PATTERNS OF SEDENTARY TIME AND PHYSICAL ACTIVITY IN OLDER ADULTS: DO SEX AND GENDER MATTER?

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DEDICATION

This thesis is dedicated to Dr. Jennifer Copeland, who has provided me with the guidance, support, and opportunities needed to succeed in my master's degree and later in my professional career. I would also like to dedicate this thesis to my parents, whose love and support is the foundation for all my success.

ABSTRACT

Prolonged sedentary time and inadequate physical activity are detrimental to the health of older adults. Sex and gender may influence health and movement behaviours that impact health. The purpose of this research was to scope the available literature on sex and gender in sedentary behaviour and then explore the relationship between biological sex and gender traits on movement behaviour patterns among older adults. In the scoping review, 210 articles were screened and 41 were identified that examined sex and/or gender in relation to sedentary behaviour in older adults. Almost all studies used sex- and/or gender-related terms interchangeably. Of the 41 articles, 28 studies suggested the division of household labour is the main explanation for any observed sex and/or gender differences in sedentary behaviour. The remaining 13 studies identified other factors that may influence this relationship, like social support, access to transportation, and area-level crime incidence. To further explore the relationship, observational data from 72 healthy older adults (80.1 ± 9.4 years) were examined. Movement behaviours were assessed using ActivPAL4™ inclinometers and participants completed the 30-Item Bem Sex-Role Inventory to assess masculine and feminine traits. There were no statistically significant associations between movement behaviour variables, sex, and masculine and feminine scores. This exploratory study demonstrates a need for consistent use of sex and gender terminology and better tools to assess gender. A more comprehensive understanding of the complexity of sex and gender in relation to health is needed to enable the creation of tailored movement behaviour interventions for the aging population.

PREFACE

M. Zdjelar and J. L. Copeland planned and designed the project and J. L. Copeland provided funding. M. Zdjelar wrote all chapters with editing done by J. L. Copeland. Chapter 2 search strategy was developed by University of Lethbridge Health Sciences Librarian, D. Scott, and the screening process was completed by M. Zdjelar and J. L. Copeland. M. Zdjelar contributed to data collection and analysis for Stand When You Can data used in Chapter 3. Ethics approval for Stand When You Can was obtained through the University of Lethbridge. All members of the supervisory committee provided editorial contributions to the proposal and thesis.

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LIST OF ABBREVIATIONS

ADL	Activities of daily living
BSRI	Bem Sex Role Inventory Questionnaire
HRQOL	Health-related quality of life
MET	Metabolic equivalent of task
MVPA	Moderate-to-vigorous physical activity
PCS	Physical component scores
QOL	Quality of life
SBRN	Sedentary Behaviour Research Network
SEM	Social Ecological Model
SGBA	Sex- and Gender-Based Analysis

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

Introduction

The world's population of older adults is rapidly increasing (United Nations [UN], 2015). It is estimated that the global population of older adults (aged 65 years and over) will reach around 2.1 billion by the year 2050, meaning it will have more than doubled from the population in 2015 (UN, 2015). For this reason, there is an increasing focus in health research to optimize well-being in older adults. Increasing physical activity and reducing passive sedentary time can have a significant beneficial impact on overall well-being and healthy aging (Copeland et al., 2017). Movement guidelines have been developed to help Canadians maintain a healthy physical lifestyle (Canadian Society for Exercise Physiology [CSEP], 2021); however, it is important to recognize that there are a variety of different factors that may influence physical activity and sedentary behaviour within specific populations, such as age, sex, gender, environment, education, socioeconomic status, cultural norms, and societal norms (Bethancourt et al., 2014; Booth et al., 2002; Chastin et al., 2015; CSEP, 2021; Statistics Canada, 2021).

What is Sedentary Behaviour and Physical Activity?

Movement behaviours include the components of physical activity, sedentary behaviour, and sleep (CSEP, 2021; Tremblay et al., 2017). *Physical activity* is defined as any voluntary movement involving skeletal muscles and increased energy expenditure above resting metabolic rate (Thivel et al., 2018; World Health Organization [WHO], 2020). Physical activity is often characterized by duration, intensity, frequency, modality, and context, while *exercise* is a type of physical activity that is planned and repetitive in nature to maintain or develop a specific physical fitness goal (Thivel et al., 2018).

Typically, physical activity is categorized by three levels of intensities: light-, moderate-, and vigorous-intensity.

In adults and older adults, *light-intensity physical activity* requires minimal physical effort and does not result in elevated heart rate or shortness of breath (CSEP, 2017). Light-intensity physical activity is described to be between the energy expenditure of 1.5 and 3.0 metabolic equivalents (METs); this can include a light walk or light household tasks (CSEP, 2017; Norton et al., 2010). *Moderate-intensity physical activity* is described to be any physical activity that has an energy expenditure between 3.0 to 6.0 METs and results in elevated heart rate; this can include activities such as a brisk walk (CSEP, 2017; Norton et al., 2010). Lastly, *vigorous-intensity physical activity* is any physical activity that substantially increases heart rate and body temperature and has an energy expenditure of more than or equal to 6.0 METs, such as running or swimming (CSEP, 2017; Norton et al., 2010). In physical health research, moderate- and vigorous-physical activity is often combined as *moderate-to-vigorous physical activity* (MVPA).

The Canadian Society for Exercise Physiology (2021) developed the Canadian 24-Hour Movement Guidelines, which provides information for every age group on the health benefits of decreasing sedentary time, increasing physical activity, and accumulating the right amount of sleep. It is recommended that Canadian adults (ages 18-64 years) and older adults (ages 65 years and over) accumulate at least a minimum of 150 minutes of MVPA per week (CSEP, 2021). In 2017, the Sedentary Behaviour Research Network (SBRN), comprised of a group of researchers and healthcare professionals, clearly defined terminology commonly used in sedentary behaviour and physical activity research; the following definitions were summarized from the SBRN project (Tremblay, et al., 2017).

Sedentary behaviour is defined as a class of behaviours characterized by low levels of metabolic energy expenditure ($\leq$ 1.5 METs) that are completed in a lying, seated, or reclined position, while awake (Tremblay et al., 2017). *Sedentary time* is the duration of time spent in any sedentary behaviour throughout the day within any context, such as at home, work, or school (Tremblay et al., 2017). However, sedentary time is not to be confused with physical inactivity. *Physical inactivity* is defined as an insufficient level of physical activity that does not meet the current recommendations for one's age and ability groups (Tremblay et al., 2017). For example, an individual may have an occupation that involves high amounts of sedentary time but could still meet the current physical activity guidelines (i.e., Canadian 24-Hour Movement Guidelines), therefore this individual would be highly sedentary but not physically inactive (Owen et al., 2010). In contrast, another individual whose occupational time is primarily spent standing or moving around but does not participate in the daily recommended physical activity guidelines would be considered physically inactive but not highly sedentary.

The majority of Canadian adults spend most of their waking hours in various sedentary behaviours (Colley et al., 2011). The 2021 Canadian Community Health Survey self-report results for adults over the age of 65 show that 44.1% of Canadian males meet the recommended physical activity guidelines, while only 37.1% of females meet the guidelines (Statistics Canada, 2022). Maintaining healthy movement behaviours among the older adult population is necessary for healthy aging, however, older adults on average are not very active. It was reported that older adults spend, on average, more than eight hours per day in sedentary behaviour, with very few meeting the minimal recommended amounts of physical activity (Colley et al., 2011; Copeland et al., 2015; Harvey et al., 2015; Matthews et al., 2008). This is consistent with device measured data from the Canadian Health Measures Survey and the US National Health and Nutrition Examination Survey, where it was reported that 69% of waking hours are spent sedentary in Canadian adults, ages 20-79 years (Colley et al., 2011), and that sedentary time increases as age increases (Sparling et al., 2015).

Sedentary Behaviour in Older Adults

Aging is often associated with increased sedentary time and decreased physical activity (Diaz et al., 2016; Dogra & Stathokostas, 2014). Older adults, on average, accumulate more sedentary time than middle-aged adults, younger adults, and children; these results from a device-based study also show that older adults aged 75 years and over accumulate more sedentary time than individuals 65 to 74 years of age (van Cauwenberg et al., 2015). Studies measuring the diurnal activity patterns in older adults found that there is a notable increase in sedentary time and decrease in physical activity throughout the day, where late afternoon and evening times had the highest reported sedentary time (van Cauwenberg et al., 2015) and lowest physical activity (Arnardottir et al., 2013; Copeland & Esliger, 2009; Davis et al., 2011). This is consistent with another study where older adults accumulated more sitting time in the afternoon and evenings, in comparison to morning time (Leask et al., 2015), possibly as a way of regulating energy expenditure throughout the day (Chastin et al., 2014).

With aging, there is often a change in routine and/or living environment. It has been consistently reported that older adults in residential communities, such as independent and assisted living residences, spend more time sedentary than their community-dwelling peers (Brach et al., 2019; Kotlarczyk et al., 2020; Voss et al., 2020a). Activities of daily living (ADLs) are often provided for residents in congregate living environments (i.e., housekeeping and cooking) (Voss et al., 2020b; Zimmerman &

Sloane, 2007), thus encouraging participation in more sedentary activities, such as reading, watching television, or computer use (Sebastião et al., 2019). These sedentary activities may have beneficial or detrimental consequences on the physical function, cognitive function, quality of life, and well-being of older adults in residential communities (Rosenberg et al., 2016).

Consequences of Physical Inactivity and Sedentary Time on Physical Function

Healthy physical function in older adults is important for performing basic and instrumental ADLs and maintaining the ability to complete ADLs is critical for successful aging (Dogra & Stathokostas, 2012; Garber et al., 2010). Older adults are the most at risk for functional limitations and disability, thus it is imperative to understand the consequences that prolonged periods of sedentary time and lack of physical activity have on overall physical function (Copeland et al., 2017). Decreased physical activity and increased sedentary behaviour have been well documented as risk factors for overall health and well-being, and older adults spend the most time in sedentary behaviour and least time in physical activity compared to any other age group (Colley et al., 2011; Matthews et al., 2008). This is a concern as research shows that participating in high amounts of sedentary time and low physical activity is associated with a decline in physical function in older adults (Rojer et al., 2021).

Both excessive sedentary time and physical inactivity can have detrimental effects on health, however they are independent health risks (Balboa-Castillo et al., 2011; Gennuso et al., 2013; Katzmarzyk et al., 2009; Rosenberg et al., 2016). While physical activity guidelines exist for older adults, it may not be feasible to adhere to the weekly recommended physical activity guidelines, especially for those in assisted living residences. However, participating in any level of physical activity, even if under the recommended 150 minutes per week, may have positive associations with physical function and mortality risk (Hupin et al., 2015). It was found that older adults who performed less than 150 minutes of MVPA per week had a 22% reduced risk of mortality in comparison with those who do not or are unable to engage in only MVPA (Hupin et al., 2015). Thus, participating in any level of MVPA in older adults is beneficial, regardless of if they are able to meet physical activity guidelines or not.

Older adults who follow the daily physical activity recommendations have reduced risk of all-cause cardiovascular disease and mortality, functional and cognitive limitations, fractures, risk of falling, ADL disability, cancer, type II diabetes, musculoskeletal diseases, dementia, and depression (Cunningham et al., 2020; de Rezende et al., 2014; Healy et al., 2011; Paterson et al., 2010; WHO, 2010). A meta-analysis of prospective cohort studies found that individuals with high levels of physical activity had 38% reduced risk of cognitive decline and participating in low-to-moderate levels of physical activity resulted in 35% reduced risk of cognitive decline (Sofi et al., 2010). This was summarized in a recent systematic review, concluding that participating in physical activity has a positive association on physical function with quality of life and improved cognitive function (Cunningham et al., 2020).

Over the last two decades, there has been growing research on sedentary behaviour as a risk factor for functional impairments and mortality (de Rezende et al., 2014). In older adults, prolonged periods of daily sedentary time have been associated with an increased risk of cardiovascular disease and all-cause mortality (de Rezende et al., 2014; Katzmarzyk et al., 2009; Matthews et al., 2012; Owen et al., 2010; Patel et al., 2010; Pavey et al., 2012; Powell et al., 2018). Specific sedentary behaviours, such as television viewing time, have additionally been associated with increased risk of all-cause mortality (Copeland et al., 2017; Keadle et al., 2015; Saunders et al., 2020), with one study stating that watching television for more than five hours a day can increase the risk of mortality to 28% (Keadle et al., 2015). In addition to cardiovascular disease and all-cause mortality risk, sedentary behaviour was also associated with decline in cognitive function, increase in depressive symptoms, risk of disability, decreased physical activity levels, and negative physical health-related quality of life in adults (ages 18-64 years) and older adults (ages 65 years and over) (Saunders et al., 2020).

Consequences of Sedentary Time on Cognitive Function

Increasing age is a risk factor for certain cognitive impairments, such as dementia (WHO, 2023). Currently, there are over 55 million people living with dementia, globally; dementia is one of the most common cognitive impairments in older adults and this number is estimated to increase by 10 million cases each year (WHO, 2023). Poor cognitive function is a risk factor for cognitive impairment and disability of ADLs (Copeland et al., 2017; Rajan et al., 2012). As the older adult population rapidly increases, it is important to understand how movement behaviours influence cognitive function (Nagamatsu et al., 2014).

Regularly meeting physical activity guidelines reduces risk of all-cause dementia, along with promoting and maintaining healthy cognitive functioning later in life (Cunningham et al., 2020; Falck et al., 2017; Nagamatsu et al., 2014). While evidence shows that increasing physical activity can promote physical and cognitive health (Cunningham et al., 2020), little is known about the effects of sedentary behaviour on cognitive function (Copeland et al., 2017). A recent systematic review demonstrated strong evidence that living a highly sedentary lifestyle is negatively associated with cognitive function, particularly with memory, executive function, and global cognition scores (Falck et al., 2017). This was evident in a large longitudinal study, where it was found that over six hours of television viewing time per day resulted in higher depressive symptoms in a group of independent English older adults (aged > 60 years) and worse global cognitive function (coefficient: -1.16, 95% CI: -1.00 to -1.31), while the inverse relationship occurred in individuals who participated in cognitively stimulating sedentary activities, such as internet use (Hamer & Stamatakis, 2014). Clearly the relationship between sedentary behaviour and cognitive function is highly complex and it may be beneficial to explore the specific dose and mode of sedentary behaviour and cognitive activities (Copeland et al., 2017; Falck et al., 2017; Kesse-Guyot et al., 2012).

