Implementability of a Community-Based Intervention to Reduce Sedentary Time-The EngAge Project

By

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Bachelor of Science in Kinesiology, University of New Brunswick 2024

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

Master of Science in Kinesiology

In the Graduate Academic Unit of Kinesiology

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This thesis is accepted by the
Dean of Graduate Studies

THE UNIVERSITY OF NEW BRUNSWICK

August, 2025

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Abstract

This study evaluated the implementability of a 9-week home-based intervention to reduce older adults' sedentary behavior. The main outcome, implementability, was assessed using eight criteria: adherence, adverse events, completion, engagement, dropouts, quality, training, and user satisfaction. It was hypothesized that completers would meet a minimum cut-off of 5/8 tested with a one-proportion test. Secondary outcomes included changes in physical functions and objectively measured sedentary behavior. Forty-two people participated (age 66 to 75; 74% female). Despite a high number of dropouts (n=18), all completers met six or more implementability criteria, 87% met seven ($p=0.01$), and 52% all ($p=0.84$). For completers, two out of three physical function tests showed significant improvement ($p < 0.05$), along with increased daily steps and upright time ($p < 0.05$). Given the small number of resources needed to deliver the intervention and the high proportion of older people with high sedentary behavior, the intervention could be scaled up.

Acknowledgement

I would like to acknowledge Research New Brunswick and the Canadian Institutes of Health Research for funding the project, which made this research possible. I want to acknowledge my colleagues at the Cardiometabolic Exercise & Lifestyle Laboratory, as well as my committee members, for their support throughout my research project. I want to thank my family for their endless love, encouragement, and unwavering support. I am especially thankful to my son, Rowan, for always reminding me to persevere and push my limits. Your inspiration has been a driving force behind my achievements. Finally, I would like to acknowledge and thank my supervisor, Dr. Danielle Bouchard. Without your encouragement and guidance, I would not have pursued this degree, and without your knowledge and unwavering support, I could not have completed it. Thank you for your endless support and mentorship.

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Curriculum Vitae

1.0 Introductory Chapter

Despite one's physical activity level, an association exists between sedentary behavior and negative health outcomes such as physical function, mental health, sleep quality, cognitive function, and social engagement (Copeland et al., 2017; Dogra et al., 2022). Age is associated with moving less, sitting more and exercising less. Older adults, usually defined as age 65+, living in the community spend approximately 80% of their awake time engaging in sedentary activities and behaviors (Rezende et al., 2014).

Sedentary time is typically defined as time spent in a sitting, lying or reclined posture with an energy expenditure less than or equal to 1.5 METs (Tremblay et al., 2017). It has many negative impacts on individuals' health and is independently associated with many chronic health conditions and clinical conditions (Booth et al., 2012). As individuals age, the accumulation of sedentary time tends to increase. Canadian adults ages 65-79 spend the most time engaging in sedentary behavior compared to all other age groups when measured using an accelerometer (Government of Canada, 2022b).

Dogra et al. (2022) proposed a stepwise approach, which is a progressive method compared to traditional approaches for reducing sedentary time. This approach is designed for inactive older adults, comprising four steps to help individuals become physically active over time. The first step is to reduce sedentary time. This approach differs from the traditional strategies as reducing sedentary time can be the outcome without changing the exercise levels. The same group performed a systematic review and identified a lack of interventions for reducing sedentary behavior for older adults (65+) living in the community (Katsoulis et al, 2024b). Based on the results, a co-creation process was done with key partners to develop the best intervention for older adults living in the community

to sit less (Katsoulis et al, 2024a). A total of 17 focus groups were completed (n = 50); four in older adults (6 women, 8 men), five with primary care providers (10 women, 4 men), and eight with exercise/recreation professionals (19 women, 3 men). The co-creation process yielded consistent themes/elements (e.g., simple, motivational messaging) across groups, while also revealing variance in others (e.g., the need for education, delivery mode). The information gathered was used to design the EngAge intervention.

Most studies in the literature test the efficacy of an intervention (e.g., reducing sedentary behavior) (Klaic et al., 2022) but fail to plan for evaluating if the intervention will be usable and sustainable for the older adults. By identifying factors that are key to ensuring efficacious interventions are implemented into practice, approximately US $85 billion in health research waste could be saved annually (Chalmers & Glasziou, 2009; Ivers & Grimshaw, 2016). Therefore, it may be important to assess an intervention's implementability first or, concurrently with assessing the intervention's intended outcomes, instead of the outcome measures exclusively.

The primary objective of the study was to assess the implementability (≥5/8 positive implementability criteria based on the implementability framework) of the EngAge intervention, developed through a systematic review by Katsoulis et al. (2024b) and a co-creation process with key informants (Katsoulis et al., 2024a). The eight criteria tested were based on the answers of participants (older adults) to a survey based on the Conceptual framework of the implementability of healthcare interventions (i.e., feasibility, scalability and sustainability) (Klaic et al., 2022). In addition, secondary outcomes (e.g., physical functions, sedentary behavior) were explored. The results from this implementability trial were used to determine if the proposed intervention is implementable –and if there were

any improvements to physical function and reducing sedentary behavior. The latter will help guide the required sample size for a future randomized trial.

The median age of participants was 70 years old. Most participants were females (73%) and Caucasian (83.3%). A total of 18 people did not complete the intervention. However, for all of those who completed the intervention, the minimum number (5/8) of the implementability criteria were met, while 7/8 criteria were reported as met by 87% of participants (95% CI 0.68-0.96, $p < 0.01$), and 52% of participants reported 8/8 criteria met (95% CI 0.33-0.71, $p < 0.84$). The least attained criterion of the six successful criteria was adherence (58%), while the highest attained successful criteria was training (100%). Dropout rate was high for this intervention (42%) with variability between sites (Site 1:20%; Site 2:71%; Site 3:60%). An average decrease for the 8-Foot-Up-and-Go from median (25-75th) of 7.5 seconds (6.1-8.5) to 6.5 (5.3-8.3)($r= -0.7$, $p<0.05$) was observed, while the 30-second Chair Stand test had an increase from 10.5 repetitions (9.0-12.0) to 13.0 (11.0-15.5) ($r= -0.5$, $p<0.05$) completed. A significant increase in daily step time 64.1 minutes (43.3-88.5) to 91.9 (73.4-102.8) ($r= -0.5$, $p<0.05$), daily step count 4831 (IQR: 2986-6120) to 7382 (5770-7747) ($r= -0.6$, $p<0.05$), and daily upright time from 4.3 hours (3.6-5.4) to 5.0 (4.3-6.8) ($r= -0.5$, $p<0.05$) was observed.

Despite the high dropout rate, those who completed the intervention valued it highly and demonstrated positive outcomes. Considering the minimal resources needed to implement the intervention and the widespread sedentary behaviour among older adults, the intervention showed promising improvements based on feedback and has the potential for scaling up.

2.0 Literature Review

Aging

Aging is the progressive change in an organism that leads to a decline in function and ability, taking place over the entire adult life span and is divided into two categories: chronological age and biological age (Guarente et al., 2024). The National Institute on Aging describes older adults as people aged 65 or older; however, there is no universally accepted standard for the definition of aging, and it depends on the organization (National Institutes of Health, 2022). Individuals age differently based on their physical and social environments. These environments can impact an individual's opportunities and health behavior in combination with personal characteristics (e.g., sex, ethnicity, family history)(World Health Organization, 2022).

Chronological age refers to the time that has elapsed since an individual's birth to a specific date. In contrast, biological age refers to the gradual accumulation of cellular damage in an individual and different biological and physiological developmental factors (Maltoni et al., 2021). The molecular and cellular damage accumulation over time leads to a gradual decrease in physical and mental capacity and an increased risk of diseases and death. Chronological aging is largely associated with other life transitions, such as retirement, moving into long-term care homes and death (World Health Organization, 2022).

Healthy aging is a newer concept the World Health Organization (2020) describes as developing and maintaining an older adult's functional ability that enables well-being. Healthy aging focuses on physical health and well-being (preventing or managing chronic diseases), whereas successful aging has a broader focus beyond physical health (Wong, 2018).

The concept of successful aging, gained popularity after a publication that discussed the differences between "usual" and "successful" aging (Rowe & Kahn, 1987), and was followed by subsequent research identifying the three key components of their model for successful aging (Rowe & Kahn, 1997) which were: the low probability of disease and/or disability related to disease (physical), high cognitive (psychological) and physical function capacity and active engagement with life (sociological). There are many variations of the successful aging theory that take into consideration different contextual factors in comparison to the original model published however, this model, by Rowe & Kahn has been and continues to be frequently cited, (Stowe & Cooney, 2014).

Sedentary activities are proposed to have a significant association with lower odds of successful aging in middle-aged and older adults (potentially in a dose-dependent manner), therefore, a reduction in sedentary behavior could positively impact how one ages and help older adults age successfully and healthy (Dogra & Stathokostas, 2012).

