Comparing Online and In-Person Delivery of a Fall Prevention Exercise Program for Older Adults

by

Vanessa Pitre

Bachelor of Science in Kinesiology, University of New Brunswick, 2020

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

Supervisor: Danielle Bouchard, PhD., Faculty of Kinesiology

Examining Board: Stephan Dombrowski, PhD., Faculty of Kinesiology, Chair
Jeremy Noble, PhD., Faculty of Kinesiology
Grant Handrigan, PhD., École de Kinésiologie et Loisir, Université de Moncton

This thesis is accepted by the
Dean of Graduate Studies

THE UNIVERSITY OF NEW BRUNSWICK

April 2022

Abstract

Exercise is the most important strategy to reduce the risk of falls in older adults. Falls have important individual and societal consequences. As a result, many communities offer fall prevention exercise programs. Offering an exercise program online could improve accessibility. The Zoomers on the Go program is offered for 12 weeks, 2x/week, to adults aged 50+, by a peer leader. Due to the social distancing restrictions and governmental lockdown orders imposed during the COVID-19 pandemic, the program transferred from in person to online delivery. The main outcome of this study was lower body strength measured using the 30-second chair stand test delivered online (n= 103) compared to in person delivery (n=95). Secondary outcomes include other physical function tests, demographics, self-perceived benefits, drop-out, and attendance. Online delivery is associated with a greater attendance, with no difference in functional benefits between delivery modes. However, in-person delivery could offer more health-related benefits reported by participants.

Acknowledgements

I would like to thank the Cardiometabolic Exercise and Lifestyle (CELLAB) research team as this project would not have been possible without their assistance. Specifically, I would like to thank my supervisor Dr. Danielle Bouchard who has provided me with continuous guidance and support while continuing to enable me to become a better researcher throughout my graduate degree.

Table of Content

List of Tables

List of Figures

Chapter 1: Introduction

The number of older adults in Canada is continuously increasing. By 2037, the number of people aged 65 years and older is expected to grow by 23% (Government of Canada, 2019b). With an estimated life expectancy at age 65 of 19.5 years and 22.2 years for men and women respectively (Statistics Canada, 2022). This age group is the least physically active with only 33% of them reaching the current Canadian Physical Activity Guidelines (Government of Canada, 2021b).

Physical inactivity can lead to many health and functional problems. Physical function is the ability to perform activities of daily living (Rikli & Jones, 1999). Poor physical function in older adults can lead to loss of independence and increased risk of falls (Buchner et al., 2017).

Falls is the leading cause of injury in older adults in Canada (Canada, 2016). They cause up to 85% of all injury-related hospitalizations in older adults and cost up to $2 billion every year in direct healthcare costs. Over one third of older adults are admitted to long-term care homes after being hospitalized for a fall (Canada, 2016).

Many studies have found that exercise is the single most effective way at reducing the risk of falls (Tricco et al., 2017). It is for this reason that many communities offer exercise programs for older adults. In New Brunswick one of the programs offered to older adults is the Zoomers on the Go program. Zoomers on the Go is a peer-led exercise program to reduce the risks of falls offered to adults aged 50 years and older. It is a 12-week program with two sessions of 60 minutes each per week. It includes aerobic exercises, resistance training, balance, and flexibility activities. It has been demonstrated that this program leads to an improvement in physical functions, stress, and depression (Bouchard et al., 2021).

The COVID-19 pandemic has caused this program, as with many others, to shift to an online delivery rather than the original intent of in person delivery. Research shows that 68.2% of older adults aged 65+ in Canada have access to internet and that 61.7% of them use it on a daily basis (Government of Canada, 2019a). Online delivery allows for a more expansive reach with 47.4% of New Brunswick older adults living in rural areas which has traditionally limited access to the Zoomers on the Go programs for rural New Brunswickers although rural areas have limited internet availabilities (Age-Well, 2021) Online delivery also allows older adults who do not have trained peer-leaders in their region to access the program.

The main outcome of this study was to test if the improvements in lower body strength, measured by the 30-second chair stand, were different when the program was delivered online compared to when delivered in-person. Secondary outcomes included other physical function tests like endurance, measured by the 2-minute step test (online) or 6-minute walk test (in-person), and balance, measured by the single leg stance test. Demographics, dropouts, attendance, self-perceived mental and physical benefits were also measured and analyzed. The ability to use technology was assessed via the Functional Assessment of Currently Employed Technology Scale (Lepkowsky, 2017).

Chapter 2: Literature Review

2.1 Aging

There are many different definitions for ageing. Generally speaking, ageing can be defined as the loss of function over time (López-Otín et al., 2013) leading to death (Kirkwood & Austad, 2000). Ageing is often quantified with chronological age which is the number of years since an individual was born (Belsky et al., 2015). However, chronological age is a poor indicator of health status; an 80-year-old may require little support and still be healthy while a 60-year-old might require significant care and support (Beard et al., 2016). Biological aging is the decrease in physiological ability to meet demands that occur with chronological ageing (Adams & White, 2004).

The average age of most modern countries is increasing. Between 2015 and 2050, the world's population over the age of 60 will nearly double; from 12% to 22% (World Health Organization, 2018). In 2019, the number of adults aged 60+ was one billion, this number is expected to increase to 1.4 billion by 2030 and 2.1 billion by 2050 (World Health Organization, 2020a). Life expectancy at age 65 is predicted to rise from 17 years in 2015-2020 to 19 years by 2045-2050 (United Nations, 2019). Latest data shows that we may have hit the peak in certain areas, for example in New Brunswick, data shows that for the first-time life expectancy is dropping (New Brunswick Health Council, 2021).