Popular sedentary activities among older adults are often cognitively engaging (Dontje et al., 2018). Passive sedentary activities, such as watching television, are negatively associated with cognitive function (Copeland et al., 2017; Kesse-Guyot et al., 2012; Raichlen et al., 2022; Saunders et al., 2020). However, cognitively engaging activities, such as computer use, have been associated with better cognitive function in both verbal memory and executive functioning (Copeland et al., 2017; de Rezende et al., 2014; Kesse-Guyot et al., 2012; Saunders et al., 2020; Verghese et al., 2003), as well as reduced odds of developing mild cognitive impairment and dementia by 30-50% (Geda et al., 2011; Raichlen et al., 2022; Verghese et al., 2003). These findings are consistent with previous literature where different types of sedentary behaviour may have different associations with cognitive function in older adults (Copeland et al., 2017). This highlights the association of sedentary behaviour with human brain health, suggesting that the effects of leisure sedentary time on cognitive function is context specific (Raichlen et al., 2022).

The intention of some cognitive research is to help delay onset and progression of cognitive impairments and dementia with improvements to physical activity and sedentary behaviour (Nagamatsu et al., 2014). In addition to meeting current physical activity guidelines, it is recommended that older adults break up their uninterrupted sitting time every 30 minutes and replace this passive sitting time with light-intensity physical activity to reduce the risk of development of cognitive impairments (Falck et al., 2017). While sedentary behaviour and physical activity have influence on physical and cognitive functioning, they may also influence quality of life and well-being in older adult populations.

Consequences of Sedentary Time on Quality of Life & Well-Being

The World Health Organization (2012) defines *quality of life* (QoL) as an individual's internalized perception of their own life and experiences, in terms of cultural influence and personal value systems. This multi-dimensional concept impacts the overall physical, mental, and social aspects of one's life (Balboa-Castillo et al., 2011; WHO, 2012). Six domains have been identified by the World Health Organization (2012) that influence QoL: physical health, psychological state, independence level, social relationships, environment, and personal/religious/spiritual beliefs. Overall QoL and well-being often decreases with aging, however behaviours that affect QoL, such as physical activity and sedentary behaviour, may be modified to maximize QoL and well-being as we age (Balboa-Castillo et al., 2011).

Studies show that habitual movement behaviour can affect QoL within *health-related quality of life* (HRQoL) domains (Hakimi et al., 2022; Saunders et al., 2020). A survey using the EQ-5D-5L health status questionnaire on a population of Spanish community-dwelling older adults revealed that this specific population of older adults rated psychological state and depression, functional independence, and social relationships as the most important dimensions for their QoL (Martinez-Martin et al., 2012). This shows how important the social, physical, and mental domains of QoL are to older adults' overall health.

A recent systematic review published by Hakimi, and colleagues (2022), examined all existing evidence on the associations between QoL and movement behaviours in community-dwelling healthy older adults. The results showed that MVPA was strongly and positively associated with all domains of QoL, and that cognitively stimulating activities (e.g., reading or computer use) were positively associated with QoL, while passive and less stimulating sedentary activities, such as leisure screen time (e.g., watching television) had detrimental associations with the physical domain (Hakimi et al., 2022). One of the studies in this review was Sansano-Nadal and colleagues (2021), and they reported that device-measured MVPA was significantly associated with the physical component scores (PCS) of the 12-Item Short-Form Health Survey (SF-12) questionnaire, which is used to describe an individual's self-reported perception of their HRQoL; for every one hour increase in MVPA, there was an increase of 6.4 units in the physical component score in the fully adjusted model (average PCS: 45.0 ± 9.1).

Similar findings were reported in a cross-sectional isotemporal substitution study, which allowed for comparing substitutions in activity types, examining the associations between physical activity intensities and QoL and well-being (Buman et al., 2010). This study reported that replacing 30 minutes of sedentary time a day with light-intensity physical activity or MVPA was positively associated with the physical health domain of QoL (Buman et al., 2010). Another study using isotemporal substitution analysis reported that replacing sitting time with light-intensity physical activity for one hour per day was associated with improved QoL in the physical health domain (Balboa-Castillo et al., 2011). This was further explored in a systematic review and meta-analysis by Boberska and colleagues (2018), where they concluded that lower levels of sedentary time were associated with better HRQoL in the physical health domain.

Within the psychological domain of QoL, older adults had better psychological well-being when participating in light-intensity physical activity, such as walking (Hakimi et al., 2022). When participating in MVPA, it was found that older adults had improved mental and emotional well-being, as well as life satisfaction (Hakimi et al., 2022). Similar to cognitive function, sedentary behaviour was associated with QoL (Hakimi et al., 2022). For example, one cross-sectional study using isotemporal substitution analysis found that re-allocating 30 minutes a day from other movement behaviours (such as sedentary behaviour and sleep) towards MVPA resulted in a 3% increase in self-reported EQ-5D-5L health questionnaire scores, as opposed to 30 minutes of less MVPA and more sedentary time, which resulted in a 4% decrease in self-reported EQ-5D-5L scores (Verhoog et al., 2020).

Evidence suggests that decreasing sedentary time among older adults has the potential to decrease the risk of depression (da Costa et al., 2023; Saunders et al., 2020), cardiometabolic disease (Powell et al., 2018), all-cause mortality (de Rezende et al., 2014), and impaired cognitive and physical function (Copeland et al., 2017), as well as improve QoL and well-being (Hakimi et al., 2022). While the overall negative impacts of prolonged sitting time and low physical activity have been examined throughout the literature, it is more difficult to measure the specific determinants behind these behaviours. Therefore, in order to improve healthy aging initiatives and provide recommendations to specific populations about healthy movement behaviours, we must understand the determinants of sedentary behaviour and physical activity in older adults.

Determinants of Sedentary Time in Older Adults

As age increases, there are many physiological changes that occur, such as a decrease in physical function and mobility limitations (Booth et al., 2002; Greenwood-Hickman et al., 2016; Kotlarczyk et al., 2020; Tam-Seto et al., 2016), pain and stiffness (Chastin et al., 2014; Voss et al., 2020a), and fatigue (Greenwood-Hickman et al., 2016; Kotlarczyk et al., 2020; Sparling et al., 2015; Voss et al., 2020a). However, the physiological changes that occur during aging do not solely determine the amount of sedentary time one participates in, but also factors such as environment or social surroundings.

Multiple factors determine sedentary behaviour across different populations and age groups (Kotlarczyk et al., 2020; Owen et al., 2011). The Social Ecological Model (SEM) states that behaviour is influenced by individual, social, environmental, organizational, and policy factors (Stokols, 1996). Owen and colleagues (2011) identified four domains that influence sedentary behaviour: household, leisure, occupation, and transportation. These four domains have been cited across multiple studies that explore determinants of sedentary behaviour among independent living and community-dwelling older adults.

Adults and older adults who live independently must complete ADLs, such as daily household chores, which is a key factor for maintaining daily physical activity (Owen et al., 2011). Older adults often transition to disability-friendly living residences due to changes in physical and mental wellness, however, this is drastically different from independent living (Brach et al., 2019). In some assisted living residences, services such as housekeeping, cooking, and transportation are carried out by staff members, while allowing the residents to maintain independence and facilitate social interactions (Brach et al., 2019; Dontje et al., 2018; Kotlarczyk et al., 2020; Voss et al., 2020b; Zimmerman & Sloane, 2007). While assisted living provides residents with assistance for some daily activities, as well as 24-hour medical emergency (Voss et al., 2020b; Zimmerman & Sloane, 2007), it eliminates the need for individuals to complete daily household tasks, and as a result it reduces the opportunity for engaging in light physical activity and increases sedentary behaviour (Dontje et al., 2018; Kotlarczyk et al., 2020; Palmer et al., 2019). Thus, older adults who live in assisted living residences spend significantly more time sedentary than their community-dwelling peers (Brach et al., 2019; Voss et al., 2020b). Household tasks are a key domain for maintaining activity among older adults, and a change in this domain may lead to changes in habitual movement.

A recent qualitative study conducted semi-structured focus groups with Canadian older adults in assisted living (Voss et al., 2020a). Nine common themes for motivations to reducing sedentary behaviour were identified during the focus groups that follow the individual, social, and organizational domains of the SEM: device use, avoiding discomfort of prolonged sitting time, prevent loss of mobility, availability of meal services, sense of obligation, self-identity, social encouragement and engagement, companionship, and availability of interesting activities (Voss et al., 2020a). However, some barriers to reducing sedentary behaviour included themes such as fear of falling, social norms, environment, lack of transportation, lack of ADLs, and absence of weekend activities (Voss et al., 2020a); these barriers were common themes for residents transitioning from individual living to assisted living environments. The results are consistent with another study conducted in the United States, where older adults reported that living environment and change in routine when transitioning to assisted living facilities contributed to an increase in sedentary behaviour (Kotlarczyk et al., 2020).

In addition to physical barriers and changes in routine, older adults are often perceived by society as a highly sedentary and fragile age group, and are encouraged by family, friends, and caregivers to sit more frequently (Chastin et al., 2014; Greenwood-Hickman et al., 2016; Palmer et al., 2019; Tam-Seto et al., 2016; Voss et al., 2020a). This results in the fear of instability, lack of confidence, or the individual sense that they will be a burden to anyone if they fall or feel fatigued (Chastin et al., 2014; Dogra & Stathokostas, 2014; Voss et al., 2020a). Fear of falling is often a concern when regarding environmental factors, where older adults do not feel safe going for walk with the lack of rest areas in residential or congregate living environments (Chastin et al., 2014; Greenwood-Hickman et al., 2016; Kotlarczyk et al., 2020; Tam-Seto et al., 206; Voss et al., 2020a). Furthermore, older adults often enjoy sedentary activities, such as reading, which can be cognitively stimulating and difficult to perform while standing or walking (Dontje et al., 2018), thus encouraging prolonged sitting time (Greenwood-Hickman et al., 2016; Tam-Seto et al., 2016; Voss et al., 2020a). While sedentary behaviour is influenced by many different factors, as stated by the SEM, two individual factors that are known to impact health and health behaviours, are sex and gender.

Sex and Gender as Determinants of Movement Behaviour

Many movement behaviour studies focus on sex-related effects, due to the physiological differences of the male and female body, which are assumed to be easier to quantify within health science research. While sex- and gender-related factors have been cited in the literature as important predictors for physical and cognitive health (Copeland et al., 2017), the terms ‘sex’ and ‘gender’ are often misused or mentioned briefly but not elaborated on (Williams et al., 2023).

The term *sex* refers to the biological features of the human body; this includes physiological features of gene expression, chromosomes, hormone levels and functionality, and the physical reproductive anatomy (National Academy of Science [NAS], 2022). The term *gender* is a sociocultural construct that encompasses the expression, behaviour, role, and identity of an individual and how they perceive themselves within society (NAS, 2022; Mauvais-Jarvis et al., 2020). *Gender expression* refers to the way an individual expresses themselves within society, typically through appearance and behaviour (NAS, 2022). Gender exists on a continuous scale and is not confined strictly to masculinity and femininity but is fluid and may change over time (NAS, 2022; Vafaei et al., 2014). Furthermore, *gender norms* determine positional power of individuals within society (Mauvais-Jarvis et al., 2020; NAS, 2022; Shannon et al., 2019). Due to the everchanging nature of the term ‘gender’, it is often overlooked in health research and medical practices, as it may be difficult to understand or categorize in the physical sciences (Mauvais-Jarvis et al., 2020).

A cross-sectional study of Dutch older adults aimed to describe movement behaviours and their correlates in older adults using device-based measures of activity (van Ballegooijen et al., 2019). It was found that 72% of men were highly physically active and highly sedentary compared to only 28% of women who had a similar movement pattern. Women tended to have low physical activity and low sedentary time (70%), in contrast to only 30% of men having similar movement patterns (van Ballegooijen et al., 2019). This is in line with other self-report studies that found that men spend more time in MVPA compared to women, who spend more time in light-intensity physical activity (Davis et al., 2011; Li et al., 2017; Troiano et al., 2008; van Ballegooijen et al., 2019). A possible explanation for gender differences in physical activity may be that men prefer to engage in more MVPA than women, despite older females reporting less sedentary time than older males (Colley et al., 2022; Statistics Canada, 2021).

Results from the 2018/2019 Canadian Health Measures Survey study indicated that men would prefer to engage in physical activity due to higher confidence and overall body strength while women were more motivated to be physically active if they received external support (Statistics Canada, 2021). Self-report data collected from the Canadian Community Health Survey showed that men were more confident engaging in physical activity, in addition to having the time and finances for different forms of physical activity (Statistics Canada, 2021). Furthermore, previous research showed that, on average, women do twice as much household chores as their male partners, who often contribute to more traditionally “masculine” household chores, such as home repairs (Cerrato & Cifre, 2018). These differences in gender roles could broadly explain why women spend more time in light-intensity physical activity. However, these examples oversimplify the relationship between overall health and sex- and gender-related factors while relying solely on the male/female (sex) or man/woman (gender) binary variables (Williams et al., 2023).

Studies of habitual movement behaviour in older adults focus on sex-related factors for explaining differences in physical function, and for targeting individuals for training interventions (Ghareeb et al., 2022). However, research suggests that gender traits can affect physical function and well-being independently of biological sex (Ahmed et al., 2016; Canadian Institutes for Health Research [CIHR], 2019; Mauvais-Jarvis et al., 2020; van Ballegooijen et al., 2019). Gender may be associated with health behaviour and overall health outcomes among older adults (Willerth et al., 2020). Yet, through examination of the current literature, little research has been done to account for gender traits in sedentary behaviour and physical activity intervention strategies among older adults beyond the binary variables of ‘man’ and ‘woman’.