Prevalence

The aging population is growing globally. The projected prevalence of 2.1 billion people aged 60+ by 2050, compared to one billion of the population being 60+ in 2020, with two-thirds of this projected population living in low- and middle-income countries (World Health Organization, 2022).

Globally, life expectancy has increased by 6.6 years (from 66.8 years to 73.4 years) between 2000 and 2019. Healthy living expectancy has also increased by 5.4 years. However, this increase was due to a decline in mortality instead of a reduction in the number of years someone lived with a disability (World Health Organization, 2024).

In 2021, the proportion of seniors in Canada was 18.5%, and older adults are projected to make up 25.9% of Canada's population by 2068 (Government of Canada, 2022a). The

aging of Western populations has mainly stemmed from a decrease in fertility rates, the aging of the "baby boomers", and the increase in life expectancy (de Meijer et al., 2013). The global population is living longer, but this does not mean during these additional years, they are living without health conditions (chronic conditions/diseases), disabilities, or functional limitations. Many individuals experience a significant disability (1.3 billion people), which represents 16% of the world's population (WHO, 2023). Of the individuals aged 60 and older, 46% have a disability, with 250 million experiencing a moderate or severe disability (United Nations, 2024) . For countries that have a life expectancy over 70 years of age, people are spending an average of eight years living with a disability and having a disability can double an individual's chance of developing certain (e.g., diabetes, obesity, and asthma) (World Health Organization, 2023; Disability World, 2014).

In 2017, 38% of people aged 65 and older were living with a disability in Canada, with the top three disabilities being pain-related, flexibility, or mobility-related (Government of Canada, 2022c). When it comes to chronic conditions, 73% of individuals aged 65 years and older have at least one of the ten most common chronic diseases, with the highest prevalence being hypertension with 65.7% (Government of Canada, 2020). Interestingly, those living rurally have a higher prevalence of having multiple chronic conditions than those living in urban areas. The increased prevalence of older adults, along with the increase in life expectancy, creates a unique set of multifaceted challenges on a provincial, national, and global level.

Challenges Associated with Aging

As individuals age, they face a new set of challenges. These can be related to health- social, environmental, and economic outcomes (Yashin et al., 2007).

Physical Health Challenges. Hypertension, periodontal disease, osteoarthritis, ischemic heart disease and diabetes are the five most common chronic conditions and diseases with a high prevalence in the older adult population (Government of Canada, 2020). Along with the increase in the prevalence of chronic conditions as an individual age, there is a decline in functional ability. Sarcopenia, defined as the loss of muscle mass with aging – creates challenges for older adults such as impacting quality of life and loss of independence (Alliance for Aging Research, 2017). This decline can impact the quality of life by causing impairment of physical function and a decline in mobility (Barry, 2020).

Chronic conditions contribute to geriatric syndromes, defined as multifactorial conditions common among older adults but do not fit into specific disease categories. Geriatric syndrome includes instability and falls, frailty, mobility impairment, cognitive impairment, visual/hearing impairment, urinary incontinence, dizziness and depressive symptoms (Koroukian et al., 2016; Rockwood & Mitnitski, 2007). The geriatric syndrome may also majorly impact the quality of life, independence and longevity (Flacker, 2003; Inouye et al., 2007).

There are geriatric-relevant health outcomes that have specific associations with sedentary time such as physical function, cognitive function, QOL and mental health (Copeland et al., 2017). Therefore, this creates another set of challenges for this population regarding sedentary behavior as the amount of time spent performing sedentary behavior could not only increase the risk of chronic conditions/diseases and

decrease functional ability, but it could also affect these geriatric syndromes, having an impact of independence, longevity, and quality of life.

Sedentary behavior and lifestyles, which dominate in the older adult population, result in an early onset of chronic conditions, diseases, ill health, and frailty (McPhee et al., 2016). This creates a unique challenge as there are more older adults living longer with an early onset of ill health. The decline in physical functions and increase in chronic conditions and geriatric syndromes as one ages creates challenges beyond an individual level, such as economic and social challenges.

Economic Challenges. Economic challenges are faced with an increase in the population's average age. One of the main impacts is an increase in the dependency ratio and an increase in government spending on health care and pensions (Pettinger, 2023). The demographic dependency ratio considers both the youth population and the senior population to working-age population (Statistics Canada, 2016). Globally, the amount of the population that is considered part of the working-age population has decreased from 75% in 1960 to 55% in 2022 (*World Bank Open Data*, 2024), while the population aged 65+ has doubled from 5% to 10% during the same period. It is projected that by 2056, the total demographic dependency ratio could increase to 84 dependents for every 100 working-age individuals due to the increase in older adult populations (Statistics Canada, 2016).

The old-age dependency ratio – defined as the number of individuals aged 65 and older per 100 working-age people (Organization for Economic Co-operation and Development, 2025) - increased from 13 ratios in 1971 to 27.4 ratio in 2020 (Knoema, 2020) and is expected to double by 2075 (if aging thresholds remain constant). This increase in the dependency ratio creates a challenge economically due to the increase in

people claiming benefits and the decrease in working-age individuals paying income taxes to support the aging population. Another challenge faced economically is the cost of healthcare for older adults. Chronic conditions can exponentially increase the cost of healthcare, and older adults are disproportionately affected by them; 95% have at least one chronic condition, and 80% have two or more (National Council on Aging, 2023). 45.7% of total healthcare expenditure in 2019 was spent on Canadians aged 65 (Globerman, 2021). Over the next ten years, the aging population will add 93 billion dollars to healthcare costs (Gibbard, 2018). The older adult population has grown at an annual rate of 1.75% since 1974 (Knoema, 2020). If the population continues to grow at this rate there is potential for economic instability as the cost of health care is more for older adults and the proportion of older adults continues to increase.

Social Challenges. Aging also presents challenges and opportunities to strengthen/address the social needs of this population. . Older adults may lack opportunities for social activity engagement or may not engage in these opportunities, which can lead to diminished physical and motor functionality, ultimately creating a high exposure to loneliness and isolation in this population. This population is at risk for developing depression and cognitive disorders from the lack of social engagement opportunities (Hao et al., 2017). Embedding in high-quality close relationships and feeling socially connected is associated with decreased risks for all-cause mortality and a range of disease morbidities (Holt-Lunstad et al., 2017).

Aging is a progressive process, and with an aging population, a new set of complex challenges arises. Finding a balance between individual, social, and economic levels is crucial, as they are all interrelated and influence and affect each other. As one ages, the amount of time spent being sedentary increases, which is not only a personal

health concern but also highlights the broader systematic issues faced (i.e., lack of social opportunities, public transportation (Lamanna et al., 2020)). Strategies are needed to address these barriers, allowing this population to engage within their community, which could help to reduce the risks associated with excessive sedentary time.

Health Literacy

Health literacy is defined as "the personal knowledge and competencies that accumulate through daily activities, social interactions and across generations. Personal knowledge and competencies are mediated by the organizational structures and availability of resources that enable people to access, understand, appraise and use information and services in ways that promote and maintain good health and well-being for themselves and those around them" (World Health Organization, 2021).

Research has shown that as one ages, functional literacy begins to decline (Baker et al., 2000). Low health literacy is associated with poorer health outcomes (Chesser et al., 2016). Other factors such as socio-economic status, race, cognition and education level can also contribute to poor health literacy levels (Cutilli, 2007). With the prevalence of older adults increasing, it is essential to provide them with the means to achieve adequate health literacy. The National Assessment of Adult Literacy reported that 68% of older adults had difficulty understanding numbers and calculations while 71% experienced difficulty using printed materials and 80% using health-related documents (Kutner et al., 2006).

There are many screening tools to assess health literacy (Bonaccorsi et al., 2025); the Test of Functional Health Literacy in Adults (TOFHLA) being one of the most commonly used (Chesser et al., 2016), consisting of 50 reading/comprehension questions and 17 numerical questions, with a maximum time of 22 minutes to complete the test

(Parker et al., 1995). In comparison, the Short Test of Functional Health Literacy in Adults (STOFHLA) another commonly used tool (Chin et al., 2011) includes a total of 36 questions that participants must choose the word that best fits the blank in each sentence and must be completed in seven minutes (Nurss et al., n.d.). Functional Health literacy scores are interpreted as the following: adequate health literacy (23-36); marginal (17-22); inadequate (0-16). The majority of the screening tools are not validated with older adults specifically, making it difficult to ensure the reliability of results from the tool (Bonaccorsi et al., 2025).