With an increasing senior population comes an increase in healthcare costs. For example, the cost of health care to the government for the average senior in Canada, is about $12,000/year compared to $2,700/year per younger resident (Gibbard, 2018). In the US, 60% of lifetime healthcare costs are spent after age 65 (Alemayehu & Warner, 2004). The cost of care in people with three or more chronic conditions is 10 times higher than for people with no chronic conditions (Bodenheimer & Berry-Millett, 2009).

Chronic conditions are defined as conditions that last more than one year and require ongoing medical attention, limits activities of daily living or both (Friedman et al., 2008). Chronic conditions such as cancer, respiratory diseases, heart disease, musculoskeletal disease, mental and neurological disorders are highly prevalent in older adults (World Health Organization, 2014). More than half of the older population currently have more than one chronic condition and that number increases with age (Marengoni et al., 2011). The leading causes of many chronic conditions are related to lifestyle (Cameron, 2019) such as insufficient physical activity levels.

2.2 Physical Activity

Physical activity is defined as any movement that increases energy expenditure (World Health Organization, 2020b). Exercise is defined as physical activity that is planned, structured, repetitive and has a goal. Exercise can be seen as a subcategory of physical activity (Caspersen et al., 1985).

The World Health Organization's (2020b) Physical Activity Guidelines recommend that adults aged 65+ should participate in regular physical activity and do at least 150 minutes of moderate-intensity aerobic physical activity, or at least 75 minutes of vigorous-intensity aerobic activity or a combination of both every week. They should also do muscle strengthening activities two or more days per week as well as three or more days per week of functional balance physical activity. The World Health Organization also recommends that older adults should limit the time spent in sedentary behaviours and they should replace sedentary behaviour with physical activity of any intensity (World Health Organization, 2020b). The specific recommendations are different depending on the main outcome. Despite many benefits to exercise (Bean et al., 2004; de Labra et al., 2015), this age group is the least physically active with only 33% of them reaching the current Canadian Physical Activity Guidelines (Government of Canada, 2021b) and therefore the remaining portion of the population are considered insufficiently active.

Aerobic exercise has been shown to improve memory, cardiorespiratory fitness, and executive functioning in older adults (Kovacevic et al., 2019; Ludyga et al., 2016). Aerobic exercises can also delay disability in older adults (Paterson & Warburton, 2010). Meeting the aerobic portion of the physical activity guideline can lead to a 30% decrease in the risk of morbidity, mortality, and loss of independence with greater gains at greater levels of aerobic physical activity (Paterson & Warburton, 2010).

Several mechanistic pathways have been identified that lead to improvements in overall functionality as a result of performing aerobic exercise (Stillman et al., 2016). These mechanisms are typically divided in three levels leading to cognitive change. Level one being the cellular and molecular changes that happen in the body when a person exercises. Level two being the changes that occur to the brain when a person exercises. Level three is the behavioural and socioemotional changes that occur when a person exercises. Similar mechanisms occur when a person is doing resistance training (Herold et al., 2019). For more information on mechanisms see Stillman et al. (2016).

There are many benefits to muscle strengthening activities for older adults. Resistance training has been shown to improve muscle strength, balance, and mobility in older adults (Borde et al., 2015; Copeland et al., 2019; Granacher, 2012). A systematic review by Peterson et al. (2010) showed a significant association between muscle strengthening activities and upper and lower body strength improvements in older adults establishing the importance of full-body resistance training as a prevention and treatment tool for age-related declines in physical function. Muscle strengthening activities have also been shown to effectively improve gait speed, chair stand, time walked, stair climb and reducing physical disability (Liu & Latham, 2009).

Older adults are the least physically active group, 33% of older adults aged 65+ do not attain the Physical Activity Guidelines (Government of Canada, 2021b) and only 10% of them meet the resistance training aspect of the Physical Activity Guidelines (Bennie et al., 2016; Merom et al., 2012). Physical inactivity is the fourth (5.5%) leading risk of death in the world preceded by high blood pressure (12.8%), tobacco use (8.7%), and high blood glucose (5.8%) (World Health Organization, 2009). Physical inactivity in older adults can lead to decreased aerobic fitness, musculoskeletal and cognitive decline, and increased risk of chronic conditions (Bowden Davies et al., 2019; Lee et al., 2012).

It is estimated that physical inactivity is the cause of 6-10% of major chronic conditions and causes 9% of premature mortality (Lee et al., 2012). Also, inactive adults aged 50 years and older could gain 1.1-3.7 years without cardiovascular disease by participating in moderate to vigorous physical activity (Franco, 2005). The number of older adults who are physically inactive tends to increase as they get older. Adults 75+ are twice as likely to be inactive than those aged 60-64 (Murtagh et al., 2015). Women (88%) are also more likely than men (74%) to be physically inactive (Page & Lee, 2010; Sun et al., 2013). While the effects of short-term physical inactivity may be reversible in a younger population reversibility is harder to achieve in the older population (Bowden Davies et al., 2019). The Catabolic Crisis Model proposes that age related changes (e.g., decrease in muscle mass and strength) can be caused and/or accelerated by physical inactivity in older adults (Bowden Davies et al., 2019). One of the most important consequences to physical inactivity is a reduction in physical capacity defined as the inability to do the activities of daily living independently as expected for one's age (Rikli & Jones, 1999).