There is a growing understanding of the importance of considering gender traits in health research (CIHR, 2019; Mauvais-Jarvis et al., 2020; Williams et al., 2023). Although sex differences can help explain the pathophysiology of disease through genetic, epigenetic, and hormone regulations in clinical research, societal roles can influence behaviours that impact disease representation and health promotion (Mauvais-Jarvis et al., 2020; Shannon et al., 2019). For this reason, gender equality in health research is necessary for inclusivity, global health, economic and social gain, as well as reducing mortality (Shannon et al., 2019).

Currently, only 50% of the research projects funded by the Canadian Institutes of Health Research consider sex- and gender-related variables, while 28% of publications refer to sex- and gender-specific results in text and in the findings (CIHR, 2019). Many studies in the health sciences and biomedical research focus primarily on sex-related variables as it is assumed to be easily quantifiable due to its nature of dichotomous categorization; however, in a study done by Garcia-Sifuentes and Maney (2021), appropriate statistical tests for examining sex-specific effects are not always used and sex differences are often misrepresented. For this reason, appropriately examining sex and gender in health research is necessary for better representation in the scientific field (Mauvais-Jarvis et al., 2020). When sex and gender are not accounted for in health research, there is a missed opportunity to individualize health aid and optimize disability-free life expectancy (CIHR, 2019). As such, the purpose of the following research is to scope the available literature on sex and gender in sedentary behaviour research among older adults, clarify key terms and concepts, identify the knowledge gaps in the literature that need further exploration, and to give an example of how gender might be explored beyond dichotomous variables as a factor that may impact movement behaviours.

CHAPTER 2: SCOPING REVIEW

Background

As life expectancy increases, the older adult population is rapidly increasing (United Nations [UN], 2015). It is estimated that older adults (aged 65 years and over) will comprise 2.1 billion members of the world's total population by 2050, which is more than double the amount from 2015 (UN, 2015). These demographic changes have increased attention on the promotion of healthy aging and well-being among older adults. Older adults are the most sedentary age group and spend, on average, more than nine hours per day in sedentary pursuits (Harvey et al., 2015). This is a problem because research demonstrates that accumulating high amounts of sedentary time poses many health risks for older adults (Saunders et al., 2020). It is important to understand the determinants of highly sedentary behaviour to help minimize health risk to the aging population.

Sedentary behaviour is defined as a class of behaviours that are completed in a lying, seated, or reclined position, while awake, and requires a low energy expenditure of less than 1.5 metabolic equivalents (METs) (Tremblay et al., 2017). The duration of time spent in any of these behaviours is referred to as *sedentary time* (Tremblay et al., 2017). Prolonged periods of sedentary time are associated with many adverse health outcomes independent of physical activity, such as increased risk of cardiometabolic disease (Powell et al., 2018), impaired cognitive function (Copeland et al., 2017; Raichlen et al., 2022), impaired physical function (Copeland et al., 2017; Rojer et al., 2021), risk of depression (da Costa et al., 2023; Saunders et al., 2020), lower health-related quality of life (Saunders et al., 2020), and increased all-cause mortality (de Rezende et al., 2014). Reducing sedentary time and breaking up sedentary patterns may be beneficial for health outcomes in older adults. For example, lower levels of sedentary time are associated with better physical function (Dogra et al., 2017; Panten et al., 2017; Sardinha et al., 2015), better self-rated overall and mental health (Panten et al., 2017), reduced metabolic disease risk (Healy et al., 2008), better cardiorespiratory fitness (Dogra et al., 2017; Sardinha et al., 2015), and better physical health-related quality of life (Boberska et al., 2018). Therefore, decreasing sedentary time, by breaking up sitting time or sedentary activities, may be beneficial to older adults' cognitive and physical function. As such, it is critical to understand the variables that affect sedentary behaviour to inform intervention strategies and facilitate better sedentary behaviour in older adults.

Determinants of sedentary behaviour are complex and include factors such as age, socioeconomic status, body mass index, education level, and sex and/or gender. *Sex* refers to the biological features of the human body and the physical reproductive anatomy assigned at birth, while *gender* is a sociocultural construct that is comprised of behaviour, expression, role, and identity of an individual and how they perceive themselves within society (National Academy of Science [NAS], 2022; Ritz & Greaves, 2022). Sex- and gender-related factors may affect both sedentary behaviour and health. A systematic review of studies from more than 10 countries reported that older men tend to spend more time in sedentary pursuits than older women (Harvey et al., 2015). Despite this finding, the sex- and gender-related variables are often examined only superficially in research and are sometimes misused and misrepresented (Williams et al., 2023).

A recent study by Williams and colleagues (2023) concluded that relationships between sex- and gender-related factors and health outcomes are often oversimplified in the literature and tend to rely on the dichotomization of sex and gender variables as male/female and man/woman, respectively. Similarly, sedentary behaviour research in older adults often stratifies results by sex, likely due to perceived effect of physiological differences between males and females on health. Although gender is often overlooked in health research, we know that sociocultural factors also influence health and health behaviours (Ritz & Greaves, 2022).

The objective of this scoping review was to determine if there are sex or gender differences in sedentary behaviour among older adults. As part of the scoping review, we also wanted to clarify how researchers were defining and measuring sex and gender and identify the knowledge gaps in the literature that need further exploration.

Methods

This review followed the Joanna Briggs Institute method for evidence synthesis (Peters et al., 2020) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for the Scoping Reviews Checklist (PRISMA-ScR) (see Appendix 1) (Tricco et al., 2018).

Eligibility Criteria

To explore sex or gender differences in sedentary behaviour research among older adults, we included studies that met the following criteria: peer-reviewed papers, theses, or dissertations (grey literature); published in the English language; available in full-text; included older adults (a sample or sub-sample with a mean age of at least 65 years and a minimum age of 60 years). Reviews or qualitative studies were included; conference abstracts were excluded. Additionally, the research needed to include an assessment of sedentary behaviour or sedentary time (device-based measures or self-report) and examine sex and/or gender differences in relation to sedentary behaviour. Studies that simply provided demographic information for males/females and men/women separately were excluded. Studies that conducted a sex- and gender-based analysis (SGBA) in relation to sedentary behaviour were included. As gender is an evolving social construct, there were no limits established for date of publication. In some instances, the term 'physical inactivity' was used instead of 'sedentary behaviour', therefore terminology and definitions of sedentary behaviour, time, and activities, were carefully considered.

Information Sources and Search Strategy

Studies published in the bibliographic databases of MEDLINE, APA PsycINFO, Web of Science, and SPORTDiscus were searched on August 3 and 9, 2023, by a health sciences librarian. Search terms were identified through consultations between the librarian (DS) and other members of the research team (MZ and JLC) and a review of the titles and abstracts of four seed articles (Ashe et al., 2020; Bellettiere et al., 2015; Compernolle et al., 2021; Prince et al., 2020). Elements of search strings developed for previously published reviews also informed the search strategy (Chastin et al., 2021; Demicheli et al., 2018; Jayanti et al., 2022). The search string was first developed for MEDLINE (Figure 1) and then adapted for the other three databases. Search results for each database are provided in supplementary data (Appendix 2, Table S1). The final results of the search were exported into EndNote™ 20 software (Clarivate, Philadelphia, PA, USA) and then into the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) for the screening process.

When possible, subject headings from controlled vocabularies (e.g., MeSH) were used in the search. To increase sensitivity, concepts were also entered in the search string as keywords, with truncation (e.g., watch*), and proximity operators (e.g., adj3) used when appropriate. Boolean operators connected subject headings and keywords as shown in Figure 1. No limits were placed on publication date, though results were limited to work written in English.

Figure 1

MEDLINE Search Strategy for Scoping Review

1. exp Aged/ [MeSH]
2. exp Geriatrics/ [MeSH]
3. ((old* or age*) adj3 (people* or person* or adult* or women* or men* or citizen* or residen*)).mp.
4. (elderly or senior* or geriatric*).mp.
5. or/1-4
6. exp Gender Identity/ [MeSH]
7. Sex Factors/ [MeSH]
8. gender*.mp.
9. sex.mp.
10. or/6-9
11. Sedentary Behavior/ [MeSH]
12. Screen Time/ [MeSH]
13. (sedentary adj (behavior* or behaviour* or time)).mp.
14. (physical* adj inactiv*).mp.
15. ((television or TV or driv* or computer* or screen or screens) adj2 time).mp.
16. ((television or TV or screen or screens) adj2 (watch* or view*)).mp.
17. or/11-16
18. 5 and 10 and 17
19. limit 18 to english language

Note. Abbreviations: MeSH = medical subject heading; exp = used with a MeSH term to include all narrower MeSH terms; .mp. = field code for multi-purpose; adj# = search for records with terms within # words of each other; * after keyword indicates truncation (e.g., watch* will retrieve "watch", "watched", "watching", etc.).

Selection of Sources of Evidence

After the eligibility criteria were established, the screening process was done independently by two researchers (MZ and JLC) using the Covidence software (Veritas Health Innovation, Melbourne, Australia). In the initial title/abstract screening phase, if a publication did not provide enough information for the researchers to confidently exclude from the results, then that publication was included for the full-text review. After each round of title/abstract and full-text screening, the researchers met to resolve any conflicts and revise, if necessary, the eligibility criteria.

Data Extraction and Data Items

After the full-text review was completed independently by both researchers, data extraction was performed by one researcher (MZ) using Microsoft Excel (Microsoft Corp., Redmond, WA, USA). The following information was extracted from all eligible studies: study design (cross-sectional, scoping review, randomized control trial, longitudinal), location (country), study population (community-dwelling), age (range and mean), number of participants, inclusion and exclusion criteria, method of recruitment, demographic information (in-person or online questionnaires, surveys, interviews), sedentary behaviour (measurement, type, sex and/or gender stratification, age stratification), sex and/or gender assessment (measurement and terminology used), and where were sex and/or gender discussed (e.g., introduction, methods, results, discussion, conclusion). Study investigator (JLC) reviewed data extraction to ensure consistency and accuracy.

Synthesis of Results

Once data extraction was completed by MZ and reviewed by JLC, data were summarized by MZ. Studies were examined for how sex and/or gender were assessed in relation to sedentary behaviour, terminology of sex- and gender-related variables used, how these variables were discussed, and whether they addressed the objectives of this scoping review. Results were grouped by two common themes that arose in the study results and discussion sections: whether the results considered sex and/or gender as a determinant of sedentary behaviour or as a moderator of the health effects of sedentary behaviour.

Results

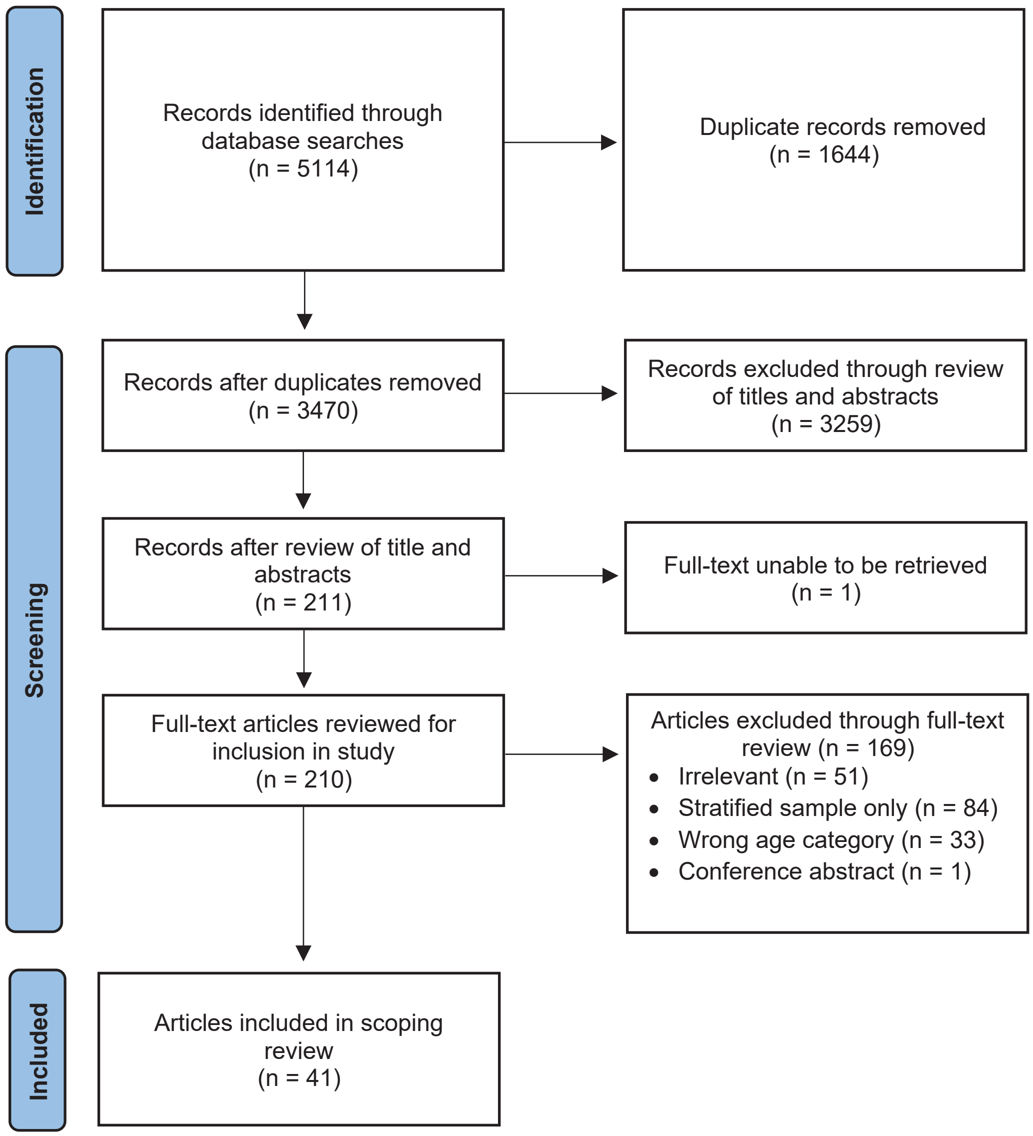
Study Selection

The bibliographic information (e.g., title, abstract, authors, publication information, subject headings) for each search result was imported into EndNote™ 20 for deduplication and review. A total of 5114 results were returned from the four database searches (Appendix 2, Table S1). After duplicates were removed using the Bramer method (Bramer et al., 2016), 3499 unique records remained for potential inclusion in the study. These records were then imported into Covidence software and independently reviewed by two researchers (MZ and JLC). An additional 29 duplicates that were not detected during the initial deduplication process were identified, with 3470 records remaining for title and abstract screening.