To help combat health literacy challenges for older adults, there are guidelines used for developing materials. There are resources available for health professionals and organizations to utilize for communication guidance, web communication guidance, and assessment tools, such as the Clear Communication initiative, to ensure that individuals can easily understand health information (National Institute of Health, 2025). One strategy recommendation is to use participatory design when developing your materials, meaning that the users of the materials are included in the design process. The use of pictures, narrative communication, use of headings with information spread into reasonable sizes are recommendations to improve materials (Centers for Disease Control and Prevention, 2024b). The use of pictures that are linked to the information within the material is effective for individuals with the comprehension of and ability to recall the information (Houts et al., 2006; Schubbe et al., 2020). The Center for Disease Control and Prevention (2024b) recommends the use of narrative communication (i.e., examples, anecdotes, quotations, vignettes, personal stories) to provide readers with statistical information as well as the use of headings and breaking up information and statistics to reduce the likelihood of individuals being overloaded.

By including these possible strategies in the development of materials, older adults are more likely to understand the health information.

Sedentary Behavior

Definition of Sedentary Behavior

Confusion can arise when differentiating physical activity, sedentary behavior, and physical inactivity concepts. Therefore, it is essential to understand the definitions and their differences.

Based on a literature review conducted by the Sedentary Behavior Research Network, sedentary behavior is defined by its impact on energy expenditure and posture. Sedentary behavior includes sitting during commuting, work, home and leisure time (Owen et al., 2010). Older adults spend 80% of their awake time performing sedentary behavior (Rezende et al., 2014).

Sedentary time in awake time is often categorized into three broad categories: leisure, occupation or transport (Hallgren et al., 2020). Passive sedentary behavior activities have been defined by Kikuchi et al., (2014) as the following: watching television, listening to music, talking or sitting around time while mentally active sedentary behavior was considered as either reading or internet usage during leisure time (Kikuchi et al., 2014). A scoping review did report that not all sedentary activities are equally detrimental and more studies are needed to distinguish these activities (Copeland et al., 2017).

Physical activity is defined as body movements generated by skeletal muscle contractions that raises energy expenditure above resting metabolic rates and can be characterized by frequency, intensity, duration, its modality, and context of practice

(Thivel et al., 2018). To be considered active, it is usually based on a minimum of 150 minutes of moderate to vigorous intensity, two sessions of resistance training and some balance activities (Centers for Disease Control and Prevention, 2024a; Canadian Society for Exercise Physiology, 2021). As a result, physical inactivity is described by Thivel et al. (2018) as representing the non-achievement of physical activity guidelines. More broadly and more adapted to older adults, physical activity can be evaluated with questionnaires about day-to-day tasks such as the Keele Assessment (Wilkie, 2010) or the Physical Activity Scale for the Elderly (Schuit et al., 1997).

Measuring Sedentary Behavior

Sedentary behavior can be measured using device-based or self-reported measures. Device-based measures are supposed to be impartial/unbiased, by using a device to obtain the data (Mobbs, 2021), while self-reported measures are evaluated based on someone's perception ,opinions and judgements,

Self-reported Measures. self-reported measures are obtained using self- and/or proxy-report questionnaires as well as diaries (Atkin et al., 2012). Self-reported measures can be beneficial, as they offer insight into what specific activities individuals may participate in while sedentary.

Device-based Measures. Devices such as accelerometers, posture monitors (inclinometers), wearable cameras, heart-rate monitors, and multi-sensors (accelerometers placed in different anatomical sites) have been previously used to estimate sedentary behavior objectively (Aunger & Wagnild, 2022).

One measurement that can be used to measure sedentary behavior is direct observation. This method has the advantage of requiring minimal equipment, allowing context assessment, and distinguishing between non-ambulatory postures. There is the

potential for individuals to experience the Hawthorne effect, where they will change their behavior because they are being watched (Berkhout et al., 2022). The disadvantage is the high need for human resources. Direct observation has high validity and reliability as long as the observer (s) have adequate training to classify behaviors (Aunger & Wagnild, 2022).

An inclinometer can differentiate between sedentary and active behavior and report when an individual performs different behaviors such as lying down, sitting, stepping, or standing. This device is small and discreet under clothes and allows continuous 24-hour wear protocol. These devices can measure total sedentary time but cannot capture contextual information or determine specific occurring behaviors. As a result, the best strategy is to combine an inclinometer with an accelerometer or a self-reported journal. Inclinometers have a very high reliability (≥95% agreement with direct observation) and validity (inter-device reliability >0.99) (Aunger & Wagnild, 2022).

An accelerometer (e.g., Actigraphy, GENEActiv, Axivity) can identify physical activity intensity and sedentary behavior, based on movement rather than position. Accelerometers (when worn on the thigh) have very high reliability and validity (≥90% agreement with direct observation). When worn on the wrist, reliability ranges from medium to high (depending on processing methods) while still having very high validity. When these devices are worn on the hip, the reliability is low (58% agreement with direct observation); meanwhile, validity is still very high (Aunger & Wagnild, 2022). When worn on the wrist and hip, they are unable to distinguish between sitting and standing postures. Based on previous studies, the Hawthorne effect is reduced significantly after wearing the device for more than three days (Trost et al., 2005).

The ActivPAL device, is an accelerometer and inclinometer (Sellers et al., 2016).

The typical wear time for the ActivPAL is seven days to ensure accurate assessments of an individual's sedentary behavior (Chan et al., 2017; Edwardson et al., 2017). Still, the device can record and store memory for up to 14 days (PAL Technologies, 2024). The ActivPAL device is worn on the anterior midline of the thigh; the location of this sensor allows for rich information about posture and transitions between standing and being sedentary (sitting/lying) (Lyden et al., 2017). Anything less than 20 degrees from horizontal (0 degrees) is considered sedentary (Bassett et al., 2014). However, with the use of transitions from sitting to standing in addition to accelerations, it is possible to track posture.

Using different technologies or means to measure sedentary behavior gives us quantitative data and provides insights into real values for sedentary behavior. Still, it is essential to understand what motivates individuals to spend the time we are measuring as sedentary. Understanding the factors that influence this population's decision to be sedentary could enable researchers to develop strategies to reduce this amount of time and measure the change using these devices or methods.

Factors Influencing Sedentary Behavior

Understanding the factors that impact an individual's sedentary behavior is important for reducing it. Sedentary behavior is influenced by a complex interaction between environmental, socio-cultural, and individual factors (e.g., interpersonal, personal and developmental) (Nuwere et al., 2022; Rawlings et al., 2019). The increase in occupational sedentary behavior (office jobs), decrease in facilities/spaces for exercise, and the increased penetration of technological devices such as phones and television contribute to the increase in people living a sedentary lifestyle (Park et al., 2020). These habitual behaviors formed during working years could influence their

sedentary behavior after retiring (Suorsa et al., 2021).

Personal and developmental factors could include health status, retirement, and previous job types (Nuwere et al., 2022). Societal and environmental factors, which could be considered as possible facilitators and barriers, include physical terrain and weather, the availability and affordability of transportation, and the acceptability of leisurely activities locally, as well as senior centers and other community institutions.

A systematic by Rawlings et al. (2019) identified three analytical themes influencing sedentary time: the impact of different life stages on sedentary behavior, lifestyle factors influencing sedentary behavior and the barriers and facilitators to changing sedentary behavior. The four stages of life were broken down into childhood, student and adulthood, retirement and later life, and illness. The three main barriers/facilitators to changing sedentary behavior were education on sedentary behavior, strategies to change sedentary behavior and the benefits of the change (Rawlings et al., 2019).

In a study with 11 community-dwelling older women (65+) Chastin et al., (2014) performed a qualitative investigation identifying the determinants of sedentary behavior, motivation, barriers, and strategies to reduce sedentary behavior. Based on this investigation, there were five main determinants for these participants to perform sedentary activities. These were: physical complaints, lack of environmental facilities or stimuli, pleasure and relaxation, peer and societal pressure and mental health reasons. The sedentary behavior patterns share similarities with spending more time in the afternoon or sitting all day. Pain, fatigue, and functional limitations impacted their decision to sit down. Lack of confidence and lack of motivation were two barriers that

contributed to these participants' reason to sit for long durations (Chastin et al., 2014).

Weather, an environmental factor, can also influence how individuals allocate time to certain activities and behaviors in 24 hours. Adults tend to be less active and more sedentary when the weather is extreme (Ferguson et al., 2023). Since environmental factors can impact geographic location can influence an individual's behavior; different countries have different levels of sedentary behavior.

In summary, there are numerous factors that can have a positive or negative impact on people's sedentary behavior. When creating and implementing an intervention, it is essential to consider these barriers, factors, and facilitators to provide participants with better resources and opportunities. Understanding and being aware of what acts as barriers can help determine how to interact with the individual to guide them to the goal of reducing sedentary behavior.