2.3 Physical Function

An increasing number of older adults are choosing to stay in their homes for as long as they can, a concept called ageing in place. In fact, the Canada Mortgage and Housing Corporation found that 85% of adults aged 55+ stated wanting to age in place (Government of Canada, 2008). This is encouraged by governments because it is a cost-effective solution for governments by reducing the amount of people in nursing homes. For example, the PACE program is a program for older adults that require nursing-home level care but can safely stay in the community, the cost of the PACE program is estimated to be 16 to 38% lower than the out-of-pocket cost for older adults to go to a nursing home (Petigara & Anderson, 2009). However, to do so, they must be able to take care of themselves safely and independently.

Activities of daily living are often classified into two large categories, basic activities of daily living and instrumental activities of daily living. Basic activities of daily living include ambulating, feeding, dressing, personal hygiene, continence, and toileting. Instrumental activities of daily living include transportation, shopping, managing finance, meal preparation, house cleaning and maintenance, managing communications with others, and managing medications (Edemekong et al., 2021). Up to 142 million older adults worldwide are unable to meet either the basic or instrumental needs (World Health Organization, 2020a).

Physical function is a construct that can be estimated subjectively and objectively. Subjective measures of physical function are self-reported, meaning that it is relying on the subject's perception of their physical functions (Latham et al., 2008). This is done with the help of questionnaires. Questionnaires have the potential to reach a large number of subjects and are cost-effective. However, questionnaires allow for the subject's misperceptions of their abilities or the misinterpretation of the question or answer (Reiman & Manske, 2011) and can be challenging for older adults with cognitive disorders. Physical function questionnaires generally assess the perceived difficulty a person has at performing activities of daily living. Popular and validated questionnaires include the Barthel ADL index (Collin et al., 1988), the Functional Status Questionnaire (Jette et al., 1986), the Katz Activities of Daily Living Index (Katz, 1983) and the Physical Functioning Assessment in Your Environment (Tomey & Sowers, 2009). These questionnaires consist of measuring how independent a person is at performing activities that make them functional.

Many performance-based activities have been validated and are used to assess physical function. Those include tasks challenging different aspects of functions required to be physically independent: power, muscle strength, agility, and balance. One of the most popular battery of tests is the Senior Fitness Test (Rikli & Jones, 1999). The Senior Fitness Test consists of six tests that replicate common activities of daily living (e.g., getting up from a chair, walking, lifting, bending, and stretching). Those tests are the chair stand test, measuring lower body strength; the arm curl test, measuring upper body strength; the chair sit and reach, measuring lower body flexibility; the back scratch test, measuring upper-body flexibility; the 8-foot up and go test, measuring agility; and the 6-minute walk test or 2-minute step test, measuring aerobic fitness (Rikli & Jones, 1999).

Physical function is important because it is associated with many important outcomes, including the risk of falls. For example, a walking speed greater or equal to 1.0 meter per second has been associated with greater independence, lower hospitalizations rate, and lower mortality rates (Friedmann et al., 2001; Studenski et al., 2003). Cardiorespiratory fitness in older adults is important to remain functionally independent in the community (Paterson & Warburton, 2010). Cardiorespiratory fitness decreases on average 3-6% every decade from age 20 and more than 20% per decade from the age of 70 (Fleg et al., 2005). A maximal oxygen consumption of over 15 ml/kg/min in women and 18 ml/kg/min in men is needed to continue to be independent in the community (Shephard, 2009). However, when older adults approach that threshold, they might start avoiding certain activities that require them to get near their maximal capacity creating a cycle of further reducing their aerobic capacity that will cause more avoidance in activities (Fleg et al., 2005).

Similar to cardiovascular fitness, maintaining lower extremity strength in older adults is important to delay and prevent disability (Guralnik et al., 1995). Decreased lower extremity strength is associated with higher risks of falls, lower balance (Bohannon, 1995), higher risk of mortality, hospitalization, fracture, and length of hospitalization (Beaudart et al., 2017; Sobestiansky et al., 2019). It is important to measure lower body strength to be able to identify those at higher risk. On average, community-dwelling older adults perform anywhere between 39 to 71 sit-to-stand motions on a daily basis (Bohannon, 2015; Grant et al., 2011).

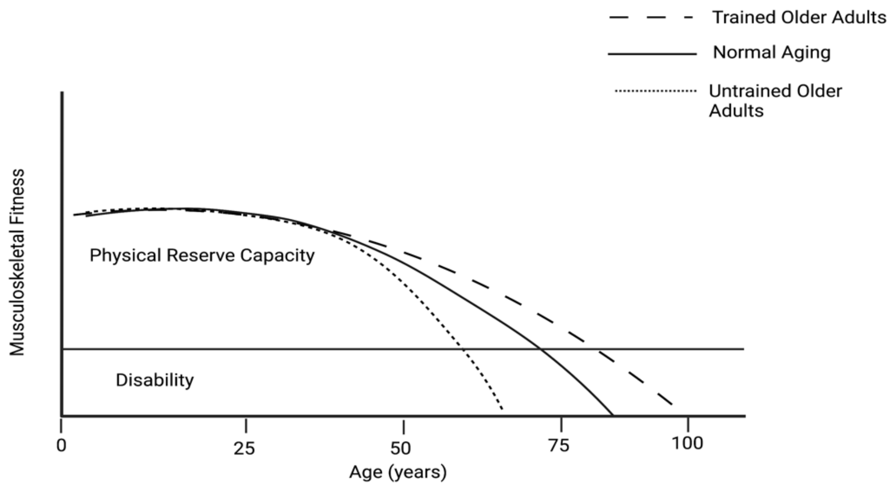

Figure. 1 Association between Musculoskeletal Fitness and Aging according to training levels