Through the initial review of the title and abstract screening information in the records, 3259 items that did not meet the inclusion criteria were removed from consideration. Of the 211 remaining records, the full texts of 210 were gathered for the second full-text review and one item could not be retrieved neither through the library's collections nor the interlibrary loan. Two researchers independently conducted the full-text review (MZ and JLC), removing a further 169 items from consideration and identifying 41 items for inclusion in the study, including one scoping review. Of the 169 items removed, 84 studies simply stratified their sample by sex and/or gender and sedentary behaviour, however there was no further analysis of the sex and/or gender effects with sedentary behaviour, therefore they were excluded. See Figure 2 for a flow diagram of the review process.

Figure 2

PRISMA Flow Diagram



Note. Flow chart of the screening and study selection process following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021).

The remaining 41 studies were analyzed and discussed; 26 studies analyzed sex and/or gender as a determinant of sedentary behaviour and 15 studies explored how sedentary behaviour may affect health outcomes differently between the sexes and/or genders. Of the 41 items included, 28 identified the division of household labour between genders as the main source of differences between sedentary behaviour and sex and/or gender, eight of which considered sex and/or gender as a moderator of health effects of sedentary behaviour. As a result, studies that provided a simple explanation of key findings based only on the division of household labour are presented in the supplementary data (Appendix 3, Table S2) and the remaining 13 items that were identified as addressing the research question in a more comprehensive manner are presented in Table 1.

Study Characteristics

The items included were published between 2013 and 2022 (see Table 1). These studies were conducted in 8 different countries: Japan (*n* = 3) (Kikuchi et al., 2013; Shibata et al., 2022; Sumimoto et al., 2021), Canada (*n* = 2) (Ashe et al., 2021; O'Neill & Dogra, 2016), Taiwan (*n* = 1) (Lin et al., 2019), New Zealand (*n* = 1) (Wright-St Clair et al., 2017), Scotland (*n* = 1) (Strain et al., 2018), Sweden (*n* = 1) (Finkel et al., 2018), Belgium (*n* = 1) (Compernolle et al., 2021), and Spain (*n* = 1) (Marquet et al., 2020). Two studies used data from multiple different countries (Bergens et al., 2021; Leung et al., 2021). A majority of studies were cross-sectional in nature (*n* = 10) (Ashe et al., 2021; Bergens et al., 2021; Compernolle et al., 2021; Kikuchi et al., 2013; Lin et al., 2019; Marquet et al., 2020; O'Neill & Dogra, 2016; Shibata et al., 2022; Strain et al., 2018; Sumimoto et al., 2021), two were longitudinal cohort studies (Finkel et al., 2018; Wright-St Clair et al., 2017), and one was a review (Leung et al., 2021). Characteristics of the 41 items included are summarized in Appendix 3 (Table S2).

Table 1

Summary of Key Findings (n = 13)

Author, Year, Location, and Study Design	Participants (Older Adults)		Sedentary Behaviour		Sex and/or Gender		Key Findings
	N (*n* or % women)	Age (mean ± sd and/or range)	Type	Measurement	Terminology Used	SGBA	
Ashe et al. (2021); Canada; Cross-sectional	224 (112)	71.1 (5.9)	Sedentary activities; Total ST	ActiGraph GT3X; Self-report questionnaire (CHAMPS)	Gender	Sex and/or gender as a moderator of SB effects on health	Older men reported having ↑ computer screen time and total ST per day than older women; No statistically significant associations between SB and hsCRP in older men and women; Older men and women may have different approaches to maintaining health
Bergens et al. (2021); Europe; Cross-sectional	229 (146)	Women: 67.4 (1.6) Men: 67.4 (1.5)	Total ST; Sedentary bouts	ActiGraph GT3X+	Both	Sex and/or gender as a moderator of SB effects on health	↑ ST in females = ↑ IL-6 and fibrinogen; ↑ ST in males = ↓ IL-10; Sex-related differences between SB patterns and pro-anti-inflammatory biomarkers in older adults may be explained by differences in hormone levels between males and females
Compernolle et al. (2021); Belgium; Cross-sectional	696 (373)	74.2 (6.2)	Sedentary activities	Self-report questionnaire (BEPAS; Busschaert)	Both	Sex and/or gender as a determinant of SB	Types of SB and duration of ST within each type vary between older men and women
Finkel et al. (2018); Sweden; Longitudinal cohort (17-year follow-up)	1398 (59%)	64.9 (range: 36-91)	Sedentary activities	Self-report questionnaire	Both	Sex and/or gender as a determinant of SB	Sedentary activities vary between genders; Social, cognitive, and physical activities ↓ after age 70; Women participated in more cognitive/sedentary activities than men; Social activities ↓ in men
Kikuchi et al. (2013); Japan; Cross-sectional	1665 (800)	Women: 69.6 (2.9) Men: 69.5 (3.0)	Sedentary activities (TV time)	Self-report questionnaire	Gender	Sex and/or gender as a determinant of SB	TV viewing time varies among Japanese men and women and sociodemographic correlates; Women ↑ TV viewing time if they lived alone, did not drive, were overweight, located in a regional area, and had ↓ MVPA; Men ↑ TV viewing time if they were overweight or underweight, not employed full-time, had ↓ education and ↓ MVPA

Leung et al. (2021); United States, Australia, United Kingdom, Canada, The Netherlands, and Spain; Scoping review (*n* = 18 studies)	1059 (42-90%)	Range: 61-101	Total ST; Sedentary activities; Sedentary bouts	ActiGraph (GT3X+, GT3X, GT1M); ActivPAL (3, 4); Fitbit; MTI-7164; Self-report questionnaire	Both	Sex and/or gender as a moderator of SB effects on health	Total ST was ↑ in high-level care facilities in comparison to intermediate/mixed-level care facilities; Older men in intermediate/mixed-level care facilities were more sedentary than older women
Lin et al. (2019); Taiwan; Cross-sectional	1068 (530)	Range 65-74, 75+	Total ST	Self-report questionnaire (SBQ-OA)	Both	Sex and/or gender as a moderator of SB effects on health	Area-level crime incidence had a negative association with PA in older men and a positive association with SB in older women
Marquet et al. (2020); Spain; Cross-sectional	227 (126)	Members: 76.6 (5.9) Non-Members: 73.5 (7.3)	Total ST	ActiGraph GT3X+	Both	Sex and/or gender as a moderator of SB effects on health	Older women (75+) who attended senior centers had an ↑ PA and ↓ ST; Older men (75+) who attended senior centers had a ↓ PA and ↑ ST
O'Neill & Dogra (2016); Canada; Cross-sectional	9128 (4650)	Range: 60-64, 65-69, 70-74	Sedentary activities	Self-report questionnaire (CCHS-HA)	Both	Sex and/or gender as a moderator of SB effects on health	Sedentary activities (computer use and reading) had a positive association with life satisfaction among older females; Sedentary activities (visiting others) had a positive association with sense of belonging to a community among older males
Shibata et al. (2022); Japan; Cross-sectional	281 (108)	74.4 (5.2)	Total ST	Active Style Pro HJA-350IT	Sex	Sex and/or gender as a moderator of SB effects on health	↑ total ST was adversely associated with ASM were linearly negatively associated (linearly in older females; non-linear in older males); Sex-differences in muscle pathology may explain the results
Strain et al. (2018); Scotland; Cross-sectional	2986 (1659)	Range: 65-74, 75+	Sitting time (work); Leisure ST; Leisure TV/screen ST	Self-report survey (SHeS)	Both	Sex and/or gender as a determinant of SB	ST among working middle-aged men and women were similar to ST of non-working older men and women; Important to look at work-related ST

Sumimoto et al. (2021); Japan; Cross-sectional	1546 (837)	Women: 70.5 (7.0) Men: 70.2 (7.0)	Sedentary activities (TV time)	Interview-led survey (NIPPON DATA2010)	Both	Sex and/or gender as a determinant of SB	TV viewing time increased with age in both men and women (↑ 80-89 years); Only among older women (aged 65+), ↑ TV viewing time was associated with lower education status and living alone
Wright-St Clair et al. (2017); New Zealand; Longitudinal cohort	649 (363)	Range: 80-90 (Māori) 85+ (non-Māori)	Sedentary activities	Interview-led questionnaire	Both	Sex and/or gender as a determinant of SB	Māori Men: Most important activity was walking/fitness Māori Women: Most important activity was gardening non-Māori Men: Most important activity was sports non-Māori Women: Most important activity was reading

Note. The ↑ sign indicates "higher", and the ↓ sign indicates "lower".

Abbreviations: ST = Sedentary Time; SB = Sedentary Behaviour; TV = Television; SD = Standard Deviation; hsCRP = High-Sensitivity C-Reactive Protein; SGBA = Sex- and Gender-Based Analysis; PA = Physical Activity; MVPA = Moderate-to-Vigorous Physical Activity; ASM = Appendicular Skeletal Muscle Mass; CHAMPS = Community Health Activities Model Program for Seniors Questionnaire; BEPAS = Belgian Environmental Physical Activity Study in Seniors; SBQ-OA = Sedentary Behavior Questionnaire for Older Adults; CCHS-HA = Canadian Community Health Survey – Healthy Aging; SHeS = Scottish Health Survey; NIPPON DATA2010 = National Integrated Project for Prospective Observation of Non-communicable Disease and its Trends in the Aged 2010.

Synthesis of Results

Sex and/or Gender as a Determinant of Sedentary Behaviour

Six studies looked at sex and/or gender as a determinant of sedentary behaviour (Compernolle et al., 2021; Finkel et al., 2018; Kikuchi et al., 2013; Strain et al., 2018; Sumimoto et al., 2021; Wright-St Clair et al., 2017). Of these six, one study used gender-related terminology correctly, referring to 'men' and 'women' as gender terms. The remaining five studies used 'sex' and 'gender' terms interchangeably (i.e., 'males', 'females', 'men', 'women'). All six studies used self-report or interview-led questionnaires as a measurement of sedentary behaviour and analyzed the type of sedentary activities: only one study examined self-report sitting time among working and non-working adults (Strain et al., 2018).

Key findings in Table 1 revealed that older men and women differ in preferred types of sedentary activities (Compernolle et al., 2021; Finkel et al., 2018). Television viewing time was found to vary among older men and women and different sociodemographic correlates, such as living and education status (Kikuchi et al., 2013; Sumimoto et al., 2021). Strain and colleagues (2018) found that older age may not be the only reason for high sedentary time in the population, but that work-related sedentary time is also an important factor when considering interventions to decrease sedentary time. In older Māori and non-Māori men and women, certain sedentary activities have different levels of importance in everyday life, such as reading or watching television in women (Wright-St Clair et al., 2017).

Sex and/or gender as a Moderator of Sedentary Behaviour Effects on Health

There were seven studies that examined sex and/or gender as a moderator of sedentary behaviour effects on health (Ashe et al., 2021; Bergens et al., 2021; Leung et al., 2021; Lin et al., 2019; Marquet et al., 2020; O'Neill & Dogra, 2016; Shibata et al., 2022). Of these seven studies, one study used 'gender' terminology correctly (Ashe et al., 2021), and one used 'sex' terminology correctly (Shibata et al., 2022), referring to 'males' and 'females' as biological sex terms. As shown in Table 1, three studies used device-based measures for analyzing sedentary behaviour (Bergens et al., 2021; Marquet et al., 2020; Shibata et al., 2022). Two studies measured sedentary behaviour by self-report questionnaire (Lin et al., 2019; O'Neill & Dogra, 2016), and one study used both device-based and self-report measures to examine sedentary behaviour (Ashe et al., 2021).

Table 1 provides the key findings for studies that discussed sedentary activities, total sedentary time, and sedentary bouts. Older men generally accumulate more total sedentary time than older women (Ashe et al., 2021; Leung et al., 2021; Marquet et al., 2020). Lin and colleagues (2019) demonstrated that the incidence of area-level crime rate has a positive association with sedentary behaviour in older women but not older men.

Although the sex- and/or gender-related terminology were frequently used interchangeably, two studies looked at biological sex differences among older males and females in relation to sedentary time (Bergens et al., 2021; Shibata et al., 2022). Bergens and colleagues (2021) examined the effect of sedentary time on pro- and anti-inflammatory biomarkers in older adults and found that there are biological sex differences between males and females in the regulation of systemic inflammations. Additionally, Shibata and colleagues (2022) analyzed sex differences between prolonged sedentary time and appendicular skeletal muscle mass (ASM) and found that an increase in prolonged sedentary time was negatively associated with ASM linearly in women, non-linearly in men. In a study using a large national dataset, it was found that various sedentary activities, such as computer use/reading and visiting others, had a positive association with life satisfaction among older women and sense of belonging to a community among older men (O'Neill & Dogra, 2016).

Discussion

This review explored sex and/or gender differences in sedentary behaviour among older adults. Of the 210 items included for the full-text review, 84 articles were excluded because although they stratified the analysis by sex and/or gender, they did not discuss the results or offer any further consideration of how sex or gender may influence their findings or conclusions. Among the 41 items included in the review, eight studies consistently used sex- and gender-related terminology, such as males/females and men/women, respectively (Appendix 3, Table S2). The remaining 33 studies used sex- and gender-related terms interchangeably, demonstrating a lack of understanding of the difference between the two. Using sex- and gender-related terminology interchangeably dismisses the complexity of the relationship between biological and sociocultural factors on health behaviour (Williams et al., 2023). For example, a researcher may analyze gender-related differences in sedentary behaviour but refer to these differences as 'sex' differences.

Of the 41 studies included in this review, 28 studies indicated that sex and/or gender differences in sedentary behaviour were explained by the division of household labour among older men and women, with women performing more household chores and thus accumulating less sedentary time. This simple explanation, while possibly having merit, relies on gender stereotypes of men and women and would not apply in all situations, such as older adults who live alone, reside in assisted living, or have homecare support for domestic chores. For example, older adults who live in assisted living are provided with services that assist in activities of daily living (ADLs) (Zimmerman & Sloane, 2007) such as housekeeping and cooking. Therefore, in this case, the explanation of division of household labour would not apply. Yet, differences in sedentary behaviour among older men and women have been reported in assisted living residences (Leung et al., 2021; Leung et al., 2017). To our knowledge, the division of household labour among older men and women has not been substantiated with data, other than a few physical activity studies conducted in Japan (Inoue et al., 2011; Murayama et al., 2019).