Impact of Sedentary Behavior on Functional Health

Physical health differs from functional health however sedentary time can impact both. Physical health refers to a metabolic and cognitive state without any disease (Garcia-Falgueras, 2021), whereas, functional health refers to a person's ability to perform activities of daily living and their quality of life (World Health Organization, 2020) . To summarize the difference, physical health refers to the overall state of health of the physical body, and functional health refers to the body's ability to perform activities based on its physical health

Sedentary behavior is a modifiable risk factor associated with many chronic conditions and/or clinical conditions (Booth et al., 2012). Increasing time spent performing sedentary behavior increases an individual's risk of premature mortality (Park et al., 2020). Inversely, less sedentary time may be a protective factor in maintaining

physical and psychological health (Nuwere et al., 2022). Spending more time sitting can also negatively impact multiple critical physiological systems functionality such as aerobic capacity, skeletal muscle metabolism/function, telomeres/genetic stability, and cognitive function, which play a role in functional ability (Thyfault et al., 2015). The dose and type of sedentary behavior are important factors that impact health outcomes, as certain types of sedentary behavior (cognitive engagement) can benefit older adults (Copeland et al., 2017).

Sedentary lifestyles are strongly associated with cardiovascular diseases, diabetes mellitus, cancer and premature mortality (Katzmarzyk et al., 2019). Sedentary behavior can also lead to other metabolic dysfunctions other than insulin resistance, such as a perturbation of insulin-like growth factor axis and changes in the circulation levels of sex hormones (Park et al., 2020).

Not only does sedentary behavior affect the previously mentioned conditions, which are commonly thought of when looking at the impact on health from sedentary behavior, but it can also impact bone mineral density. A negative correlation was found between sedentary behavior and lumbar bone mineral density, which means as sedentary behavior increases the risk of osteoporosis (Lin et al., 2023).

Sedentary behavior is associated with poor physical function in older adults (Gilchrist et al., 2022). Functionality is multidimensional, and the ability to perform instrumental activities of daily living and basic activities of daily living is indirectly associated with sedentary behavior, however, these relationships are mediated by aerobic exercise as well as nutrition and flexibility of the lower limbs (Garcia Meneguci et al., 2021). More sedentary time increases the risk of developing disabilities related to instrumental activities of daily living and/or basic activities of daily living disabilities

(Storeng et al., 2018).

Along with the decline in functionality from the lack of adherence to healthy lifestyles and behaviors, sedentary behavior is associated with individuals having disabilities in activities of daily living, whether they participate in physical activity or not (Chen et al., 2016; Dunlop et al., 2015). Dunlop et al., (2015) reported that for each hour spent performing sedentary behavior daily, there is a 46% greater risk of having issues with activities of daily living.

Breaks in sedentary time have a positive association with improving physical function in older adults (Sardinha et al., 2015), which can enhance one's abilities in daily living activities and support independence. In a study by Lai et al., (2023) it was concluded that physical function outcomes based on breaks in sedentary time can be affected by the time of day when breaks in sedentary time are performed. Individuals who broke up sedentary time during the evening more frequently, were found to have better lower extremity strength (Lai et al., 2023). An association was also found between an increase in breaks in sedentary time and a lower risk of having a disability in instrumental activities of daily living (tasks requiring complex thinking skills or organizational skills (Cleveland Clinic, 2024)) (Chen et al., 2016). In one study, it was found that individuals who did not break up sedentary time at least seven times every hour were more at risk for being unable to perform activities of daily living and were at an increased risk for physical dependance regardless of time spent performing moderate to vigorous physical activity (Sardinha et al., 2015). These results together highlight the importance of and benefits from breaking up sedentary time as well as the negative impact that can occur from not breaking up sedentary time enough can have, and that sedentary time has negative impacts regardless of the amount of time you spend being

physically active.

To conclude, sedentary time can have a large impact on adults 65 and older, as it can negatively impact health and physical function. Finding strategies to improve physical function and health could lead to benefits as previously explained for one's health and improve one's ability to be independent and perform activities of daily living.

Interventions to Reduce Sedentary Behavior with Older Adults

Chastin et al. (2021) summarized interventions to reduce sedentary behavior (Chastin et al., 2021). Based on seven studies with 397 older adults as participants (284 females) in adults 60+, they found that interventions for reducing sedentary behavior can be delivered at individual, environmental or policy levels as proposed by the socio-ecological model, which highlights the various levels of influences for behavior changes (Panter-Brick et al., 2006).

At the individual level, interventions could be delivered on a one-on-one basis or through the community to reach more individuals. This type of intervention focuses on behavior change techniques, to drive the individual to change the specific behavior being targeted. The Stepwise approach has been proposed to reduce sedentary behavior (Dogra et al., 2022). This approach may lead to highly sedentary and/or inactive individuals being more successful in adhering to better lifestyles instead of starting with physical activity at moderate to vigorous intensity by targeting prolonged and uninterrupted sitting (Dogra et al., 2022). This approach could be the first step for individuals to become physically active and perhaps stop at this first step and still have benefits.

At the environmental level, interventions can include changes in the physical layout of the domestic environment and changes to the built environment. A systematic

review performed by Gardner et al., (2016) for adults acknowledged that interventions focused on environmental restructuring, persuasion, or education had better success at reducing sitting time and that the behavior change techniques found to be useful were self-monitoring, problem-solving, as well as restructuring the social and/or physical environment (Gardner et al., 2016). At the policy level, interventions could be used to develop new policies that promote a reduction in sedentary behavior and encourage individuals to stand more in public spaces (Chastin et al., 2021).

Our group performed a systematic review to inform a co-created intervention aimed at reducing sedentary behavior for older adults living in the community that was recently conducted to determine the structure of the proposed intervention. This systematic review included 17 interventions with 617 people aged between 60 and 90. Most studies had completion rates above 80%. Within-group findings showed promise for reducing sedentary time satisfaction/adherence to interventions, which was generally high. The most promising strategies were providing hard copies of the intervention and having individual meetings (Katsoulis et al.,2024b). This systematic review led to the development of the intervention through a co-creation process (Katsoulis et al., 2024b), involving key informants to inform the intervention's design. The co-creation process is a collaborative approach that can be used involving decision makers to develop and design the interventions that will be used as they contribute to defining the directions and purposes, as well as solving any problems that may be faced along the way (Patient-Centered Outcomes Research Institute, 2023). This method of developing an intervention enables decision-makers, members of the community, individuals who are healthcare workers, as well as policymakers, to participate in the development of meaningful interventions (Lazo-Porras et al., 2020). A study identifying the effectiveness of using

the co-creation process for research concluded that, based on the 26 primary studies included in their search that used the co-creation process, they showed small to moderate positive effects on several immediate health-related outcomes and broader applications to public health (Halvorsrud et al., 2021). In addition, the co-creation process in public health is beneficial in multiple ways, including creating a greater relevance and applicability of the research, improving trust and engagement among stakeholders, fostering long-term relationships with stakeholders and increasing the uptake and implementation of the findings from the research conducted (Heimburg & Cluley, 2021; Messiha et al., 2023). In the case of our co-creation process (Katsoulis et al., 2024a), there were 17 focus groups (n = 50); four in older adults (6 women, 8 men), five with primary care providers (10 women,4 men), and eight with exercise/recreation professionals (19 women, 3 men). Participants expressed various personal preferences and opinions on the components necessary for a relevant intervention based on the Staircase Approach. Some themes were consistent across and within groups (e.g., simple, motivational messaging), while others differed (e.g., education, delivery mode, and contact). This process yielded novel findings about the needs and preferences of inactive community-dwelling older adults. The elements of this intervention were combined into the intervention within the proposed study. Another advantage of developing an intervention based on the co-creation process is to gauge implementability at the beginning of the process.

The Importance of Frameworks, Models and Theories

Using theories, models, and/or frameworks can help researchers understand the mechanisms that impact success; it can also help structure data collection and analysis (Nilsen, 2015). It is commonly proposed to test implementation outcomes in addition to

effectiveness outcomes to help understand the odds of scalability and sustainability (Curran et al., 2012). However, implementation sciences call for an evidence-informed intervention to be tested (Bauer et al., 2015). Aside from implementation sciences, implementation outcomes can be collected to inform the scalability and sustainability of initiatives.

The Conceptual Framework of Implementability proposed by Klaic et al., (2022) focuses on five concepts of intervention in healthcare: acceptability, fidelity, feasibility, scalability or sustainability. In comparison to other frameworks, this framework focuses on real-world applicability, trying to ensure it is practical for use outside of a controlled setting. This framework also sets specific criteria that is recommended to be re-evaluated over time. These specific criteria fit into at least one of the five concepts to measure success of an intervention, making evaluation of an intervention straightforward with recommendation to test in different settings and time points

Other frameworks that are commonly used in implementation science are RE-AIM which stands for Reach, Effectiveness, Adoption, Implementation and Maintenance (RE-AIM, 2025). This framework has been primarily used to evaluate the impact of an evidence-based intervention on public health (Holtrop et al., 2021). This framework is comprehensive, but complex and time-consuming, making it difficult to apply in resource-limited settings.