Physical activity is the most often recommended strategy for older adults to achieve and maintain high physical function scores and remain independent (Buford et al., 2014; Lin et al., 2020). Resistance training has been shown to improve balance, walking ability, gait speed, chair stand time and reduce muscle weakness (Giné-Garriga et al., 2014; Lee et al., 2018; Liu & Latham, 2009). Aerobic exercises have also been shown to improve physical functions such as walking speed or aerobic endurance (Boyne et al., 2017; Pang et al., 2013; Paterson & Warburton, 2010). One of the main reasons for seniors to stay physically active is to reduce the risk of mortality and morbidity as well as maintaining their independence (Paterson & Warburton, 2010) and reducing their risk of falls (Tricco et al., 2017). Interestingly, physical function is a predictor of falls in older adults (Buchner et al., 2017).

2.4 Falls

The World Health Organization defines falls as an event that results in a person coming to rest unintentionally on the ground or at any lower level. Fall-related injuries can be fatal or lead to functional disabilities (World Health Organization, 2021). Falls are the second leading cause of unintentional injury death with an estimated 684 000 fatal falls every year (World Health Organization, 2021). Up to 50% of falls in the 65+ population occur in their homes (Public Health Agency of Canada, 2014). On average, falls cost up to $10,000 per person (Hoffman et al., 2017) and can lead to mortality, morbidity, reduced functioning, early nursing home admission, and reduced quality of life (Rubenstein & Josephson, 2006). Many older adults do not acknowledge or recognize their fall risk and see falls as an unavoidable consequence of ageing (Stevens et al., 2017). However, one in three adults aged 65+ living in the community fall every year and that increases with older age and in institutionalized older adults (Rubenstein & Josephson, 2006).

A systematic review by Schwenk (2012) found that there are three main ways of measuring falls: prospective reporting using calendars or journals, retrospective reporting using interviews, questionnaires, and medical records. The Fall Efficacy Scale International is a scale that measures confidence in performing a range of activities of daily living without falling (Yardley et al., 2005). Similarly, the Activities-specific Balance Confidence Scale (ABC) assesses older adults' fear of falling through personal balance confidence (Schepens et al., 2012). The St Thomas Risk Assessment Tool assesses the risk of falling in hospitals (Webster et al., 2008). These tools have been found to be the most used validated falls questionnaires and were all designed to be administered in different settings (e.g., hospital, nursing home, emergency department)

(Ruggieri et al., 2018). These methods of measuring falls all have limitations (Hauer et al., 2006; Schwenk et al., 2012) as they rely on the recollection of events and are self-reported.

There are many risk factors associated with falls and most falls are due to a combination of risk factors (Ambrose et al., 2013). There are both intrinsic and extrinsic risk factors associated with falls. Risk factors like demographics (e.g., age, sex, race), systems (e.g., impaired balance, gait, vision, hearing, cognition, incontinence, muscle weakness, fear of falls), and diseases (e.g., arthritis, chronic pain, vertigo, frailty, cardiovascular disease) are all considered intrinsic risk factors. Extrinsic risk factors are things like medications (e.g., psychotropics, sedatives, diuretics), hazards in and around the home or community, footwear, clothing, and assistive devices (Ambrose et al., 2013; Deandrea et al., 2010; Sousa et al., 2017).

Older adults who are inactive have a higher risk of falls (Bryant et al., 2015). A systematic review and meta-analysis by Soares et al. (2019) found that the risk of recurrent falls in inactive older adults was 39% higher than active older adults. Inactive older adults also have a 29% increased risk of fractures compared to active older adults (Cunningham et al., 2020).

In fact, exercise is the most effective way to reduce the risk of falls (Tricco et al., 2017). For example, a low amount of moderate to vigorous physical activity is associated with a higher rate of incident falls (Buchner et al., 2017). Sherrington et al. (2019) found that exercise programs that focus on balance, functional exercises and resistance training were the most effective at reducing the risk of falls (34%), while balance and functional exercises reduced the risk of falls by 24% when compared with a control group and that exercise of any type reduced the risk of falls by 23%. Exercises focusing on anticipatory control, dynamic stability, functional stability limits, reactive control and flexibility, are recommended as reported in a recent paper published by Sibley et al. (2021). Even if regular exercise is associated with a reduction in falls, 94% of exercise programs specifically offered to reduce the risk of falls in Canada fail to meet the evidence-based guideline (Touchette et al., 2021) that state that exercise programs should challenge balance, be offered on an ongoing basis and be offered for at least three hours every week to significantly reduce the risk of falls as recommended by Sherrington et al. (2017). One of the most cost-effective and popular ways to offer exercise programs to reduce the risk of falls is by certifying leaders to act as peers (Washburn et al., 2014).

2.5 Peer-led

A peer-leader is an individual who has shared experiences and similar population characteristics (Chemtob et al., 2018). The social cognitive theory (Bandura, 2004) and the self-determination theory (Ryan & Deci, 2017) suggest that peer volunteers can enhance self-efficacy of participants by seeing others cope with barriers to active ageing it shows them that they can also cope with those barriers and increase their level of social support and connectedness (Stathi et al., 2021).