Only 13 studies explored sex or gender differences in sedentary behaviour in a more comprehensive manner that considered or measured factors beyond household chores. Some other factors may play a role in observed gender differences in sedentary behaviour among older adults. For example, Kikuchi and colleagues (2013) found that living alone and not owning a driver's licence was associated with prolonged television viewing time in Japanese older adults. They suggest that in Japan, older women who live alone and do not have a driver's licence may stay home more often as they have limited means of transportation (Kikuchi et al., 2013). A study conducted in Taiwan found that area-level crime incidence had a positive association with sedentary behaviour in older women but not men (Lin et al., 2019). They postulate that older women who live in areas with a high crime rate may prefer to stay home thereby participating in more sedentary time (Lin et al., 2019). Another study found that older women who attended senior centers decreased their sedentary time and increased their physical activity, but the older men increased their sedentary time (Marquet et al., 2020). Marquet and colleagues (2020) speculate that older men prefer to engage in sedentary activities at these centers, such as playing cards or reading the newspaper, while older women prefer more structured and active social activities that motivate them to leave their homes. These gender-related factors should be considered when developing sedentary behaviour interventions for older adults.

Kikuchi and colleagues (2013) analyzed television viewing time as a sedentary activity and found that time spent watching television varies among Japanese older men and women, depending on other sociodemographic correlates, such as employment and education status, body composition, geographical location, owning a driver's license, and living situation. In this study, gender terms, such as 'men' and 'women' were used consistently throughout the text, however this limits gender as a binary variable. The use of gender-related variables within health research are often confined to dichotomous variables and do not provide discussion beyond these stereotypical categorizations of 'men' and 'women'.

Of the 41 articles included, there was no mention of specific tools used to measure sex and/or gender, other than by self-report, survey, or interview. A recent scoping review identified 77 different instruments available to measure sex and gender in quantitative health research (Horstmann et al., 2022). However, the majority of these instruments were developed on an American student population and continue to dichotomize sex- and/or gender-related variables (i.e., males and females, men and women) (Horstmann et al., 2022). There is a definite need for a more comprehensive tool to measure sex and/or gender in sedentary behaviour research beyond the stereotypical representation of masculinity and femininity.

Most studies included in this review analyzed gender differences in patterns or types of sedentary behaviour among older men and women, and a few examined biological sex differences (Bergens et al., 2021; Shibata et al., 2022). Although most research in movement behaviour focus on sex differences in physical activity and sedentary behaviour, they often refer to the sociocultural interactions that the individuals are exposed to and that influence the way they behave, and not the physiological differences between males and females. Sex is often used as a proxy for gender in human health research, and although this may be reasonable, it does suggest a limited understanding of the relationship between sex and/or gender and sedentary behaviour patterns among older adults. This illustrates the importance of using sex- and gender-related terminology consistently and appropriately in human health research.

Strengths and Limitations

This study presents a few strengths as a contribution to movement behaviour research. The search strategy was intentionally created to broadly scope the literature as to not exclude research that may be applicable to our research question. Additionally, this review provides an insight on how sex and/or gender are studied in sedentary behaviour research.

There are several limitations to this study. A majority of studies included in this review only measured sedentary activity for the duration of one week. This is problematic because measuring activity at one point in time cannot completely explain habitual movement behaviour differences observed among older men and women. Additionally, the studies included in this review did not state how information on certain sociodemographic variables, such as sex and/or gender, were obtained, other than by self-report, survey, or interview. Although sex is often referred to as "sex assigned at birth", gender is a complex sociocultural variable and to our knowledge, there are no appropriate measures available to assess gender within health research. Lastly, the focus of studies published only in the English language may have resulted in missing important information from studies published in other languages.

Conclusion and Future Directions

To our knowledge, this scoping review is the first to examine the complex relationship between sex and/or gender variables and sedentary behaviour among older adults and how these variables are applied in movement behaviour research. Of the 41 studies included, 28 studies identified the division of household labour as the main source of difference between sex and/or gender and sedentary behaviour; the remaining 13 studies explored the relationship between sex and/or gender and sedentary behaviour in a more comprehensive manner. Some factors that may influence the relationship between sex and/or gender and sedentary behaviour among older adults include owning a driver's license, area-level crime incidence, and social support.

There is a need for consistency and understanding of sex- and gender-related terminology among movement behaviour research, as most studies use the terms interchangeably. All studies included in this review presented gender-related variables as binary 'men' and 'women'. It is assumed that many of these studies rely on stereotypical 'masculine' and 'feminine' traits to define 'men' and 'women', respectively. However, these assumptions, for example the narrative that older women participate in less sedentary time than older men because they are responsible for more household chores, do not apply in situations where housekeeping services are provided, such as in assisted living or high-level care facilities. Thus, it is important to understand the complexity of biological and sociocultural influences on behaviour in order to develop appropriate interventions to decrease sedentary behaviour in the aging population.

Older adults are the most sedentary demographic, and further exploration of the mechanisms that impact the relationship between sex and/or gender and sedentary behaviour, as well as better tools to assess sex- and/or gender-related variables, may help inform future research on the influence of biological and sociocultural factors on health behaviour in older adults.

CHAPTER 3: OBSERVATIONAL DATA ANALYSIS

Background

Physical activity and sedentary behaviour are important predictors of health among the older adult population (Dogra & Stathokostas, 2012), however people over the age of 65 years are the most sedentary and least physically active demographic (Colley et al., 2011; Matthews et al., 2008). *Physical activity* refers to any voluntary movement that increases energy expenditure above resting metabolic rate (Thivel et al., 2018). Older adults participating in sufficient levels of physical activity, for example maintaining 150 minutes of moderate-to-vigorous physical activity per week (Canadian Society for Exercise Physiology [CSEP], 2021), may reduce the risk of various non-communicable diseases, functional and cognitive decline, fractures, reoccurring falls, activities of daily living (ADL) disability, and all-cause mortality (Cunningham et al., 2020). Prolonged periods of *sedentary behaviour*, defined as a class of behaviours that are completed in a lying, seated, or reclined position while awake with low levels of energy expenditure ($\leq$1.5 METs) (Tremblay et al., 2017), may increase the risk of cardiometabolic disease (Powell et al., 2018), impaired cognitive and physical function (Copeland et al., 2017), and mortality (de Rezende et al., 2014). Emerging research on insufficient levels of physical activity and prolonged sedentary time as risk factors for health in older adults has encouraged researchers to investigate the effects of health behaviours in order to mitigate negative health risks and promote healthy aging.

Human behaviours are highly complex as they are influenced by many different factors. Researchers often use ecological models to better understand potential influences on movement behaviours (i.e., physical activity, sedentary behaviour, and sleep). Ecological models assume that behaviour is influenced by intrapersonal, sociocultural, organizational, environmental, and policy factors (Sallis et al., 2008). Many studies analyze intrapersonal and sociocultural factors on health, for example biological sex and gender, respectively. *Sex*, referring to the biological features of the human body assigned at birth (National Academy of Science [NAS], 2022), and *gender*, a sociocultural construct that includes the expression, behaviour, role, and identity of an individual within society (NAS, 2022), are frequently presented by researchers as important predictors of health (Copeland et al., 2017), however these factors are often oversimplified and misrepresented (Williams et al., 2023).

Williams and colleagues (2023) highlight the complexity of including sex and gender in biomedical and health science research. They state that many behavioural studies hyper focus on sex differences between males and females when at the molecular level, they are not very different (Williams et al., 2023). Gender is a sociocultural construct that defines an individual's experience and self-perception within society and therefore may influence our physical and perceived health, however it is often used in conjunction with sex-related factors (Williams et al., 2023). Additionally, there are very few tools available that are properly designed to measure gender in health science research; they often rely on stereotypical gender traits, such as the Bem Sex Role Inventory (BSRI) (Bem, 1974), the Personal Attributes Questionnaire (PAQ) (Spence et al., 1974), and Conformity to Masculine Norms Inventory (Mahalik et al., 2003). The BSRI is still the most widely used instrument to measure gender roles in current literature (Horstmann et al., 2022).

Limited research has been published that explores the effect of biological sex and sociocultural gender traits on movement behaviour, beyond the binary variables of male/female and men/women, respectively. Additionally, as shown in Chapter 2, researchers often compare sexes and genders in behavioural research and assume that differences are defined by roles within the household. For example, older community-dwelling women often participate in more light-physical activity and less sedentary time than older men (Cabanas-Sánchez et al., 2020); it is regularly stated that the reason for these differences is because older women are more involved in household chores, such as cooking and cleaning, than older men (van Ballegooijen et al., 2019).

While household chores may indeed play a role in movement behaviours, this simplistic explanation of observed gender differences does rely on the assumption that household chores are divided by binary gender categories among older adults. More research is needed that examines sex- and gender-related traits or behaviours in order to understand how sex and gender impact health and health behaviours. The purpose of this study was to explore the differences of biological sex and traditional gender traits on movement behaviour patterns in older adults. In order to strengthen the understanding of the relationship between sex and/or gender and movement behaviours, the prevalence of, or lack of, association between the variables must be examined.

Methods

Data Source and Participants

The data for this secondary analysis were collected from 72 volunteers over the age of 65. Participants from two different studies of older adults were used for the current study; one was a multi-site study of a sedentary behaviour intervention among residents in assisted living (*n* = 54, 78% female) and one was a study of sedentary behaviour and cognitive function among community-dwelling older adults (*n* = 18, 56% female). The two studies had different purposes but baseline data from both studies were used for the present analysis. Both studies were approved by the University of Lethbridge Human

Participant Research Committee Protocol (protocol #2021-064 and #2021-118). For both studies, the inclusion criteria were the ability to complete questionnaires in English, to give informed consent, and to stand up from a seated position independently, with or without mobility aids.

Procedures

All participants provided informed consent (see Appendix 4 and 5 for the consent form for each study). Age and sex were collected by self-report, and participants completed the 30-Item BSRI questionnaire (Appendix 6). Participants were asked to wear an ActivPAL4™ inclinometer for seven consecutive days, with a minimum of four valid days of wear time data, as suggested by Edwardson and colleagues (2017). The inclinometer was secured to the middle anterior right thigh using Tegaderm™ medical tape (3M, London, ON, Canada) and participants were given additional tape if needed.

Measures

Assessment of Sedentary Time and Physical Activity

Sedentary time and physical activity were assessed using ActivPAL4™ inclinometers with the PAL Technologies software (v.8.10.12.60) (PAL Technologies Ltd., Scotland, UK). ActivPAL4™ inclinometers monitor body positioning and movement patterns throughout the day (Edwardson et al., 2017). The ActivPAL4™ inclinometers have been validated previously (Edwardson et al., 2017), and have shown to be a reliable measurement of sedentary behaviour among free-living adults. In this study, the variables used to determine sedentary behaviour and physical activity were daily 'sit-to-stand transitions', 'step count', 'sedentary bouts', 'standing time', 'primary lying time', and 'sitting time'; these variables were used to calculate 'total sedentary time' and 'moderate-to-vigorous physical activity' (MVPA).

Assessment of Sex- and Gender-Related Variables

Participants were asked to provide their "sex assigned at birth". Gender traits were assessed using the Bem Sex Role Inventory (BSRI) 30-Item questionnaire (Appendix 6). It is a self-report questionnaire that assesses an individual's self-identified gender role based on stereotypical gender-associated traits within American society (Bem, 1977; Gale-Ross et al., 2009; Geldenhuys & Bosch, 2020). This questionnaire identifies 30 traits that are traditionally seen as masculine (instrumental), feminine (expressive), or neutral (Geldenhuys & Bosch, 2020). Validity and reliability of the 30-Item BSRI has been previously reported (Campbell et al., 1997; Geldenhuys & Bosch, 2020; Holmbeck & Bale, 1988).

The instrumental, expressive, and neutral traits each had ten items, and the instrument and expressive items were used to score masculinity and femininity, respectively. Neutral traits were originally incorporated in the BSRI to determine whether the participants gave inaccurate responses to the more sensitive traits, in order to seem more socially desirable (Geldenhuys & Bosch, 2020; Vafaei et al., 2014). Thus, neutral traits are not involved in the calculation of masculine and feminine scores. Participants rated themselves for each item on a scale of one (never true) to seven (always true), where the lowest score was closer to one and the highest score was closer to seven (Appendix 6) (Geldenhuys & Bosch, 2020).

Each participant had a raw score between one and seven for masculinity and for femininity. These scores were used to explore associations between masculinity and femininity and movement behaviours. Additionally, using the method proposed by Bem (1977), the median-split method was used to determine the within-sample thresholds for each gender expression. The median for both feminine and masculine traits were calculated on a complete dataset, after missing values were removed. The medians dichotomize ‘femininity’ and ‘masculinity’ in the sample, therefore if an individual scores greater than or equal to the sample median, then they are considered ‘high’; scoring below the sample median results in a ‘low’ score (Ahmed et al., 2016). Each participant received a score for both masculine and feminine traits, therefore the medians dichotomize ‘masculinity’ and ‘femininity’, and results would fall under any of the following four options: high masculine/low feminine (masculine), low masculine/high feminine (feminine), high masculine/high feminine (androgynous), low masculine/low feminine (undifferentiated). As an example of the significance of the four categories, if one were to score ‘high’ in both masculinity and femininity, then they would be considered ‘androgynous’, implying that they are not as heavily influenced by sociocultural expectations and may have higher success within society in comparison to individuals in the other categories (Bem, 1977; Geldenhuys & Bosch, 2020).