Gap in the Literature

There are benefits to sitting less, regardless of one's activity level (Healy et al., 2008). However, many interventions have reduced sedentary behavior by increasing

exercise. While these traditional interventions replace sedentary behaviour, the stepwise approach proposed by Dogra et al. (2022) is progressive and targets reducing sedentary behaviour rather than replacing it with physical activity. This approach allows people who cannot perform traditional physical activity t a feasible option to reduce sedentary time, improving their health or functional outcomes. This approach highlights reducing sedentary time as the goal or the first step to being physically active. Based on the previous work done (i.e., a systematic review, the co-creation process), which was based on the Stepwise Approach (Dogra et al., 2022), the objective of the study was to test the implementability of an intervention to reduce sedentary behavior for community-dwelling people aged 65+ while exploring if sedentary time reduces.

The primary objective of the study was to assess the implementability of the EngAge intervention, ensuring it not only worked but was also well accepted by end users, as outlined in the framework developed through a systematic review and a co-creation process with key informants. It was hypothesized that for those who completed the intervention, at least 5 of the eight individual criteria of implementability would be met (i.e., adherence, adverse events, completion, engagement, dropouts, quality, training, and user satisfaction). In addition, secondary outcomes (e.g., physical functions, sedentary behavior) were measured. The results from this study will be used to determine if the proposed intervention is implementable and whether it could improve physical functions and reduce sedentary behavior. In addition, the changes in sedentary behavior will help guide the required sample size for a future randomized trial.

3.0 References- Introductory and Literature Chapters

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4.0 Article

Implementability of a Community-Based Intervention for Adults Age 65+ to Reduce Sedentary Time: The EngAge Project

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To be submitted to the Journal of Activity, Sedentary and Sleep Behaviors

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Abstract

Background: Sedentary behavior is independently associated with numerous health and functional outcomes and is a modifiable risk factor linked to various chronic and/or clinical conditions. People aged 65 and above spend an average of nine hours (80%) of their awake time in sedentary behavior per day. Strategies to reduce sedentary behavior for older adults living in the community are scarce, and not all show a significant reduction in sedentary behavior.

Methods: This implementability trial aimed to test the implementability of the evidence informed EngAge intervention, which was created based on a systematic review, engagement with end-users (older adults, exercise/recreation professionals, and primary healthcare providers), and a co-creation process with researchers. Implementability was assessed using the implementability framework, which requires a positive outcome for at least five of the eight minimum criteria: adherence, adverse events, completion, engagement, dropouts, quality, training, and user satisfaction. It was hypothesized that for those who completed the intervention, at least five of the eight criteria would be met. A secondary aim was to explore changes in movement behaviour-related outcomes, such as physical function (i.e., 30-minute chair stand, Timed-up-and-Go, and 2-minute steps test) and device-measured sedentary behaviour (i.e., Step count, Sedentary time, Upright time, Step time, and sedentary-to-upright movements), assessed using an ActivPAL.

Results: The majority of participants were female (73%), Caucasian (83%) and 70 years old (n=?). A total of 18 people did not complete the intervention. However, for all the completers, the minimum number (5/8) of the implementability criteria were met. In contrast, 7/8 criteria were reported by 87% of participants (95% CI 0.68-0.96, p <0.01),

and 52% of participants reported 8/8 criteria met (95% CI 0.33-0.71, p < 0.84). The least attained criterion of the six successful criteria was adherence (58%), while the highest attained successful criterion was training (100%). Dropout rate was high for this intervention (42%) with variability between sites (Site 1: 20%; Site 2: 71%; Site 3: 60%). An average decrease for the 8-Foot-Up-and-Go from median (25-75th), with effect size represented as r, of 7.5 seconds (6.1-8.5) to 6.5 (5.3-8.3)(r= -0.7, p<0.05) was observed, while the 30-second Chair Stand test had an increase from 10.5 (9.0-12.0) to 13.0 (11.0-15.5) (r= -0.5, p<0.05) completed. A significant increase in daily step time 64.1 minutes (43.3-88.5) to 91.9 (73.4-102.8) (r= -0.5, p<0.05), daily step count of 4831 (2986-6120) to 7382 (5770-7747) (r= -0.6, p<0.05), and daily upright time of 4.3 hours (3.6-5.4) to 5.0 (4.3-6.8) (r= -0.5, p<0.05) was observed.

Conclusions: The dropout rate was 42%; however, for those who completed the intervention, it was valued highly and demonstrated positive outcomes. Considering the minimal resources needed to implement the intervention and the widespread sedentary behavior among older adults and its impact, the intervention showed promising improvements based on feedback and has the potential for scaling up.

Keywords

"Sedentary behavior" "inactive" "physical inactivity" "prolonged sitting" "older adults" "seniors" "aging" "aging population" "active aging" "community program" "implementation"

Background

Sedentary time is typically defined as time spent in a sitting, lying or reclined posture with an energy expenditure less than or equal to 1.5 METs (Tremblay et al., 2017). It has many negative impacts on individuals' health and is independently associated with many chronic health conditions and clinical conditions (Booth et al., 2012). These negative impacts on health can impact older adults' quality of life and ability to age healthy (Dogra & Stathokostas, 2012). As individuals age, the accumulation of sedentary time tends to increase. Canadian adults ages 65-79 spend the most time engaging in sedentary behavior compared to all other age groups when measured using an accelerometer (Government of Canada, 2022b). Older adults, usually defined as age 65+, living in the community, spend approximately 80% of their awake time engaging in sedentary activities and behaviors (Rezende et al., 2014). Interestingly, the effect of sedentary behaviour is interrelated to one's physical activity level (Copeland et al., 2017; Dogra et al., 2022).

Dogra et al., (2022) proposed a stepwise approach to progressively increase physical activity among inactive seniors, comprising four steps, the first of which involves reducing sedentary time. This approach differs from traditional strategies in two ways: firstly, it emphasizes progressing from step one (sedentary behaviour) rather than starting at step three (moderate-to-vigorous physical activity), and secondly, since reducing sedentary time has benefits in and of itself, it can also be the outcome without changing exercise levels. The same group performed a systematic review and identified a lack of progressive interventions for reducing sedentary behavior for older adults (65+) living in the community without increasing physical activity (Katsoulis et al, 2024b). Based on the results, a co-creation process was conducted with key partners to develop the most effective

intervention for older adults living in the community aimed at reducing sitting time (Katsoulis et al., 2024a). A total of 17 focus groups were conducted (n = 50), comprising four with older adults (6 women, 8 men), five with primary care providers (10 women, 4 men), and eight with exercise and recreation professionals (19 women, 3 men). The co-creation process yielded consistent themes and elements (e.g., simple, motivational messaging) across groups, while also revealing variance in others (e.g., the need for education, delivery mode). The information gathered was used to design the EngAge intervention.

Most of the studies in the literature test the efficacy of the intervention as the main outcome (e.g., reducing sedentary behavior) (Katsoulis et al., 2024b) without testing the implementability of the intervention itself. As a result, interventions are available, but their implementability remains unknown. Therefore, the future ability to translate these interventions into practice remains unknown. Scalability of trial interventions depends on many factors (i.e., complexity of interventions, human resources limitations) (Yamey et al., 2012). By identifying key factors that ensure the efficacy of interventions is implemented into practice, approximately US $85 billion in health research waste could be saved annually (Chalmers & Glasziou, 2009; Ivers & Grimshaw, 2016). This highlights the importance of not only testing efficacy but implementability to help ensure the eventual translation of interventions into practice if the intervention is successful.

The primary objective of the proposed study was to assess the implementability of the EngAge intervention using the conceptual framework of implementability of healthcare interventions (Klaic et al., 2022). The results from our study were used to understand if the proposed intervention was implementable and could improve physical functions and reduce

sedentary behavior. The latter will inform the required sample size for a future randomized trial.

Given the prevalence of sedentary time among older adults, it is crucial to investigate possible strategies for developing an implementable intervention and potentially reducing sedentary behavior to help older adults reap the potential benefits of sitting less.

Methods

Study design: The study design was an Implementation trial.

Setting/recruitment: The study was conducted at three different sites: one rural, one clinic, and one urban. Participants were recruited using either posters/program guides, social media, or local partnerships. Site 1, was conducted in New Brunswick, Canada at a university in a rural city with a total population of approximately 60 000 people recruited through Facebook; Site 2 was recruited through local networks in Ontario, Canada with a health clinic where data collection was also conducted, with an estimated total population of 132 000 people; Site 3 recruited via physical posters and program guides in a senior community centre in Ontario, Canada, where the study was also conducted out of with a total population of 175 000 people. Site 1 was managed (i.e., recruitment, testing, and check-ins) by a single person, whereas the other two sites had multiple people for administering and overseeing the intervention. Each site aimed to recruit up to 20 participants each. Data was collected from September 2024 until June 2025.

Participants: To be eligible to participate, participants had to meet the following criteria:

- Aged 65 years or older; reporting six or more hours per day of sedentary activities during awake time based on the Physical Activity and Sedentary Behavior Questionnaire (Canadian Society for Exercise Physiology, 2016);
- Community dwellers who have access to transportation to attend the in-person testing sessions.
- Not meeting the weekly aerobic (150 minutes) *and* strength training (2+ days) physical activity guidelines (Canadian Society for Exercise Physiology, 2021).