Peer volunteers all have different motives for volunteering in their communities, others well-being, life circumstances, reconnecting with the community, and personal fulfilment are a few examples of why certain older adults have decided to become volunteers (Stathi et al., 2021; Withall et al., 2018). Some of the reported benefits to peer volunteering are increased personal fulfilment, increased social engagements, increased confidence, feeling needed, and having a more active engagement in their communities. Peer volunteers have described volunteering as personally rewarding, a great way to learn and acquire new skills, as it provided them purpose in life and an opportunity to socialize (Stathi et al., 2021). Von Bonsdorff & Rantanen (2011) found that older adults who volunteer have better self-reported health, functioning, physical activity levels, life satisfaction and decreased risk of depression and mortality.

Peer-led exercise programs have been shown to have significant improvements in older adults' physical function, participation, physical activity levels, and quality of life (Bouchard et al., 2021; Burton et al., 2018; Izutsu et al., 2017). Waters et al. (2011) even found that peer-led classes were more effective at maintaining and improving strength and balance than the non-peer-led group. Moreover, the same group reported that participants in professionally led classes were more likely to join a peer-led group when compared to a control group (Waters et al., 2011). Exercise programs offered by peers have higher retention and participation rates than programs offered by non-peers (Dorgo et al., 2013).

Werner et al. (2014) offered a 20-week low-intensity community-based, peer-led exercise program to 432 older adults in the United States. The program consisted of 40 sessions of 45 minutes each and included aerobic, strength, balance, and flexibility exercises. Participants received a resistance band to complete the exercises and at the end of every session, they would receive a handout with exercises that they could do at home. This study found that participation in this community-based peer-led exercise program improved physical function, improved perceived overall health, and decreased BMI. They also found that confidence to participate in physical activity improved with greater improvement in physical fitness and improvements in perceived satisfaction in body function.

Robertson et al. (2014) found that while the benefits of peer-led and professional-led exercise classes might be similar there is considerable value in peer-leaders. Peer leaders serve as key figures within the networks of older adults in the community, they often possess personal knowledge and knowledge of local and social events that a professional leader might not possess. Dorgo et al. (2013) found that peer-led exercise classes for older adults were superior to classes led by young professionals. It was found that peer-led classes improved overall physical and mental well-being, social functioning, increased general health in older adults and had higher adherence rates compared to classes led by professionals. A qualitative study by Jin et al. (2019) found that peer-led exercise classes improved the quality of exercise for older adults.

Beauchamp et al. (2021) offered an online program for older adults with older adult exercise instructors that had previous experience offering exercise programs for older adults. This trial found higher self-reported mental and physical health in the intervention groups when compared to the control group.

2.6 Fall Prevention Programs

Long-term participation in fall prevention programs has been shown to be effective in reducing falls in high fall risk populations (Wurzer et al., 2014).

Systematic reviews by Cadore et al. (2013) and Gillespie et al. (2012) found that multi-component exercise programs that include strength, endurance, and balance training to be the most effective way to improving gait, balance, strength, and reduce the rate of falls and fractures. The use of resistance bands in fall prevention programs has been shown to improve strength and balance in older adults (Bouchard et al., 2021; Page & Lee, 2010).

Many studies have identified facilitators and barriers to fall prevention programs for older adults. Kiami et al. (2019) found that programs being offered close to home, a free program, and a friendly group leader were some facilitators to fall prevention programs. Other studies have also found that a pleasant environment and a sense of care were also facilitators to fall prevention programs (dos Santos et al., 2021). Some of the barriers identified by Kiami et al. (2019) were the belief that they are not going to fall, lack of time, programs not offered close to home and the belief that the program will not help them prevent falls. Other barriers identified in other studies are the presence of physical and mental health problems and lack of a caregiver or family support (dos Santos et al., 2021). Older adults with a history of falls are twice as likely to register for a fall prevention program and those with fear of falling are four times more likely to register for a program (Kiami et al., 2019).

The Otago exercise program is a well-known fall prevention program for older adults age 80+. It was developed at Otago Medical School and implemented across New Zealand. The exercise program includes strength and balance exercises with progressions by increasing ankle cuff weights and number of sets, it also includes a walking plan. The exercises are individually prescribed to the participants and are re-evaluated five times during the program during home visits by trained instructors (Robertson & Campbell, 2003). The Otago exercise program was also shown to reduce the risk of mortality by 45% and significantly reduce the risk of falls (Thomas et al., 2010).

Stand Up! is well-known fall prevention program for older adults aged 60+. This program is also known as PIED and was developed in Québec, Canada. The program consists of 2 exercise sessions per week for 12-weeks. Participants are invited to do one additional session on their own at home with the help of posters provided to them to describe exercises. The program is designed to improve various components of balance (e.g., leg strength, ankle mobility, proprioception). This program has shown to increase static balance and mobility in older adults at risk of falls (Robitaille et al., 2005).

Other well-known fall prevention programs include the A Matter of Balance program, an eight-week group intervention that emphasizes strategies to reduce the fear of falling and increase physical activity in adults aged 60 years and older (National Council on Aging, 2021). The CAPABLE program is a five-month at-home program for community-dwelling older adults with the goal of decreasing fall risk, improve mobility, and improve the ability to safely complete activities of daily living (National Council on Aging, 2021). The program is delivered by an occupational therapist, a nurse and a handyman who provides home repairs, installs assistive devices, and makes home modifications. Enhance Fitness is a low-cost group fall prevention and physical activity program (National Council on Aging, 2021). The program consists of low impact cardiovascular exercises, dynamic and static balance work, strength training and stretching.