Statistical Analysis

Statistical analysis was completed using RStudio version 2022.02.03 (R Core Team, 2022). Movement data were obtained from the ActivPAL4™ and analyzed using the CREA algorithm (v1.3) (PAL Technologies Ltd., n.d.-a) within the PALBatch software (v.8.10.12.60); output for valid days of wear time were determined using the MORA algorithm (v1.0) (PAL Technologies Ltd., n.d.-b). The CREA algorithm, by default, begins the 24-hour day at midnight and ends at 11:59pm. Data were exported using the ‘average valid day summaries’ csv output in PALBatch and only data with a minimum of four days of wear time were included (Edwardson et al., 2017; PAL Technologies Ltd., n.d.-b).

‘Total sedentary time’ was calculated in RStudio as the sum of ‘total sitting time (m)’ and ‘secondary lying time (m)’, taken from ‘average valid day summaries’ csv. PAL Technologies includes ‘seated transport time’ in their calculations of ‘total sedentary time’ from the ‘average summary outcomes’ csv export, however, ‘seated transport time’ was recently introduced with the CREA algorithm (v1.3) in 2019 and has yet to be validated, therefore it has been excluded in the calculation for ‘total sedentary time’ in this study. It is important to note that although ‘total sedentary time’ was calculated separately in RStudio, ‘seated transport time’ remains in PAL Technologies’ calculations of ‘sedentary bouts’.

Baseline descriptive statistics were calculated for total participants in both assisted and independent living samples. Normality was determined using Shapiro-Wilk tests for the ActivPAL4™ variables used. The presence of normal or non-normal distributions determined the type of correlation coefficient used on the current sample. Spearman’s bivariate correlations were calculated to determine the strength of the relationship between the movement behaviour variables and raw BSRI scores; Cohen’s *d* was calculated to measure the size of the difference between these variables. T-tests, *p*, were used to determine the significance of the relationship between movement behaviours, sex, and high/low masculine and feminine raw scores.

Results

Participant Characteristics

Table 2 shows the participant characteristics by living condition. A total of 72 participants were included in this study from two separate studies: one in assisted living (n = 54) and one in independent living (n = 18). The overall mean age of the study sample was 80.1 (9.4) years and 72% were female. The independent living participants were younger, with a mean age of 68.6 (5.3) years in comparison to the assisted living participants, with a mean age of 84.3 (6.7) years. The 30-Item BSRI raw scores for the masculine and feminine items are included in Table 2 with their mean, standard deviation, and range. For the male participants, the mean masculine and feminine scores were 4.9 (± 1.1) and 5.9 (± 0.8), respectively. For the female participants, the mean masculine and feminine scores were 4.5 (± 1.0) and 5.8 (± 0.7), respectively. The raw masculine and feminine BSRI scores did not differ between males and females in this study sample (Table 2).

Table 2

Demographic Information and BSRI Raw Scores of the Study Population by Living Condition

			BSRI Raw Scores (mean ± sd, range)	
	Participants (N, %)	**Age, years (mean ± sd)**	**Masculine**	**Feminine**
Assisted Living	54 (75)	84.3 ± 6.7 (N = 50)	4.5 ± 1.1 (1.5 – 6.2)	6.0 ± 0.6 (4.6 – 7.0)
Males	12 (17)	83.3 ± 6.3 (N = 10)	4.8 ± 1.4 (1.5 – 6.2)	6.1 ± 0.6 (4.7 – 6.8)
Females	42 (58)	84.5 ± 6.9 (N = 40)	4.5 ± 1.0 (2.0 – 6.2)	5.9 ± 0.6 (4.6 – 7.0)
Independent Living	18 (25)	68.6 ± 5.3	4.7 ± 0.9 (2.2 – 6.1)	5.4 ± 0.9 (3.8 – 7.0)
Males	8 (11)	67.6 ± 5.0	5.0 ± 0.5 (4.2 – 5.9)	5.6 ± 0.9 (3.9 – 7.0)
Females	10 (14)	69.3 ± 5.6	4.5 ± 1.1 (2.2 – 6.1)	5.3 ± 0.9 (3.8 – 6.1)
Total	72 (100)	80.1 ± 9.4 (N = 68)	4.6 ± 1.0 (1.5 – 6.2)	5.8 ± 0.7 (3.8 – 7.0)
Males	20 (28)	76.3 ± 9.8	4.9 ± 1.1 (1.5 – 6.2)	5.9 ± 0.8 (3.9 – 7.0)
Females	52 (72)	81.5 ± 9.0	4.5 ± 1.0 (2.0 – 6.2)	5.8 ± 0.7 (3.8 – 7.0)

Note. The assisted living sample had four missing values thus the mean age of the total sample was based on 68 participants. BSRI results are reflected by the mean and range of the masculine and feminine raw scores. Abbreviations: BSRI = Bem Sex-Role Inventory Questionnaire; SD = Standard Deviation.

Tests of Normal Distribution

Shapiro-Wilk tests were used to assess the normal distribution of the independent and dependent variables. Since both masculine and feminine scores were not normally distributed (masculine: W = 0.95, $p = 0.005$; feminine: W = 0.96, $p = 0.023$), Spearman's bivariate correlations were used (Table 3).

Movement Behaviours and Masculine and Feminine BSRI Scores

The strength of the relationship between movement behaviour variables and raw masculine and feminine scores are shown in Table 3. As the results show, 'total sedentary time', 'step count', and 'standing time' were significantly inversely correlated with feminine raw score ($p < 0.05$) (Table 3). There were no other statistically significant correlations between the other movement behaviour variables and masculine or feminine raw scores.

The differences between movement behaviour variables, sex, and high/low BSRI scores are shown in Table 4; high and low scores were determined using the median split method for the BSRI (high masculine ≥ 4.75, low masculine < 4.75; high feminine ≥ 5.95, low feminine < 5.95) (Table 4). The Bonferroni Correction was applied to the sample alpha (α) to control for the probability of committing a Type I Error (Armstrong, 2014); the new *p*-values are $p < .002$*, $p < .0004$**, and $p < .00004$***, where the original alpha value was divided by the number of tests performed ($n = 24$) (i.e., a *t*-test was performed for each ActivPAL4™ variable on sex, masculine score, and feminine score, therefore eight ActivPAL4™ variables were tested three times). Overall, after the new *p*-values were determined, there were no statistically significant differences in the movement variables between sexes, or between masculine, or feminine scores.

Table 3

Spearman's Bivariate Correlation and Effect Size Between BSRI Scores and Movement Behaviours

	Masculine Raw Score		**Feminine Raw Score**	
	rho, *p*	**Cohen's *d***	**rho, *p***	**Cohen's *d***
Total Sedentary Time (min/day)	0.004, 0.973	-0.017 [a]	**0.260, 0.028**	0.502 [c]
Sedentary Bouts (min/day)	-0.104, 0.384	-0.198 [a]	0.082, 0.495	0.097 [a]
Sit-to-Stand Transition (number/day)	0.013, 0.912	-0.049 [a]	-0.138, 0.246	-0.295 [b]
Standing Time (min/day)	-0.218, 0.066	-0.242 [b]	**-0.298, 0.011**	-0.688 [c]
Primary Lying Time (min/day)	0.167, 0.160	0.372 [b]	-0.028, 0.811	0.044 [a]
Sitting Time (min/day)	-0.107, 0.370	-0.232 [b]	0.171, 0.151	0.244 [b]
Step Count (steps/day)	-0.083, 0.488	-0.094 [a]	**-0.304, 0.009**	-0.471 [b]
MVPA (min/day)	-0.133, 0.264	-0.085 [a]	-0.152, 0.202	-0.174 [a]

Note. Spearman's bivariate correlation, *rho*, and Cohen's *d* were used to measure the strength, direction, and size of the relationship between the movement behaviour variables and feminine or masculine raw scores. Statistically significant units are bolded ($p < 0.05$). Abbreviations: MVPA = Moderate-to-Vigorous Physical Activity.

[a] Negligible effect size.

[b] Small effect size.

[c] Moderate effect size.

Table 4

Movement Behaviours by Sex and High/Low Masculine and Feminine Scores

Variable (mean ± sd)	Sex			Masculine			Feminine		
	Male	**Female**	***p***	**High**	**Low**	***p***	**High**	**Low**	***p***
Total Sedentary Time (min/day)	645.7 ± 130.7	646.6 ± 146.6	.982	645.1 ± 152.5	647.5 ± 131.7	.943	681 ± 136.7	611.6 ± 139.4	.037
Sedentary Bouts (min/day)	171 ± 115.2	210.5 ± 119.8	.210	187.7 ± 114.4	211.3 ± 124	.403	205.3 ± 107.9	193.7 ± 130.5	.682
Sit-to-Stand Transition (number/day)	55.8 ± 18.2	49.3 ± 12.6	.091	50.7 ± 14.2	51.4 ± 15	.835	48.9 ± 12.6	53.2 ± 16.2	.214
Standing Time (min/day)	206.1 ± 82.3	218.5 ± 92.6	.602	204.3 ± 95.1	225.9 ± 83.4	.309	186.6 ± 77.2	243.6 ± 92.7	.006
Primary Lying Time (min/day)	500.8 ± 105.3	483.5 ± 83.1	.464	504.7 ± 86	471.9 ± 90.9	.120	490.3 ± 90.1	486.3 ± 89.9	.853
Sitting Time (min/day)	590 ± 130.2	619 ± 140.1	.426	595 ± 140.3	629.8 ± 134	.328	627.7 ± 136.6	594.2 ± 137.6	.304
Step Count (steps/day)	5747.6 ± 3562.6	5291 ± 3692.5	.637	5246.3 ± 3933.9	5589.4 ± 3362.6	.692	4578.9 ± 3602.4	6256.8 ± 3523.9	.050
MVPA (min/day)	6.2 ± 12.1	8.1 ± 15.2	.623	6.9 ± 14.9	8.2 ± 14	.718	6.3 ± 13.4	8.8 ± 15.3	.462

Note. Physical activity and sedentary behaviour were measured using the ActivPAL4™; masculine and feminine scores were obtained by the BSRI questionnaire. Abbreviations: SD = Standard Deviation; MVPA = Moderate-to-Vigorous Physical Activity.

Discussion

Sex and gender may be important predictors of health and health behaviours but are often neglected in health research. Our goal was to demonstrate a different approach to exploring the relationship between sex and/or gender and movement behaviours among older adults. This study used device-based measures of sedentary time and physical activity to explore the association between movement behaviours and sex and stereotypical gender traits as reported by the BSRI.

We did not find any significant associations between device-measured movement behaviours and sex or gender. We found that both sexes scored similarly for masculinity and femininity in both assisted and independent living participants (Table 2). This is interesting because traditionally in society, males and females are viewed as the "opposite sex" and are expected to contrast one another in health research (Williams et al., 2023). In addition, previous research using the BSRI has shown that men tend to score lower for both masculinity and femininity than women (Vafaei et al., 2016). Our findings may suggest that the BSRI may be too focused on stereotypical gender traits and is unable to differentiate between men and women in the way researchers expect.

Another explanation for these findings may be that the BSRI does not truly assess 'masculinity' and 'femininity', but more 'instrumental' and 'expressive' traits (Choi & Fuqua, 2003). *Instrumental* traits (or agency) are associated with being assertive, independent, ambitious, and dominating, while *expressive* traits (or communal) are associated with altruism, warmth, compassion, and cooperativeness (Spence, 1991). Bem often refers to these traits synonymously with masculinity and femininity, due to the student responses and perception of societal roles within American culture at the time (Bem, 1974). Although males and females may differ in instrumental and expressive traits, considerable variability does exist among the sexes for both traits (Spence, 1991). Thus, assuming that instrumental and expressive traits are the same as masculinity and femininity, respectively, is problematic and may explain why males and females did not differ in their results of masculinity and femininity in our study.

The focus of this study was on sex and/or gender in older adults and originally, the BSRI was created based on self-report responses from college students and the personality traits they considered to be appropriate for the opposite sex (Bem, 1974). The students were asked to choose from 200 personality characteristics, and the BSRI items were chosen from those responses (Bem, 1974). Thus, the BSRI may not be able to capture gender-related traits properly in our older age demographic.

The "opposite sex" narrative has been shown to hyper-focus on sex differences (Williams et al., 2023) and previous literature has identified differences between older men and women in movement behaviour. Older women typically accumulate less sedentary time and MVPA than older men and participate in more light physical activity than older men (Amagasa et al., 2021; Ashe et al., 2021; Cabanas-Sánchez et al., 2019; Cabanas-Sánchez et al., 2020; Giné-Garriga et al., 2020; Suzuki et al., 2020; van Ballegooijen et al., 2019). Our analyses did not replicate these findings and the difference may be explained by the number of participants of each sex or the different living conditions among participants. In this study, 28% of participants were male (Table 2); due to the unbalanced distribution of males and females, there may have not been enough statistical power to determine the difference between the sexes. Additionally, 75% of our study population resided in assisted living residences (Table 2). As previous literature suggests, older adults in assisted living are more sedentary and less physically active than other community-dwelling older adults (Egerton et al., 2009; Sebastião et al., 2019).

Assisted living residences provide residents with assistance of some daily activities, such as meal services and housekeeping (Voss et al., 2020b; Zimmerman & Sloane, 2007), therefore, the decreased participation in activities of daily living may explain the similar movement behaviours between older men and women in our study population (Table 4).

Simply acknowledging the difference in behaviours between these binary gender-related variables does not explain why the differences exist among older men and women. There were no significant differences in movement behaviours found between individuals who scored high or low in masculine or feminine raw scores (Table 4). However, as shown in Table 3, 'total sedentary time' was positively and significantly correlated with feminine raw score, and 'step count' and 'standing time' were negatively and significantly correlated with feminine raw score. To our knowledge, there have been no studies that have examined the relationship between masculine and feminine scores with movement behaviours. Previous research using the 12-Item BSRI showed high feminine scores were associated with negative health outcomes, such as lower self-rated health (Willerth et al., 2020), higher risk of mobility disability (Ahmed et al., 2016), and poor physical performance (Ahmed et al., 2018). We wanted to present the differences between masculine and feminine scores because simply dichotomizing results by binary gender variables, such as men and women, may not be enough to understand the relationship between these variables and movement behaviours. Therefore, presenting results on a continuous scale of masculinity and femininity may be valuable, as these individual traits vary, independent of biological sex.