Eligibility was confirmed when the participant called to schedule the pre-testing session. During the pre-testing session, participants read and signed a consent form and completed a demographic questionnaire. At Site 1, more questionnaires were administered to assess the patient's readiness to change, health Literacy, and self-reported chronic conditions.

Intervention: The intervention consisted of three workbooks for participants to use at home over nine weeks. These three workbooks include the main booklet, the resource booklet, and the logbook.

The main booklet described the intervention, including information about it and its timeline. Three modules were included for participants to fill out:

Module 1: Creating goals

Module 2: Making Changes and Sticking to Them

Module 3: Adapting the Environment

These included activities to enable participants to understand how much time they spend sedentary during different activities, as well as activities to help with setting their goals,

and behaviour change techniques that could help them to achieve their personal goals (e.g., setting reminders, self-rewards, prompts/cues, social support), as well as ways to overcome barriers they may face. Lastly, information on environmental changes is provided to raise awareness of how their environment can influence their behavior.

The second booklet, the resource booklet, was an optional educational component for participants that addressed how high amounts of sedentary behavior could impact them, types of sedentary behavior that should be prioritized to change, the 24-hour Guidelines, education on goal setting as well as additional ideas for interrupting sedentary time and support for those who use wheelchairs. Education was a topic in the co-creation process that some participants felt they would like, while others did not, which is why it was optional for them to use and read.

The last booklet was the logbook, where participants tracked their progress on a daily and weekly basis. Space was provided for colored stickers to document goals met, questions asked on a scale from 1 to 5, with 1 being very low and 5 being very high, as well as short answers for barriers and successes each week. A weekly reflection page was included to allow participants to reflect on their week, answer the provided questions, and adjust accordingly to help them succeed more in the following week.

The nine-week intervention was divided into three cycles lasting 21 days each as presented in Table 1. Participants wore a device for one week, after which an orientation call was scheduled. During this call, participants could begin the nine-week intervention and would review the material with a member over the phone to explain the workbooks. After this orientation call, three other check-in calls were scheduled for the 11th day of each cycle, with a planned set of questions taking approximately 15 minutes.

Data Collection: All measures were taken pre- and post-intervention, aside from the implementability survey done at only post-testing.

Main outcome: The main outcome of the study was implementability. It was tested based on the three concepts proposed by Klaic et al. (2022) as pillars of successful implementation: acceptability, fidelity, and feasibility. Table 2 shows how these concepts were evaluated. The criteria of success were determined based on previous literature regarding the criteria (Adherence (58%), Completion (75%), Dropouts (15%)); in the absence of published literature on the criteria (Adverse events, Dosage of engagement, Quality, Training and User satisfaction), 60% (a minimum of 3 out of 5) was considered as the criteria for success as this ensured the majority of participants achieved the outcome that was expected. Adherence, Dropout rates and Completion rates were set from results by Matei et al. (2015). Data on these criteria, either come from the research staff (through summarizing the data, such as the number of participants who completed a call), during the check-in calls, such as collecting information on workbook usage by participants, or from the implementability survey during the post-testing session (Appendix A) as outlined in the table. It was arbitrarily hypothesized that a minimum of 5/8 (more than half) individual-based criteria would be reported by all participants who completed the intervention. Additional group outcomes, cost and recruitment rate, was not included as a criterion for success but rather reported for others to use. The cost to deliver this intervention was calculated by finding the sum of the booklets cost to print, and the cost for 4, 15 minutes phone sessions with a wage of $25/hour. The cost of advertisements was not included in this calculation. Recruitment rate from Facebook was calculated by taking the total number

recruited using Facebook divided by the total number who participated in the intervention (47%).

Secondary outcomes:

Sedentary Behavior. The activity monitor, an inclinometer called the ActivPAL^3, was placed on the anterior midline of the participants' thigh (Lyden et al., 2017) as per protocol (Edwardson et al., 2016) for seven consecutive days to record sedentary behavior. ActivPAL have a very high validity (≥95% agreement with direct observation) and reliability (inter-device reliability >0.99) (Aunger & Wagnild, 2022). A wear time of ten hours per day is commonly used to consider the data valid (Edwardson et al., 2016), whereas a minimum of five days (including one day during the weekend) of wear for the ActivPAL is required to achieve good reliability (Aguilar-Farias et al., 2019). The device estimates physical activity (e.g. stepping) and time spent performing different postures such as sitting, lying, or standing (PAL Technologies, 2024). A week after the first visit, participants were asked to remove it and return it to the in a prepaid envelope sent by mail. Changes in sedentary behavior was analyzed based on five daily indicators: Step Count, Sedentary Time, Upright Time, Step Time and Sedentary to Upright movements. Physical function changes were observed using three tests: 30-second chair stand test, the 8-Foot-Up-and-Go test and the 2-Minute Step test.

Physical Function Assessments. Three physical function tests from the Senior Fitness Tests were performed based on the established protocol (Rikli & Jones, 2013). First, the 30-sec chair stand test assessed lower body endurance and strength using a chair with no armrests (Jones et al., 1999). The total number was recorded. Second, the 8 Foot Up and Go Test is a coordination and agility test used to measure speed, balance, and agility (Rikli & Jones,

1999). The best of the two trials was recorded. Finally, the 2-Minute Step Test was performed to measure aerobic endurance (Bohannon & Crouch, 2019).

Descriptive characteristics. Personal information was collected at all sites, including age, sex, marital status, income, education, and ethnicity, as well as descriptive information such as the presence of any disabilities, participation in activities, and patterns of physical activity and sedentary behavior.

Additional measures: At site 1 (Rural), more questionnaires were administered. The Transtheoretical Model of Change - importance-confidence ruler technique, include two questions on a scale from 0-10 and is used to assess the patient's/person's readiness to change (CorHealth Ontario, 2025). The Short Test of Function Health Literacy for Adults (STOFHLA) was used to estimate health literacy. This questionnaire is a timed evaluation consisting of 36 questions, where participants must select the word that best fits the blank in each sentence, with two different passages to be completed within seven minutes. The STOFHLA is used for adults' health literacy to determine a person's ability to understand, interpret and read most health texts, with a score of 23 out of 36 indicating adequate health literacy (Baker et al., 1999). A chronic conditions questionnaire (Appendix C) was included, which asked about total prescribed medications taken, as well as participants selecting which chronic conditions, if any, they had.

Data Analysis

Distributions of all variables were examined to justify statistical tests. The implementability of the EngAge intervention was determined by meeting the majority (5/8 positive criteria of the Implementability Framework. The hypothesis was tested using a

one-proportion sample test for each additional criterion met. Data are presented as median (25-75th) or N (%) unless indicated otherwise. Given the distribution of the data and the small sample size of completers, secondary outcomes were evaluated using the Wilcoxon test. Effect size was calculated as $r = \frac{Z}{\sqrt{N}}$. Analyses were performed using SPSS v29.0. All data were analyzed based on whether they were non-completers or completers of the intervention, with data from all three sites combined.

Results

Table 3 provides a description of participants, divided by whether they were non-completers (n = 18) or completers (n = 24). The median age of participants was 70 years old. Most participants were females (73%) and Caucasian (83.3%). Half of the participants (n = 20) were recruited from Site 1 (Rural), seven from Site 2 (Clinic), and 15 from Site 3 (Urban). Site 1 had the highest number of completers, at 80%. Site 1 included additional descriptive information, such as the number of self-reported chronic conditions at baseline and two questions ranging from 0-10 (0 being not important/confident at all, 10 being extremely important/confident) about the importance of changing their sedentary behavior (non-completers 9.5; completers 8.5) and their confidence in changing their sedentary behavior (non-completers 7.0; completers 8.0). The median score for function health literacy was 35/36 for both the completers (34.0-36.0) and non-completers (32.5-35.0).

Table 4 summarizes the main outcome results. In total, to be deemed implementable, five out of eight criteria needed to be met. For participants who completed the Engage intervention, this criterion was met by meeting five criteria. Criteria of success for the adherence rate was set as 58% (Matei et al., 2015), which was achieved exactly. The second

criteria, adverse events had no injuries related to the intervention recorded, meeting the success criteria. The dosage of Engagement was reported as meeting the criteria, with 92% of participants reporting that they had read at least some of the booklets. Quality, training, and user satisfaction were also successful, with 88%, 100%, and 79% of participants scoring three or higher on the Likert scale, respectively. Six of the eight individual-based criteria (75%) met the criteria for success, while the remaining two individual-based criteria (i.e., completion and dropouts) did not. Although cost and recruitment rate were not used as implementability criterion, the approximate cost to deliver this Engage intervention was $46.35 ($21.35 for the booklets and $25 for one hour of work); a bit more than $1 per person, while recruitment rate from Facebook was calculated as 47%, meaning almost half of the participants for the intervention inquired from Facebook to participate, while 149 people showed interest to participate from the ad.