Fall prevention programs have been shown to significantly reduce the risks of injurious falls. A systematic review looking at the effects of fall prevention programs on injurious falls found that all injurious falls were reduced by 37% while severe injurious falls were reduced by 43% and falls resulting in fractures were reduced by 61% (El-Khoury et al., 2013). Winser et al. (2020) found that group-based fall prevention programs offered for 60 minutes twice a week focusing on lower body strength were the most cost-effective programs. Exercise programs aiming to reduce the risk of falls could be even more cost-effective and could reach a broad audience if offered using alternative delivery. This option has become even more of a possibility now that the COVID-19 pandemic has increased the use of the internet by seniors (Government of Canada, 2021a).

2.7 Alternate Delivery of Physical Activity Programs for Older Adults

There are limited studies on alternate delivery such as virtual reality, mobile applications, or online programs offered live or pre-recorded for older adults and barely any with the goal to reduce the risk of falls. There are many different technologies used to help older adults exercise without leaving their homes. Older adults have reported some facilitators and barriers to technology use and online delivery of programs. Some facilitators identified are social connectedness, ease of access, and convenience of not having to leave the house (LaMonica et al., 2021; Sanchez-Villagomez et al., 2021). Barriers associated with technology for older adults are lack of interest, anxiety and security concerns, and that online delivery of programs is not the same as in-person (LaMonica et al., 2021).

Virtual reality is the use of novel technology that immerses individuals in a computer-generated, three-dimensional world where they interact with the virtual environment using a headset (Gao et al., 2020). Virtual reality can be effective at improving balance in older adults and can be proposed as a form of fall prevention for older adults (Choi et al., 2017). However, there is no evidence that virtual reality games will prevent falls, their use in balance training may improve balance control therefore preventing falls (Pietrzak et al., 2014).

Exergames are the use of video games in an activity or program (Sinclair et al., 2007). A systematic review and meta-analysis by Chen et al. (2021) found that when comparing exergame intervention to traditional physical training (e.g., Tai Chi, strength training, etc.), exergame interventions had greater improvements in postural control and dynamic balance. In exergame interventions that lasted more than 8 weeks and had between 90-119 minutes of exergames training participants experienced significant fall reduction (Chen et al., 2021).

Mobile applications are programs downloaded onto a smartphone or tablet and can interact with older adults to help guide them through exercises. Websites are platforms where generally an older adult will find videos and instructions on how to perform each exercise. Both mobile applications and websites are self-managed ways of preventing falls. The Standing Tall program, a self-managed tablet-based exercise program, was found to reduce the rate of fall and injurious falls in older adults over a two-year period (Delbaere et al., 2021).

Live online classes are offered on a telecommunication platform (e.g., Zoom, Microsoft Teams, Skype) where an instructor delivers an exercise program to participants in real-time and the instructor can interact with the participants and the participants can interact with each other. When offering a 12-week fall prevention exercise program by videoconference to older adults, Savard et al. (2018) found that participants significantly improved their physical abilities, gained knowledge, adopted new behaviours and lifestyle habits, and reduced their risk of falls. Table 1 shows the advantages and disadvantages of each delivery method. Based on the summary, it seems that live classes offer more advantages than others. Despite the perception that older adults are not interested in technology, up to 67% of adults aged 65 years and older use the internet and 76% of them use it on a daily basis (Anderson & Perrin, 2017). However, internet use in adults aged 80+ is only at 44% (Anderson & Perrin, 2017).

Older adults who are highly educated, have high income and are married are more likely to use the internet on a regular basis (Schumacher & Kent, 2020; Vroman et al., 2015). The most used devices by older adults are phones (87%), computers (78%), smartphones (22%), and tablets (20%) and the most used applications for communications are emails, social networking, text messaging and video chat (Vroman et al., 2015).

Table 1. Advantages and Disadvantages of different technologies available to exercise

Technology	**Advantages**	**Disadvantages**
Virtual Reality	• Individualized • Best used for rehabilitation (Cano Porras et al., 2019)	• Higher Cost • Requires high skills with technology (Gao et al., 2020)
Exergames (e.g., Wii fit)	• Lower cost (Lloréns et al., 2015) • Easily accessible • High adherence	• Not suitable for everyone • Targeted for younger population (smaller font, too difficult) (Chao et al., 2015)
Mobile Applications	• Accessible and portable • High adherence (Alasfour & Almarwani, 2020) • Allows for a bigger reach	• No social interactions • Less variety • No supervision
Websites	• Easy to use • Accessible • Allows for a bigger reach • Lower cost	• No social interactions • Low adherence (Pressler et al., 2010) • No supervision

Live classes (e.g., Zoom, Microsoft Teams)	• Social interactions • Has supervision • Lower cost • Allows for bigger reach (Sanchez-Villagomez et al., 2021)	• May be hard for some older adults to use • Requires more staff (e.g., instructors, support staff) • Does not replace in-person classes (LaMonica et al., 2021)

Many studies have reported beneficial effects of internet use for older adults. Cotton et al. (2013) found that internet use was associated with lower levels of loneliness. Cresci et al. (2010) found that non-internet users had a greater number of hospitalization days, were more likely to have heart problems, stroke, diabetes and hepatitis and they were less optimistic about their lives. Older adults who do not use the internet were also less likely to use the library, learn new things, volunteer, and participate in community organizations.