Most behavioural or health research only dichotomizes gender; as shown in Chapter 2, all 41 articles focused primarily on either sex differences between 'males' and 'females' or gender differences between 'men' and 'women'. The majority of these studies simply dichotomized sex- and gender-related variables without understanding the complexity of the mechanisms that may mediate the relationship of sex and/or gender and behaviour (Horstmann et al., 2022; Williams et al., 2023). However, sex and/or gender are multi-layered, and non-binary in nature, therefore confining individuals in categorized variables, specifically for gender-related terms, may exclude individuals who do not identify with the stereotypical “masculine” and “feminine” ideology (Bolte et al., 2021; Johnson & Repta, 2012). For this reason, it is important to move beyond the dichotomization of sex and gender variables (i.e., looking at only ‘men’ and ‘women’) in order to fully understand the relationship between sex and/or gender and health behaviours, like physical activity or sedentary behaviour.

In this study, our goal was to provide an example of how sex and/or gender can be addressed when conducting movement behaviour research, even if the sex and/or gender variables are difficult to measure. A recently published scoping review revealed that the BSRI is still the most widely used instrument to measure gender as there are no instruments that present gender on a continuous scale (Horstmann et al., 2022). The majority of instruments measuring sex and/or gender that are available have been developed based on an American student population (Horstmann et al., 2022). Although this study utilizes the BSRI, we acknowledge that the focus on binary variables to assess health behaviours limits our knowledge of understanding the relationship between sex and/or gender and movement behaviour.

The original 60-Item BSRI has been heavily criticized for measuring self-perception instead of global self-concepts of masculinity and femininity (Choi & Fuqua, 2003; Colley et al., 2009). While the BSRI has stimulated research on the sociocultural influence on behaviour, Bem stated that other instruments may be more appropriate for assessing gender-related variables, as her intent was to understand broader gender-related constructs, such as certain attributes that society expects from males and females, and the advantage of having a highly masculine and feminine (androgynous) personality trait within society (Bem, 1981). Therefore, the use of the BSRI to measure gender does not capture the complex nature of gender-related variables within a continuously changing society.

As shown in Chapter 2, the majority of available studies suggest that differences in household chores can explain the difference in sedentary behaviour between older men and women. Some studies in Chapter 2 did provide explanations for sex- and/or gender-related differences other than the stereotypical assumptions about the division of household labour. Some other factors that were discussed to explain the differences in sedentary behaviour between older men and women include motivation or preferred hobbies (Finkel et al., 2018; O'Neill & Dogra, 2016; Wright-St Clair et al., 2017), prevalence of area-specific crime rates (Lin et al., 2019), or having a driver's license (Kikuchi et al., 2013).

This chapter challenges the assumptions made in previous research that men and women score differently for masculine and feminine traits and that is why they have different health outcomes (Ahmed et al., 2016). Here we showed that both men and women scored high on traditionally feminine traits and low on traditionally masculine traits, therefore simply fixating on binary gender variables may not explain the differences seen among older men and women. Future research would benefit from having an instrument that measures gender on a continuous scale, that may be applied to different populations. Not only would this promote inclusivity in health research, but it would help researchers understand the mechanisms that may mediate the relationship between sex and/or gender and movement behaviours.

Strengths and Limitations

The current study has several strengths and limitations. To our knowledge, this is the first study that tried to assess sex and/or gender in sedentary behaviour and physical activity beyond the stereotypical categorization of ‘men’ and ‘women’. Another strength includes the use of device-based measures used to assess movement behaviours.

The small sample size is one of the limitations to this study, as is the relatively fewer men participating in the study. Additionally, the definition of gender (other than the terms ‘man’ and ‘woman’) is continuously evolving and has changed in the past few decades (Williams et al., 2023). Therefore, future movement behaviour researchers may benefit from exploring sex and/or gender on a younger demographic. A significant limitation to this study is the use of the BSRI questionnaire to measure gender traits, because although it is the most widely used tool for exploring gender-specific traits (Horstmann et al., 2022), it has many limitations as discussed previously. To our knowledge, there are no available instruments that capture gender on a continuous spectrum, thus future behavioural research projects would benefit from using a self-report gender scale to properly assess gender within a specific population. Furthermore, the BSRI was not created to measure the complexity of masculinity and femininity, but rather instrumentality and expressiveness (Choi & Fuqua, 2003), as explained previously. Lastly, it may be beneficial in movement behaviour research to identify factors, other than stereotypical gender traits, that may affect behaviour, such as motivation, access to transportation, or perceived neighbourhood safety.

Conclusion

The aim of this study was to provide an example of how gender can be assessed in movement behaviour research, beyond simply dichotomizing gender. We found no differences between masculine and feminine scores among older males and females. Femininity scores were correlated with movement behaviour with higher femininity scores associated with higher sedentary time and lower physical activity. Although this exploratory study demonstrated one approach to examining gender traits and movement behaviours, future research in this field would benefit from the development of a continuous scale that measures gender using more than stereotypical perceptions of what is ‘masculine’ or ‘feminine’. Furthermore, movement behaviour research may benefit from collaborating with different fields of study, such as sociology, to better understand the overall relationship between sex and/or gender and human health behaviour. This would shift the focus in movement behaviour research from the need to categorize sex and gender and focus on the mediators that influence the relationship between sex and/or gender and movement behaviour from a multidisciplinary approach. A better understanding of this relationship may help create more tailored sedentary behaviour and physical activity interventions among the older adult population.

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APPENDIX 1: PRISMA-ScR CHECKLIST

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	

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SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	
Limitations	20	Discuss the limitations of the scoping review process.	
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

APPENDIX 2: RESULTS FROM SCOPING REVIEW DATABASE SEARCH

Supplemental Data 1 [S1]

Databases Included in Search Strategy and Results

Databases	**N**
MEDLINE	2490
APA PsycINFO	475
Web of Science	1876
SPORTDiscus	273
Total	5114

Note. Total amount of studies extracted from each four databases for the scoping review.

APPENDIX 3: STUDIES INCLUDED IN SCOPING REVIEW

Supplemental Data 2 [S2]

Summary of Total Studies Included (n = 41)

Author, Year, Location, and Study Design	Participants (Older Adults)		Sedentary Behaviour		Sex and/or Gender	
	N (*n* or % women)	Age (mean ± sd and/or range)	Type	Measurement	Terminology Used	SGBA
Amagasa et al. (2021); Japan; Cross-sectional	251 (150)	Women: 74.6 (6.7) Men: 74.1 (7.0)	Total ST	Active Style Pro	Gender	Sex and/or gender as a determinant of SB
Ashe et al. (2021); Canada; Cross-sectional	224 (112)	71.1 (5.9)	Sedentary activities; Total ST	ActiGraph GT3X; Self-report questionnaire (CHAMPS)	Gender	Sex and/or gender as a moderator of SB effects on health
Asiamah et al. (2021); Ghana; Cross-sectional	504 (252)	Range: 65-74, 75-84, 85-94, 95-104, 104+	Partial/Absolute SB	Self-report questionnaire (GPAQ)	Both	Sex and/or gender as a determinant of SB
Bellettiere et al. (2015); United States, RCT	307 (222)	83.6 (6.4)	Sedentary bouts	ActiGraph GT3X+	Both	Sex and/or gender as a determinant of SB
Bergens et al. (2021); Europe; Cross-sectional	229 (146)	Women: 67.4 (1.6) Men: 67.4 (1.5)	Total ST; Sedentary bouts	ActiGraph GT3X+	Both	Sex and/or gender as a moderator of SB effects on health
Cabanas-Sánchez et al. (2020); Spain; Cross-sectional	2514 (1332)	71.7 (4.4)	Total ST; Sedentary bouts	ActiGraph GT9X	Both	Sex and/or gender as a determinant of SB
Cabanas-Sánchez et al. (2019); Spain; Cross-sectional	432 (284)	71.7 (5.3)	Sitting time (lying, reclining, passive)	IDEEA activity monitor	Both	Sex and/or gender as a determinant of SB
Cavazzotto et al. (2022); Brazil; Cross-sectional	Total sample 561,837 (349,397)	Range: 61-70, 71-80, 80+	Sedentary activities (TV time)	Telephone survey	Both	Sex and/or gender as a determinant of SB
Cerin et al. (2016); China; Cross-sectional	402 (68.9%)	75.5 (6.2)	Total ST	ActiGraph GT3X+	Both	Sex and/or gender as a moderator of SB effects on health

Chen et al. (2015); Japan; Cross-sectional	1739 (1079)	Median 72 (IQR = 68-78)	Total ST	Active Style Pro HJA-350IT	Both	Sex and/or gender as a determinant of SB
Chou et al. (2004); China; Cross-sectional	2144 (51.5%)	69.9 (7.4)	Sedentary activities	Interview-led survey	Gender	Sex and/or gender as a determinant of SB
Compernolle et al. (2021); Belgium; Cross-sectional	696 (373)	74.2 (6.2)	Sedentary activities	Self-report questionnaire (BEPAS; Busschaert)	Both	Sex and/or gender as a determinant of SB
da Silva et al. (2018); Brazil; Cross-sectional	457 (285)	70.3 (8.3)	Sitting time	Self-report questionnaire (IPAQ)	Both	Sex and/or gender as a moderator of SB effects on health
Dogra & Stathokostas (2014); Canada; Cross-sectional	14,560 (8679)	Range: 65-69, 70-74, 75-79, 80-84, 85+	Sitting time	Self-report survey (CCHS-HA)	Both	Sex and/or gender as a determinant of SB
Espinel et al. (2015); Australia; Cross-sectional	992 (559)	Range: 65-74, 75+	Sedentary activities; Total ST	Self-report log over 2 days	Both	Sex and/or gender as a determinant of SB
Ethisan et al. (2017); Thailand; Cross-sectional	300 (50.7%)	67.4 (6.6)	Total ST	Interview-led questionnaire	Both	Sex and/or gender as a determinant of SB
Finkel et al. (2018); Sweden; Longitudinal study (17-year follow-up)	1398 (59%)	64.9 (range: 36-91)	Sedentary activities	Self-report questionnaire	Both	Sex and/or gender as a determinant of SB
Fleig et al. (2016); Canada; Cross-sectional	53 (32)	79.5 (7.8)	Total ST	ActiGraph GT3X+	Both	Sex and/or gender as a moderator of SB effects on health
Giné-Garriga et al. (2020); Denmark, Spain, Germany, and United Kingdom; Cross-sectional	1360 (840)	75.3 (6.3)	Total ST	ActiGraph GT3X+	Both	Sex and/or gender as a determinant of SB
Horgas et al. (1998); Germany; Cross-sectional	485 (235)	84.9 (8.7)	Sedentary activities; Total ST	Interview (The Yesterday Interview)	Both	Sex and/or gender as a determinant of SB

Isamu et al. (2023); Japan; Cross-sectional	512 (272)	73.5 (5.6)	Total ST; Sedentary bouts	Active Style Pro HJA-750C	Both	Sex and/or gender as a moderator of SB effects on health
Kikuchi et al. (2013); Japan; Cross-sectional	1665 (800)	Women: 69.6 (2.9) Men: 69.5 (3.0)	Sedentary activities (TV time)	Self-report questionnaire	Gender	Sex and/or gender as a determinant of SB
Kim (2019); Korea; Cross-sectional	3011 (1710)	72.9 (SE = 0.11)	Sitting time	Interview-led survey	Both	Sex and/or gender as a moderator of SB effects on health
Kubota et al. (2022); Japan; Cross-sectional	11,030 (not reported)	Range: 65-74	Sedentary travel	Survey; 24-h travel log	Gender	Sex and/or gender as a moderator of SB effects on health
Lee & King (2003); United States; Intervention	103 (93)	Study 1: 70.2 (4.1)	Sedentary activities	Self-report questionnaire (CHAMPS)	Gender	Sex and/or gender as a determinant of SB
Leung et al. (2021); United States, Australia, United Kingdom, Canada, The Netherlands, and Spain; Scoping review (*n* = 18 studies)	1059 (42-90%)	Range: 61-101	Total ST; Sedentary activities; Sedentary bouts	ActiGraph (GT3X+, GT3X, GT1M); ActivPAL (3, 4); Fitbit; MTI-7164; Self-report questionnaire	Both	Sex and/or gender as a moderator of SB effects on health
Lin et al. (2019); Taiwan; Cross-sectional	1068 (530)	Range 65-74, 75+	Total ST	Self-report questionnaire (SBQ-OA)	Both	Sex and/or gender as a moderator of SB effects on health
Marquet et al. (2020); Spain; Cross-sectional	227 (126)	Members: 76.6 (5.9) Non-Members: 73.5 (7.3)	Total ST	ActiGraph GT3X+	Both	Sex and/or gender as a moderator of SB effects on health
Martin et al. (2014); United States; Cross-sectional	2271 (1124)	Range: 60-69, 70+	Sedentary activities; Total ST	ActiGraph AM-7164	Both	Sex and/or gender as a determinant of SB

Mattle et al. (2022); Austria, France, Germany, Portugal, and Switzerland; Cross-sectional	2155 (1331)	74.9 (4.5)	Total ST	Self-report questionnaire (NHS PAQ)	Both	Sex and/or gender as a determinant of SB
O'Neill & Dogra (2016); Canada; Cross-sectional	9128 (4650)	Range: 60-64, 65-69, 70-74	Sedentary activities	Self-report questionnaire (CCHS-HA)	Both	Sex and/or gender as a moderator of SB effects on health
Park et al. (2020); Taiwan; Cross-sectional	1040 (515)	73.0 (6.1)	Sedentary activities; Total ST	Self-report questionnaire (SBQ-OA)	Gender	Sex and/or gender as a determinant of SB
Prince et al. (2020); Canada; Cross-sectional	Not reported	Range: 65+	Sedentary activities; Total ST	Actical; Self-report survey	Both (but understands the differences between the two)	Sex and/or gender as a determinant of SB
Shibata et al. (2022); Japan; Cross-sectional	281 (108)	74.4 (5.2)	Total ST	Active Style Pro HJA-350IT	Sex	Sex and/or gender as a moderator of SB effects on health
Strain et al. (2018); Scotland; Cross-sectional	2986 (1659)	Range: 65-74, 75+	Sitting time (work); Leisure ST; Leisure TV/screen ST	Self-report survey (SHeS)	Both	Sex and/or gender as a determinant of SB
Sumimoto et al. (2021); Japan; Cross-sectional	1546 (837)	Women: 70.5 (7.0) Men: 70.2 (7.0)	Sedentary activities (TV time)	Interview-led survey (NIPPON DATA2010)	Both	Sex and/or gender as a determinant of SB
Suzuki et al. (2020); Japan; Cross-sectional	136 (68)	88.0 (1.0)	Total ST	ActiGraph GT3X	Both	Sex and/or gender as a moderator of SB effects on health
van Ballegooijen et al. (2019); The Netherlands; Cross-sectional	1201 (615)	70.7 (8.0)	Total ST	ActiGraph GT3X+	Both	Sex and/or gender as a determinant of SB
Wright-St Clair et al. (2017); New Zealand; Longitudinal cohort	649 (363)	Range: 80-90 (Māori); 85+ (non-Māori)	Sedentary activities	Interview-led questionnaire	Both	Sex and/or gender as a determinant of SB

Wu et al. (2021); United States; Longitudinal	92 (46)	70.6 (6.6)	Physical inactivity/ST	Commercial Withings actigraphy watches	Both	Sex and/or gender as a determinant of SB
Yu & Schwingel (2019); China; Cross-sectional	4165 (2442)	69.2 (7.7)	Sedentary activities; Total ST	Self-report questionnaire (PASE)	Both	Sex and/or gender as a moderator of SB effects on health

Note. Abbreviations: ST = Sedentary Time; TV = Television; SB = Sedentary Behaviour; SGBA = Sex- and Gender-Based Analysis; SE = Standard Error; IQR = Interquartile Range; GPAQ = Global Physical Activity Questionnaire; BEPAS = Belgian Environmental Physical Activity Study in Seniors; IPAQ = International Physical Activity Questionnaire; CCHS-HA = Canadian Community Health Survey – Healthy Aging; CHAMPS = Community Health Activities Model Program for Seniors Questionnaire; SBQ-OA = Sedentary Behavior Questionnaire for Older Adults; NHS-PAQ = Nurses' Health Study Questionnaire; SHeS = Scottish Health Survey; NIPPON DATA2010 = National Integrated Project for Prospective Observation of Non-communicable Disease and its Trends in the Aged 2010; PASE = Physical Activity Scale for the Elderly.

APPENDIX 4: RESIDENT INFORMED CONSENT FORM (SWYC)

University of Lethbridge
Faculty of Arts & Science

Department of Kinesiology & Physical Education
4401 University Drive
Lethbridge, Alberta, Canada
T1K 3M4
Phone: 403.329.2680
Fax: 403.380-1839

In collaboration with University of New Brunswick and University of Ontario Institute of Technology

Informed Consent Form: Residents

PROJECT TITLE: Stand When You Can: Feasibility of a multi-level intervention to modify sedentary behaviour among older adults in assisted living

PRINCIPAL INVESTIGATOR:
Dr. Jennifer Copeland
Associate Dean, Faculty of Arts and Science
University of Lethbridge, 4401 University Drive
Phone: (403) 317-2804
jennifer.copeland@uleth.ca

PURPOSE OF THE STUDY

Sitting has been established as a risk factor for diseases and overall poor health. Older adults in assisted living sit more often compared to those who live in the community. The goal of this study is to reduce the amount of time spent sitting to maintain and improve the health and wellness of older adults in assisted living. We developed strategies like standing games to help limit resident's sitting time based on research and expert advice. They will be implemented for 12 weeks by a staff member (ambassador) in an assisted living residence.

The study consists of tracking sitting time, questionnaires, and interviews. We want to see if the strategies work to reduce resident's sitting time. This is for residents who are 65 years and over, able to stand from a seated position without assistance, and able to provide consent.

YOUR ROLE

- Our research staff will come in and ask you a series of questions. Your role is to answer truthfully and if you have any questions yourself, please feel free to ask the research staff for clarification.
- Once you provide consent, the research assistants will get you to perform a balance test, walking test, and a chair stand test. These tests will be done again after the program is completed.
- Then, you may be asked to wear a small ActivPal tool (it is as small as the pad of your thumb). This device measures the amount of time you spend moving. It is waterproof, so you can bathe with it. We ask that you just engage in your daily activities while wearing the device. A research assistant will help attach the device to your thigh with a special type of tape. You will have to wear it for 7 consecutive days before the program and after the program. If it is uncomfortable,

please advise the research staff and they will remove or readjust it. If during the week you decide to remove it, please keep the device in a secure place since it is expensive.

- We will also give you some questionnaires to measure motives, quality of life, and sitting time before and after the program, and hold an optional midway session at six weeks to discuss how the program is going.

POTENTIAL RISKS

There is a possibility for skin irritation from the adhesive tape that connects the ActivPal device to your leg. However, we are using Tegaderm which is gentle to the skin, flexes with the skin for greater comfort, and does not contain latex. If you feel some discomfort, please let us know so we can assist you.

You may experience some discomfort standing. However, you will only be encouraged to stand which only puts you at low risk to fall in exchange for a meaningful impact on your health. Also, staff will not include residents who are too high of a risk for falls in the study.

To minimize risks, a smaller study has been done that included 10 residents in 2019 to test out the program. No participants experienced adverse effects during that 6-week study.

POTENTIAL BENEFITS

Reducing sitting time and taking more breaks from sitting will help improve the health of older adults. Residents from our smaller study decreased sitting time, improved their physical function, and program strategies were reported as being acceptable and practical. We are hoping to find similar results through this study.

Residents will also get to try a standing program developed by researchers along with knowledge users in health care and assisted living.

INCENTIVES

If you choose to take part in the study, you will receive a ‘thank you gift’ in the form of gift cards, in local shops, for data collection before the 12-week intervention and after ($50 total). If you choose to withdraw from the study at any point, you will still receive the gift card associated with the first testing session.

CONFIDENTIALITY

Any information that can identify you will remain completely confidential and will only be disclosed with your permission. Only Dr. Copeland and her staff will have access to the data. All data will be stored in a locked environment within the Active Health Aging Lab at the UofL and will remain there for seven years, at which point it will be destroyed. If the results of the research are published, the study participant’s identity will not be revealed. The Research Ethics Board, Health Canada, and other regulatory authorities will be granted direct access to the study participant’s original records for verification of clinical trial procedures and/or data to ensure participant's rights and confidentiality.

PARTICIPATIONS AND WITHDRAWAL
Your participation in this study is strictly voluntary. You are free to withdraw at any time. You just have to contact activeaging@uleth.ca or (403) 317-5073.

QUESTIONS
Should you have any questions regarding this project, feel free to address them to Dr. Copeland either by phone, (403) 317-2804 or by email at jennifer.copeland@uleth.ca or to our research staff by phone, (403) 317-5073.

If you wish to speak to someone not associated with the project, please feel free to contact Dr. Wayne Albert, Dean of the Faculty of Kinesiology, at 506-453-4575.

Our study is also hoping to interview participants after the program so we can gather your overall experience. There will be a group interview and individual interviews that would occur at a later date.

If you are interested in doing interviews at a later date, please write down your contact info and our research staff will contact you.

____
Name

____
Email or Phone Number

Do you consent to participate in the interview after the program?

Yes / No

Do you agree to be audio-recorded when doing the interview in this research?

Yes / No

Do you consent to the use of de-identified quotes obtained during the study in the dissemination (i.e. publications/presentations) for this research study?

Yes / No

What is a de-identified quote?
De-identified quotes are quotes taken directly from an interview transcript and used in publications or presentations with all possible data linking to you as the interviewee is removed. This means all names, study IDs, personal health information, and study data will not be connected to this quote. The quote will be anonymous.

I have understood the information, including the risks of participation, and agree to participate in the study. I have been given a copy of the Consent Form, which I have read and understand. I have been given an opportunity to ask questions about the study and my participation, and I understand that I may ask questions at any time.

______________________	______________________	______
Name of Participant (Print)	Signature of Participant	Date
______________________	______________________	______
Witness (Print)	Signature of Witness	Date

APPENDIX 5: PARTICIPANT INFORMED CONSENT FORM (COGNITIVE FUNCTION STUDY)

University of Lethbridge
Faculty of Arts & Science

Department of Kinesiology & Physical Education
4401 University Drive
Lethbridge, Alberta, Canada
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Phone 403.329.2680
Fax: 403.380-1839

Sedentary Behaviour and Healthy Brain Aging

We invite you to participate in a study examining the effects of sedentary time on cognitive function and healthy brain aging in older adults. In the past two decades sedentary behaviour, like watching TV and sitting in cars has been recognized as a risk factor for poor health. We all frequently do sedentary activities in our daily lives, so understanding the association with health is a research priority. The purpose of this study is to see if a period of high sedentary time will influence cognitive function.

Procedures & Participant Responsibilities

Participation involves 4 visits to the Active Healthy Aging Lab at the University of Lethbridge. The first visit will take approximately 70-90 minutes, the second and third visits will take 15 minutes, and the fourth visit will take 70-90 minutes. Participation includes the following:

1. Completing a brief questionnaire about your health status, age, biological sex, gender and gender role orientation, and education. Your answers are strictly confidential.
2. Wearing an activity monitor (called an inclinometer) to measure your daily sedentary time and physical activity for 24 hours per day for **two** separate weeks. The inclinometer is small, lightweight, and waterproof (once secured), so it can be safely and comfortably secured to the middle of the top of your thigh for seven consecutive days using medical tape.

   For both weeks wearing the motion sensor you will simply continue your normal activities.
3. Completing a second brief questionnaire **twice** about your screen-based activities in the past week. This questionnaire will ask about the average amount of time you spent looking at screens (such as smartphones, tablets, and television) and your background screen use (such as watching television while cooking) in the past seven days. This questionnaire does **not** ask about the types of activities you complete on screens.
4. At two time points you will also complete a series of activities to assess cognitive functioning. These include a questionnaire regarding your planning and organization skills (BRIEF-A), a paper-based task that requires you to mentally rotate a figure, and two computerized tests of your organizational abilities and response time. Finally, you will assemble 4 simple LEGO© models and your hand and arm movements will be video recorded. You will not be identified. There is no right or

wrong answers on these assessments, the goal is simply to compare your scores two weeks apart.

Potential Risks and Discomforts

For all in-person visits to the Active Healthy Aging Lab, appropriate COVID-19 precautions will be taken to ensure your health and well-being. When you first arrive at the laboratory for each visit, you will be asked to don a face mask and sanitize your hands. Within the Active Healthy Aging Lab, routine sanitary procedures are regularly followed including sanitizing all laboratory surfaces and equipment before and after each visit. The researcher will wear a face mask at all times and physical distancing will be practiced whenever possible, and only one participant will be allowed in the laboratory at a time.

Benefits to Participants and/or Society

The most important benefit of your participation in this study is that you will be contributing to research that will improve our understanding of the effects of sedentary time on cognitive function. This may help us develop guidelines to promote healthy aging. Once the overall study is complete, **you can request a summary of the study results by contacting Jennifer Copeland (403-317-2804, jennifer.copeland@uleth.ca**).

Compensation for Participation

As a token of our appreciation, you will receive a $25 gift card at the completion of each week of wearing the motion sensor, for a total of $50 once your participation in this study is complete.

Confidentiality

Your anonymity will be protected by assigning an ID number to you, which will be used within the data set. A master list linking your name to your ID number will be stored on a password-protected computer, which will be kept in the principal investigator's locked laboratory. Only researchers associated with this study will have access to the master list and the data set, and all researchers will all sign a confidentiality agreement. The master list and any other personally identifying information (such as consent forms) will be destroyed one year after the study has been completed. Other anonymous data including the questionnaire responses and activity tracker data, may be kept indefinitely. The data collected in this study will be used for research purposes only, including a journal publication, and a research presentation. All data will be presented as a group (i.e. averages or percentages), and your individual identity will remain anonymous.

Freedom to Withdraw

Your participation in this research is **completely voluntary**. You are free to withdraw from this study at any time until the time of publication by contacting Jennifer Copeland (403-317-2804, jennifer.copeland@uleth.ca). Upon withdrawal, you may choose to have the data you have contributed until that point permanently destroyed (up until the time of publication). The decision to withdraw will not result in any consequences and will not impact the benefits of participating.

This letter is yours to keep. If you have questions about this research, please contact either:

Jennifer L. Copeland, PhD, Dept. of Kinesiology, (403) 317-2804
jennifer.copeland@uleth.ca

This research has been reviewed for ethical acceptability and approved by the University of Lethbridge Human Participant Research Committee. Questions regarding your rights as a participant in this research may be addressed to the Office of Research Ethics, University of Lethbridge (Phone: 403-329-2747 or Email: research.services@uleth.ca).

Consent Statement

Title of Study: **Sedentary Behaviour and Healthy Brain Aging**

Research Assistant: Kate Takeda
Faculty Supervisor: Dr. Jennifer Copeland **Phone Number:** (403) 317-2804

	Yes	No
Do you understand that you have been asked to be in a research study?	☐	☐
Have you read and received a copy of the attached Letter of Information?	☐	☐
Do you understand the benefits and risks involved in taking part in this research study?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Do you understand that you are free to leave the study at any time, without having to give a reason?	☐	☐
Has the issue of confidentiality been explained to you?	☐	☐
Do you understand who will have access to your information?	☐	☐
Who explained this study to you? ____		

By signing below, I agree to participate in this study:

____

Participant's Name Signature Date

____

Investigator's Name Signature Date

APPENDIX 6: 30-ITEM BEM SEX ROLE INVENTORY QUESTIONNAIRE

Short Form

1	2	3	4	5	6	7
Never or almost never true	Usually not true	sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true

1. Defend my own beliefs		16. Have leadership abilities	
2. Affectionate		17. Eager to soothe hurt feelings	
3. Conscientious		18. Secretive	
4. Independent		19. Willing to take risks	
5. Sympathetic		20. Warm	
6. Moody		21. Adaptable	
7. Assertive		22. Dominant	
8. Sensitive to needs of others		23. Tender	
9. Reliable		24. Conceited	
10. Strong personality		25. Willing to take a stand	
11. Understanding		26. Love children	
12. Jealous		27. Tactful	
13. Forceful		28. Aggressive	
14. Compassionate		29. Gentle	
15. Truthful		30. Conventional	