The hypothesis stated that a minimum of 5/8 individual criteria would be met by all the participants who completed the intervention. All participants who finished the intervention met at least 6/8 implementability criteria, while 87% (95% CI 0.68-0.96, $p < 0.01$) met at least 7/8 of the criteria, and 52% of participants met all criteria (95% CI 0.33-0.71, $p < 0.84$).

Table 5 summarizes the results of pre and post testing for completers (n=23) for the secondary outcomes. A significant difference in sedentary behavior was observed in two of the five daily indicators (i.e., Step Count and Step Time). Effect size is represented as *r*. Step Count, increased from a median (25-75th) of 4927.7 (3092.1-6118.2) to 7166.3 (5391.5-7648.9) (r= -0.5, $p<0.05$) steps per day, with an average increase of 2238.6 steps per day from pre- to post-testing. Similarly, step time also significantly increased from a

median of 62.9 minutes to 91.2 minutes per day (r = -0.5, $p < 0.05$), showing an increase in the average stepping time of 28.3 minutes per day. Additionally, daily upright time increased from 4.3 (3.6-5.4) hours to 5.0 hours (4.3-6.8) (r= -0.5; $p<0.05$). For physical function, the 30-second chair stand test (10.5-13.0; r = -0.5, $p < 0.05$) and the 8-Foot-Up-and-Go test (7.5–6.5; r = -0.7, $p < 0.05$) both demonstrated significant changes.

Discussion

This implementability trial aimed to determine the Engage project's implementability for older adults to reduce sedentary behavior using a home intervention that was co-created by key informants. The hypothesis is accepted, with 100% of participants reporting the intervention met 5/8 of the outcomes, while 87% of these participants reported the intervention met 7/8 of the implementability outcomes, and 52% met them all. Although 42% of participants did not complete the intervention, given the response of the completers, the cost and the nature of the intervention, and more importantly, the high prevalence of sedentary behavior within the target group, the intervention seems to be an option to reduce the behavior.

The six criteria that were met were adherence, adverse events, engagement, quality, training and user satisfaction. The two criteria not met were dropout rate and completion rate. When our results are compared to a similar trial (Matei et al., 2015) where the goal was to reduce sedentary behavior for a similar duration (eight vs nine-week intervention), and similar eligibility criteria (i.e., physically inactive based on CSEP guidelines, more than 6 hours of sedentary time per day), the dropout rate was high (42% vs. 15%). However, the dropout rate varied among sites (20% to 71%). As for the completion rate of the intervention, when sites were combined, it was 57% but again varied among sites (29%

to 80%). Nonetheless, most sites fall short of the 75% completion success criteria observed by Matei et al. (2015). The differences observed between the two studies could be explained by the differences in contact points and perhaps the material. Our intervention used a passive, at-home administration with phone check-ins, while Matei et al., (2015) had a more hands on approach with in-person check-ins happening in person at baseline, and two more times. In addition, the Engage intervention included activities for awareness of their sedentary time, an educational component, goal-setting material and a logbook to track progress whereas Matei et al (2015) focused on tips and activity recommendations to replace sedentary time with light physical activity. Based on these differences and feedback from participants, having preset goals like Matei et al. (2015) and more in-person visits may lead to fewer dropouts and more completion rate.

Some differences were observed in dropout rates among sites (Site 1: 80%; Site 2: 71.4%; Site 3: 60%) and completion rates (Site 1: 80%; Site 2: 28.6%; Site 3: 40%). That difference could be caused by the relationship built with the staff. I Having good-quality interactions, communication, and trust between the provider and participant can play a role in the success of delivering an intervention, as mentioned elsewhere (Danaher et al., 2023; Michael & Cronin, 2001).

The majority of participants (79%) in this intervention were satisfied with the intervention, which is lower than what Aunger et al. (2020) found for satisfaction levels in their Randomized controlled trial for pre-surgery adults 60+ to reduce sedentary time, which were quantitatively measured and calculated to be 90% satisfaction for users. While Aunger et al. (2020) reported higher rates of satisfaction, they employed a similar intervention timeline (eight weeks) and utilized personalized consultations to reduce sedentary time.

The difference in method of delivery (in-person vs phone calls) is a plausible reason for the difference in satisfaction, as research shows older adults' preference for in-person communication methods (Cone & Lee, 2023). As this is an implementability trial, modifications to the intervention design/format may be necessary to improve user satisfaction. Participants provided verbal feedback about merging the booklets into one booklet to reduce the need to go back and forth between them, which should be considered for improving satisfaction levels in the future.

Participants' perception of the quality of the intervention and training was high. This is not surprising as older adults prefer hardcopy materials that follow guidelines for presenting to this demographic such as larger text sizes and visual aids (Goodman & Lambert, 2023), which were considered when designing the hardcopy material for the intervention. By following these guidelines and user preferences, it is hypothesized that this strategy contributed to the perceived quality of the intervention, resulting in a positive outcome. Although cost and recruitment rate were not included in the success criteria for implementability, they are part of the conceptual framework used to test the implementability (Klaic et al., 2022). The estimated cost to deliver the EngAge intervention per participant was $46.35, or approximately $5 per week for about 50 pages total of material printed in colour. This low cost is important for public health since excessive sedentary time (>8 hours/ day) costs the Canadian healthcare system a total of $2.2 billion in 2021 (Chaput et al., 2023). Based on the literature, the typical recruitment rate (i.e., the number of people participating who saw an ad for the study) from Facebook among adults 60+ should average around 72.5% (Cowie & Gurney, 2018), calculated as the sum of participants recruited from Facebook divided by the sum of total participants.

Approximately half (20/42, 47%) of the participants were recruited via Facebook advertisements. One caveat to this calculation being that the other two sites did not recruit via Facebook advertisements. A total of 149 individuals inquired about the intervention after seeing the Facebook advertisement for Site 1, highlighting their interest in an intervention designed for older adults to reduce the time they spend sitting each day.

While sedentary time did not change significantly during the intervention, an improvement in standing time and physical activity was observed in our study, as indicated by an increase in upright time, step count, and step time. This observation is consistent with others who have reported an increase in standing time (Lewis et al., 2016) or an increase in physical activity (Fitzsimons et al., 2013). Similar to us, Abraham et al. (2023) observed an increase in step count and step time while sedentary time did not decrease (Abraham et al., 2023). These results suggest that people may not be replacing sitting time with only standing more but also with walking more therefore skipping step one from the Staircase approach Dogra et al. (2022). For the other secondary outcome, the improvements observed in physical function observed following the intervention was expected. Similarly to what was observed in this intervention, a significant increase in lower body strength using the 30-second chair stand test was observed using similar intervention with older adults (Harvey et al., 2018; Lee et al., 2020).

While the individuals who participated in this study were highly sedentary, they did not fully represent the target population for this intervention. Most of these participants were highly educated, Caucasian women that made over $80 000 annually that had access to community programs and resources. In contrast, the target population for the EngAge intervention was for individually more socially isolated with less education and fewer

opportunities within the community and/or less support. Despite the difference in target population and the participants in the intervention, a positive trend in reducing sedentary behaviors and improving physical function was observed using this low-resource intervention. This suggests that even those with greater opportunities can benefit from this intervention and for those who were the target population, the intervention may be more effective and impactful than what was observed in this intervention.

Like any study, limitations must be acknowledged. The results of the intervention are based on the individuals who completed the intervention and do not include those who did not complete it. The researchers established the criteria for success in implementability (5/8 positive criteria), as no framework outlined success criteria – only the common outcomes that were measured, with the value of each criterion unknown. Additionally, no control group was included, which limits the ability to conclude that the intervention was the sole cause of the changes observed. Also, some could argue that the secondary outcomes should be included in the implementability criteria. Finally, as multiple sites conducted the implementability trial with interactions among multiple people, there may be variability in the reliability of the recruitment process, physical function measurements, and intervention delivery, despite the use of scripted calls and training for all administrators of the calls and testing.

While this intervention has its limitations, it also has several strengths. This intervention was based on a previous systematic review and co-creation process that included focus group interviews with stakeholders, ensuring that their voices and opinions were considered when developing the intervention. In addition, while multi-site interventions can have variability, having multiple sights provides insight into the implementability of

the intervention in different locations with more diverse populations. While there are areas for improvement that did not meet the criteria for success, the intervention was successful at meeting the set criteria to be considered implementable. These findings support similar studies that interventions for sedentary behavior reduction are feasible and considered acceptable by participants who focus on goal setting.

Future research should be conducted to address these limitations. Exploring strategies to improve participant retention may help mitigate the high dropout rates. Further studies are necessary to understand the potential effects of the intervention on reducing sedentary time and its impact on physical function.

Conclusions

Despite the high dropout rate, the implementation trial highlights that for those who completed the intervention, there is potential for the Engage intervention to be scaled up for community-dwelling older adults. Along with the main outcome, the intervention also shows promise in improving not only physical function but daily step count, step time and upright time, which is important given that the prevalence of older adults is increasing, and this population accumulates the highest amount of sedentary time daily.

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Table 1. Intervention Timeline

Cycle 1	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
Week 1	Introduction module 1 + goal 1	Complete Module 2					Weekly reflection
Week 2	Complete Module 3			Phone check-in			Weekly reflection
Week 3							Weekly reflection
Cycle 2	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
Week 1	Set Goal 2	Complete Module 2					Weekly reflection
Week 2	Complete Module 3			Phone check-in			Weekly reflection
Week 3							Weekly reflection
Cycle 3	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
Week 1	Set Goal 3	Complete Module 2					Weekly reflection
Week 2	Complete Module 3			Phone check-in			Weekly reflection
Week 3							Weekly reflection

Table 2. Implementability outcomes

Outcome	Measure	Criteria for success
Adherence	Q1 Implementability survey	58% adherence rate (Matei et al., 2015)

Adverse Events	Q2-3 Implementability Survey	Zero Injuries reported.
Completion	# of participants who completed the Orientation call and phone-check ins	75% of participants reach completion of intervention (Matei et al., 2015).
Dosage of Engagement	Q4 Implementability Survey	60% (12/20) reported reading at least some of the booklets.
Dropouts	# of participants who came for testing who did not complete all four phone calls	Equal to or less than 15% of participants (Matei et al., 2015)
Quality	Q5-7 Implementability Survey	60% of people scoring 3 or more on the Likert scales
Training	Q7 Implementability survey	60% of people scoring 3 or more on the Likert scales
User Satisfaction	Q8-9 Implementability survey	60% of people scoring 3 or more on the Likert scales

Table 3. Descriptive variables of Participants

	Non-Completers n=18	Completers n=24

Age	71.00 (66.75-74.75)	69.00 (66.25-72.50)
Sex (Females)	15 (83.30)	16 (66.70)
Ethnicity (White)	15 (83.30)	20 (83.30)
Income (>80k +)	10 (55.60)	16 (66.70)
Education (University or higher)	10 (55.60)	19 (79.20)
Native Language (English)	13 (72.20)	22 (91.70)
Disability		
Physical	5 (27.80)	7 (29.20)
Neurodevelopmental	4 (22.20)	-
Sensory	1 (5.60)	4 (16.70)
Mental	2 (11.10)	2 (8.30)
Sites		
1 (Rural) N=20	4 (20.00)	16 (80.00)
2 (Clinic) N=7	5 (71.40)	2 (28.60)
3 (Urban) N=15	9 (60.00)	6 (40.00)
Recruitment Method		
Social Media	3 (16.70)	14 (58.30)
Clinic Phone call	5 (27.80)	2 (8.30)
Posters	9 (50.00)	6 (25.00)
Peer	1 (5.60)	2 (8.30)
Support at Baseline Data Collection		
Alone	16.0 (88.90)	20.00 (83.30)
Spouse/Partner Present	2.0 (11.10)	3.00 (12.50)
Rural Site (n=20)	Non-Completers n=5	Completers n=15
Health Literacy (0-36;23+ is adequate)	35 (32.5-35.0)	35 (34-36)
Sum of Chronic Conditions (#/18)	6.0 (5.25-6.75)	5.0 (2.00-6.00)
Behavior Change (0-10, 10 being highest)		
Important	9.5 (9.00-10.00)	8.5 (7.25-10.00)
Confident	7.0 (4.00-7.75)	8.0 (6.25-8.00)

Data are presented as N (%), M (25^{th} – 75^{th})

Table 4. **Implementability Outcomes (n=23)**

Outcome	Criteria for success	Results	Criterion (Yes/No)
Adherence	58% adherence rate	58%	Yes
Adverse Events	Zero Injuries reported	0	Yes
Completion	75% of participants reach completion of intervention	57%	No
Engagement	60% (12/20) reported reading at least some of the booklets	92%	Yes
Dropouts	Equal to or less than 15% of participants	42%	No
Quality	60% of people scoring 3 or more on the Likert scales	88%	Yes
Training	60% of people scoring 3 or more on the Likert scales	100%	Yes
User Satisfaction	60% of people scoring 3 or more on the Likert scales	79%	Yes
TOTAL	5 implementability criteria out of 8	75%	Yes

Table 5. Secondary Outcomes for Completers (n=19)

	Baseline	Follow-up
Physical Function		
Lower Body Strength (# Chair stands in 30s)	10.5 (9.0-12.0)	13.0 (11.0-15.5) *
Agility and Balance (Time to complete TUG)	7.5 (6.1-8.5)	6.5 (5.3-8.3) *
Aerobic Endurance (# of steps in 2 minutes)	86.5 (64.3-96.0)	87.5 (74.8-98.3)
Sedentary Behavior Daily Indicators		
Step Count (#)	4927 (3092-6118)	7166 (5391-7648) *
Sedentary Time (Hours)	10.2 (9.3-11.1)	9.3 (8.4-10.3)
Upright Time (Hours)	4.3 (3.6-5.4)	5.0 (4.3-6.8) *
Step Time (Minutes)	62.9 (44.3-87.5)	91.2 (69.4-102.5) *
Sedentary to Upright movements (#)	41.7 (34.9-52.3)	46.6 (37.6-52.6)

Data are presented as Median (25th – 75th)

*Significant difference ($p < 0.05$) between groups based on Wilcoxon tests

Appendix A: Implementation Survey

1. On average, how many times per week would you say you achieved your daily goals during the program?

	1day/wk	2days/wk	3days/wk	4days/wk	5days/wk	6days/wk	7days/wk
Goal 1							
Goal 2							
Goal 3							

2. Did you have any of the following **while participating** in the program?
   - □ Slips
   - □ Trips
   - □ Falls
   - □ Injuries
   - □ Strains/sprains
   - □ None of the above

3. If you checked any of the above to Question 2: Can you explain what happened?

   _____

   _____

   _____

4. For this program, you were provided with three booklets. Please use the following box to tell us how much you engaged with each booklet.

	I read it all	I read some of it	I didn't read it
Main Booklet (Purple booklet)			
Resource Booklet (Green Booklet)			
Logbook (Blue Booklet)			

5. On a scale from 1-5 (1 being poor, 5 being excellent), how would you rate the **quality of the presentation** of the workbooks? (E.g. colors, size, layout, font, text size)

□	□	□	□	□
Poor	Fair	Good	Very Good	Excellent

6. On a scale from 1-5 (1 being poor, 5 being excellent), how would you rate the **quality of the content** of the workbooks? (E.g., informative, interesting, clear and easy to understand)

□	□	□	□	□
Poor	Fair	Good	Very Good	Excellent

7. On a scale from 1 to 5 (1 being poor, 5 being excellent), how would you rate the **quality of engagement with the staff** who conducted the orientation and check-in calls (e.g., polite, flexible, knowledgeable, professional)?

□	□	□	□	□
Poor	Fair	Good	Very Good	Excellent

8. On a scale from 1-5 (1 being poor, 5 being excellent), how satisfied were you with the workbooks?

□	□	□	□	□
Poor	Fair	Good	Very Good	Excellent

9. On a scale from 1-5 (1 being poor, 5 being excellent), how satisfied were you with the overall program?

□	□	□	□	□
Poor	Fair	Good	Very Good	Excellent

Appendix B: Medications and Chronic Condition Questionnaire

1. How many prescribed medications do you take every week?

- 0-1
- 2-3
- 4-5
- 6+

2. Do you currently have any of the chronic conditions listed below?

A) Arthritis

- Yes
- No

B) Edema

- Yes
- No

C) Asthma

- Yes
- No

D) Emphysema

- Yes
- No

E) Blood pressure

- Yes
- No

F) Cardiac or circulation problems

- Yes
- No

G) Diabetes

- Yes
- No

H) stomach ulcer

- Yes
- No

I) digestive chronic conditions

- Yes
- No

J) liver disease

- Yes
- No

K) urinary problem

- Yes
- No

L) Osteoporosis

- Yes
- No

M) Anemia

- Yes
- No

N) Thrombosis

- Yes
- No

O) Stroke

- Yes
- No

P) Parkinson`s disease

- Yes
- No

Q) muscular dystrophy

- Yes
- No

R) thyroid problem

- Yes
- No

Curriculum Vitae

Candidate's Full Name:

Morgan Daamen

Universities attended (with dates and degrees obtained):

Bachelor of Science in Kinesiology, University of New Brunswick 2024

Publications:

N/A

Conference Presentations:

Investigating how a community peer-exercise program aiming to reduce risk of falls challenges balance Exercise Scientists and Socioculturalists in the Atlantic Provinces, 2024