A systematic review by Valenzuela et al. (2018) comparing traditional exercise programs to technology-based exercise programs (e.g., exergames, virtual reality, applications, websites) for older adults found that technology-based programs had higher adherence rates with a median adherence rate of 91.25% for technology-based programs and 83.58% for traditional programs. Online exercise programs have been shown to significantly increase lower body strength, lung function, and quality of life in older adults (Irvine et al., 2013; Sanchez-Villagomez et al., 2021; Tallner et al., 2016; Tanhamira et al., 2021). Programs using virtual reality have also been shown to improve static and dynamic balance as well as physical performance in older adults (Gao et al., 2020; Phu et al., 2019).

More recently, a feasibility study by Schwartz et al. (2021) offered an online exercise program for older adults aged 60+ that included strength exercises using body weight (e.g., sit-to-stand, lunges, standing push-ups) and aerobic exercises (e.g., step touch, walking in place with high knees). The exercise program was offered twice a week for 8 weeks and was led by an exercise professional. Measured outcomes were adverse events, adherence rates, and participant satisfaction. They reported no adverse events, adherence rates off 90%, and 97% of participants reported being satisfied with the program. They concluded that offering live, online group physical activity program was a feasible way for older adults to increase physical activity levels.

Similarly, Beauchamp et al. (2021) offered a 12-week online exercise program to adults aged 65+ who had low physical activity levels. Classes were offered seven days per week and participants were encouraged to attend at least three classes each week all classes were offered online. The program included strength, balance, flexibility, and aerobic components. Classes were led by older adults' exercise instructors. Participants were randomized to either a group exercise class, a personal exercise class or a control group. The group exercise class exercised with the other participants and was able to interact with others. The personal exercise group had access to live or pre-recorded sessions and were not able to interact with other participants. Adherence was 10% higher in the group program than in the personal program. They also found an increase in self-reported mental and physical health in both intervention groups. However, this program is not a sustainable program without the help of funding agencies or other funding sources to help cover the costs of the instructors and the multitude of class options.

Similar to other programs, a switch to online was necessary during the COVID -19. Sanchez-Villagomez et al. (2021) found that once they switched the delivery of their program from in-person to online they were able to increase their reach from 3,931 participants in the in-person program to 428,766 participants with the biggest increase being in the 60-69 years old. Their program consists of five different exercise options: yoga, Yogalates, Pilates, Tai chi, and Dance for Fun and Fitness. Each class of around 12-15 participants is offered one hour once a week for 6-weeks.

2.8 Gap in Knowledge

Based on the review of literature, it is evident that exercise has an important effect on the risk of falls. However, there is limited research comparing online and in-person delivery of exercise programs for older adults. As a result, it is unknown if the benefits of the two modes differ in the outcomes. Additionally, it is unknown whether the characteristics of participants differ between in-person and online delivery methods.

2.9 References

Adams, J. M., & White, M. (2004). Biological ageing: A fundamental, biological link between socio-economic status and health? *European Journal of Public Health, 14*(3), 331–334.

Age-Well. (2021). *The Benefits and Challenges of Virtual Geriatric Care in New Brunswick*. AGE-WELL National Innovation Hub APPTA Inc.

Alasfour, M., & Almarwani, M. (2020). The effect of innovative smartphone application on adherence to a home-based exercise programs for female older adults with knee osteoarthritis in Saudi Arabia: A randomized controlled trial. *Disability and Rehabilitation*, 1–8.

Alemayehu, B., & Warner, K. E. (2004). The Lifetime Distribution of Health Care Costs. *Health Services Research*, *39*(3), 627–642.

Ambrose, A. F., Paul, G., & Hausdorff, J. M. (2013). Risk factors for falls among older adults: A review of the literature. *Maturitas*, *75*(1), 51–61.

Anderson, M., & Perrin, A. (2017, May 17). Technology use among seniors. *Pew Research Center: Internet, Science & Tech*. Retrieved: April 26, 2022 from: https://www.pewresearch.org/internet/2017/05/17/technology-use-among-seniors/

Aspvik, N. P., Viken, H., Ingebrigtsen, J. E., Zisko, N., Mehus, I., Wisløff, U., & Stensvold, D. (2018). Do weather changes influence physical activity level among older adults? – The Generation 100 study. *PLOS ONE*, *13*(7), e0199463.

Bandura, A. (2004). Health Promotion by Social Cognitive Means. *Health Education & Behavior*, *31*(2), 143–164.

Bean, J. F., Vora, A., & Frontera, W. R. (2004). Benefits of exercise for community-dwelling older adults. *Archives of Physical Medicine and Rehabilitation*, *85*, 31–42.

Beard, J. R., Officer, A., de Carvalho, I. A., Sadana, R., Pot, A. M., Michel, J.-P., Lloyd-Sherlock, P., Epping-Jordan, J. E., Peeters, G. M. E. E. (Geeske), Mahanani, W. R., Thiyagarajan, J. A., & Chatterji, S. (2016). The World report on ageing and health: A policy framework for healthy ageing. *Lancet (London, England)*, *387*(10033), 2145–2154.

Beauchamp, M. R., Hulteen, R. M., Ruissen, G. R., Liu, Y., Rhodes, R. E., Wierts, C. M., Waldhauser, K. J., Harden, S. H., & Puterman, E. (2021). Online-Delivered Group and Personal Exercise Programs to Support Low Active Older Adults' Mental Health During the COVID-19 Pandemic: Randomized Controlled Trial. *Journal of Medical Internet Research*, *23*(7), e30709.

Beaudart, C., Zaaria, M., Pasleau, F., Reginster, J.-Y., & Bruyère, O. (2017). Health Outcomes of Sarcopenia: A Systematic Review and Meta-Analysis. *PLoS ONE*, *12*(1).

Belsky, D. W., Caspi, A., Houts, R., Cohen, H. J., Corcoran, D. L., Danese, A., Harrington, H., Israel, S., Levine, M. E., Schaefer, J. D., Sugden, K., Williams, B., Yashin, A. I., Poulton, R., & Moffitt, T. E. (2015). Quantification of biological aging in young adults. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(30), E4104–E4110.

Bennie, J. A., Pedisic, Z., Uffelen, J. G. Z. van, Charity, M. J., Harvey, J. T., Banting, L. K., Vergeer, I., Biddle, S. J. H., & Eime, R. M. (2016). Pumping Iron in Australia: Prevalence, Trends and Sociodemographic Correlates of Muscle

Strengthening Activity Participation from a National Sample of 195,926 Adults. *PLOS ONE*, *11*(4), e0153225.

Bodenheimer, T. S., & Berry-Millett, R. (2009). Care management of patients with complex health care needs. *The Synthesis Project. Research Synthesis Report*, *19*, 52372.

Bohannon, R. W. (1995). Sit-to-Stand Test for Measuring Performance of Lower Extremity Muscles. *Perceptual and Motor Skills*, *80*(1), 163–166.

Bohannon, R. W. (2015). Daily sit-to-stands performed by adults: A systematic review. *Journal of Physical Therapy Science*, *27*(3), 939–942.

Borde, R., Hortobágyi, T., & Granacher, U. (2015). Dose–Response Relationships of Resistance Training in Healthy Old Adults: A Systematic Review and Meta-Analysis. *Sports Medicine (Auckland, N.z.)*, *45*(12), 1693–1720.

Bouchard, D. R., Olthuis, J. V., Bouffard-Levasseur, V., Shannon, C., McDonald, T., & Sénéchal, M. (2021). Peer-led exercise program for ageing adults to improve physical functions—A randomized trial. *European Review of Aging and Physical Activity*, *18*(1), 2.

Bowden Davies, K. A., Pickles, S., Sprung, V. S., Kemp, G. J., Alam, U., Moore, D. R., Tahrani, A. A., & Cuthbertson, D. J. (2019). Reduced physical activity in young and older adults: Metabolic and musculoskeletal implications. *Therapeutic Advances in Endocrinology and Metabolism*, *10*,.

Boyne, P., Welge, J., Kissela, B., & Dunning, K. (2017). Factors Influencing the Efficacy of Aerobic Exercise for Improving Fitness and Walking Capacity After Stroke: A Meta-Analysis With Meta-Regression. *Archives of Physical Medicine and Rehabilitation*, *98*(3), 581–595.

Bryant, M. S., Rintala, D. H., Hou, J.-G., & Protas, E. J. (2015). Relationship of Falls and Fear of Falling to Activity Limitations and Physical Inactivity in Parkinson's Disease. *Journal of Aging and Physical Activity*, *23*(2), 187–193.

Buchner, D. M., Rillamas-Sun, E., Di, C., LaMonte, M. J., Marshall, S. W., Hunt, J., Zhang, Y., Rosenberg, D. E., Lee, I.-M., Evenson, K. R., Herring, A. H., Lewis, C. E., Stefanick, M. L., & LaCroix, A. Z. (2017). Accelerometer-Measured Moderate to Vigorous Physical Activity and Incidence Rates of Falls in Older Women. *Journal of the American Geriatrics Society*, *65*(11), 2480–2487.

Buford, T. W., Anton, S. D., Clark, D. J., Higgins, T. J., & Cooke, M. B. (2014). Optimizing the Benefits of Exercise on Physical Function in Older Adults. *PM & R : The Journal of Injury, Function, and Rehabilitation*, *6*(6), 528–543.

Burton, E., Farrier, K., Hill, K. D., Codde, J., Airey, P., & Hill, A.-M. (2018). Effectiveness of peers in delivering programs or motivating older people to increase their participation in physical activity: Systematic review and meta-analysis. *Journal of Sports Sciences*, *36*(6), 666–678.

Cadore, E. L., Rodríguez-Mañas, L., Sinclair, A., & Izquierdo, M. (2013). Effects of Different Exercise Interventions on Risk of Falls, Gait Ability, and Balance in Physically Frail Older Adults: A Systematic Review. *Rejuvenation Research*, *16*(2), 105–114.

Cameron, K. A. (2019). Chronic Conditions, from A to Z: Life expectancy is lower in America than in other developed nations, mainly due to the toll of chronic conditions, many of which are preventable. *Generations*, 8–12.

Canada. (2016, October 3). *Government of Canada—Action for Seniors report* . Retrieved: April 26, 2022 from: https://www.canada.ca/en/employment-social-development/programs/seniors-action-report.html

Cano Porras, D., Sharon, H., Inzelberg, R., Ziv-Ner, Y., Zeilig, G., & Plotnik, M. (2019). Advanced virtual reality-based rehabilitation of balance and gait in clinical practice. *Therapeutic Advances in Chronic Disease, 10*,.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126–131.

Chao, Y.-Y., Scherer, Y. K., & Montgomery, C. A. (2015). