests that the PASE questionnaire causes individuals to underestimate the total time spent performing activities but overestimate the intensity of the reported activities.

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Appendix A

PASE – Physical Activity Scale for the Elderly

Q1a. Over the past 7 days, how often did you participate in sitting activities such as reading, watching TV, or doing crafts?	Never	Seldom (1-2 days)	Sometimes (3-4 days)	Often (5-7 days)
Q1b. On average, how many hours per day did you engage in these activities?	> 1 hour	1-2 hours	2-4 hours	< 4 hours
Q2a. Over the past 7 days, how often did you take a walk outside your home or yard for any reason? (ex. Walking to work, or for fun/exercise)	Never	Seldom (1-2 days)	Sometimes (3-4 days)	Often (5-7 days)
Q2b. On average, how many hours per day did you spend walking?	> 1 hour	1-2 hours	2-4 hours	< 4 hours
Q3a. Over the past 7 days, how often did you engage in light sport/recreational activities? (ex. Bowling, fishing)	Never	Seldom (1-2 days)	Sometimes (3-4 days)	Often (5-7 days)
Q3b. On average, how many hours did you engage in these light sports/recreational activities?	> 1 hour	1-2 hours	2-4 hours	< 4 hours
Q4a. Over the past 7 days, how often did you engage in moderate sport/recreational activities? (ex. Tennis, hunting)	Never	Seldom (1-2 days)	Sometimes (3-4 days)	Often (5-7 days)
Q4b. On average, how many hours did you engage in these	> 1 hour	1-2 hours	2-4 hours	< 4 hours

moderate sports/recreational activities?				
Q5a. Over the past 7 days, how often did you engage in strenuous sport/recreational activities? (ex. Swimming, cycling)	Never	Seldom (1-2 days)	Sometimes (3-4 days)	Often (5-7 days)
Q5b. On average, how many hours did you engage in these strenuous sport/recreational activities?	> 1 hour	1-2 hours	2-4 hours	< 4 hours
Q6a. Over the past 7 days, how often did you do exercises specifically to increase muscle strength and endurance? (ex. Lifting weights, pushups)	Never	Seldom (1-2 days)	Sometimes (3-4 days)	Often (5-7 days)
Q6b. On average, how many hours did you engage in theses strenuous sport/recreational activities?	> 1 hour	1-2 hours	2-4 hours	< 4 hours
Q7. During the past 7 days, have you done any light housework, such as dusting or washing dishes?	NO		YES	
Q8. During the past 7 days have you done any heavy housework, such as vacuuming, scrubbing floors, washing windows, or carrying wood?	NO		YES	
Q9. During the past 7 days, did you engage in home repairs such as painting or wall papering?	NO		YES	
Q10. During the past 7 days, did you engage in any lawn work such as snow removal or wood chopping?	NO		YES	

Q11. During the past 7 days, did you engage in outdoor gardening?	NO		YES	
Q12. During the past 7 days, did you engage in caring for another person, such as children or dependent spouse?	NO		YES	
Q10. During the past 7 days, did you work for pay or as a volunteer?	NO		YES	
Q10a. How many hours per week did you work for pay or volunteer?	Total Hours: ___________			
Q10b. Which of the following categories best describes the amount of physical activity required for your job?	Mainly sitting with some light arm movement	Sitting or standing with some walking	Walking with some light handling (>50 lbs.)	Walking with some heavy handling (<50 lbs.)

Appendix B

Compendium of Physical Activity

Activity	Code	MET	Description
Resistance Training	02054	4.5	Resistance (weight) training, multiple exercises, 8-15 repetitions at varied resistance
Sleep	07026	0.9	Sleeping
Light House Work	05011	2.3	Cleaning, sweeping, slow, light effort
Hard House Work	05020	4.5	Cleaning, heavy or major (e.g. wash car, wash windows, clean garage), moderate effort
House Repair	06126	4.5	Home repair, general, moderate effort
Outdoor Gardening	08065	2.3	Gardening, using containers, older adults > 60 years
Lawn Care	08125	4.5	Mowing lawn, power mower, light or moderate effort
Volunteer			
- Sitting	11770	1.25	Typing, electric, manual or computer
- Sit/Stand	11791	2	Walking on job, less than 2.0 mph, very slow speed, in office or lab area
- Light Handle	11615	4.5	Standing, moderate effort, lifting items continuously, 10 – 20 lbs., with limited walking or resting
- Hard Handle	11630	4.5	Standing, moderate/heavy tasks (e.g., lifting more than 50 lbs., masonry, painting, paper hanging)

Appendix C

PASE to MET/Min/Week Strategies

Strategy 1 - Activities that duration and frequency are available

For many of the questions in the PASE questionnaire, the amount and the frequency that an activity was performed over the past seven days was asked. This made calculating MET/Min/Week for these questions simple once the intensity was pulled from the ACSM Compendium of Physical Activities (Ainsworth et al., 2011).

For example, a question from the PASE questionnaire is: "Over the past seven days, how often did you take a walk outside your home or yard for any reason?" This provides an answer that includes frequency, time, and the type of activity. After converting hours per day into minutes, this can then be multiplied by the MET value (found in the ACSM Compendium of Physical Activities) and then by the amount of days, resulting in a MET/Min/Week value. When the frequency was provided as a range, such as 1-2 times per week, the mid-value was used. Light intensity is classified as 1-2.9 MET, moderate as 3-5.9 MET, and vigorous ≥ 6 MET (Ainsworth et al., 2000). The value that was used was the median of the range. Light was 2 MET, moderate was 4.5 MET, and vigorous was 8 MET. 8 MET was chosen based on the associated MET values for individual tasks from the NHANES questionnaire. When looking at the associated MET values for different activities 10 MET was the maximum value. Therefore, the median values between 6-10 MET is 8 MET.

Strategy 2 – Activities that only have frequency

Some questions in the questionnaire only gave the frequency an individual performed activity over the previous seven days. For example, one question asks, "Over the past seven days, how many hours did you volunteer?" Although the question only gives frequency, the questionnaire gives sub-categories that can be associated with an estimated MET value. For example, the volunteer work can be described as: 1) Sitting (light intensity), 2) Sit/Standing (moderate intensity), 3) Walk – light handle (moderate intensity), 4) Walk – hard handle (moderate intensity). With these sub-categories, we can give the activities an estimated MET value. Therefore, MET/Min/Week was created by converting hours to minutes and then multiplying the given minutes per week by the estimated MET value.

Strategy 3- Neither frequency nor duration are available

The PASE questionnaire also accounts for other activities such as indoor or outdoor house work. These questions are asked in the form of "yes" or "no", distinguishing whether the individual performed this activity over the past seven days. A previously published paper from Chad et al. (2005) was used to estimate the average amount of time older adults spend performing the given activity (Chad et al., 2005). This study collected the PASE information from 764 community-dwelling older adults with a mean age of 77.4, and 79.8% of the participants were female. Table 2 demonstrates how these indexes were calculated using the PASE questionnaire and the self-reported sleep questionnaire.

Appendix D

Calculation from The PASE questionnaire for a 62- year old female

S1 – Physical Activities				
	Days	Hours	METs	MET/Min/Week
Sitting Activities	7	8	1.8	4,368
Walking	6	2	2	1,440
Light Sport	5	3	2	1,800
Moderate Sport	2	1	4.5	540
Vigorous Sport	2	0.5	8	480
Strength Activities	2	0.5	4.5	270
Sleeping	7	6	0.9	2,268
Total				**11,166 MET/Min/Week**
S2- Work/Volunteer				
Sitting	0	0	1.25	0
Sit/Stand	7 (default)	40	2	4,800
Walk - Light Handle	0	0	4.5	0
Walk - Hard Handle	0	0	4.5	0
Total				**4,800 MET/Min/Week**
S3 - Housework				
Light House Work	7 (default)	(16.8%) 5,010	2.3	1,935.86
Heavy House Work	0	0	4.5	0
Home Repair	0	0	4.5	0
Lawn Care	0	0	4.5	0
Outdoor Gardening	0	0	2.3	0
Total				**1,935.86 MET/Min/Week**

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Comeau ME, Bouchard DR, Levesque C, Jonhson M, Rioux BV, Mayo A, Sénéchal M. (2017). Association Between Functional Movement Skills and Health Indicators in Children Aged Between 9 and 12 Years old. International Journal of Environmental Research and Public Health: 1-17

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Presentations:
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Potential Functional Benefits of a Comprehensive Evaluation of Physical Activities for Older Adults (2018) R3 Innovations in Aging Conference, Fredericton, Canada

Potential Functional Benefits of a Comprehensive Evaluation of Physical Activities in Older Adults (2018) Graduate Research Conference, Fredericton, Canada.

Elastic Band Program for Nursing Home Residents with Impaired Mobility: A Pilot Study. (2017) Excellence in Aging Care Symposium, Fredericton, Canada.

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Is there an association between fundamental movement skills and body mass index in children? (2017) Canadian Obesity Network Summit, Banff, Canada

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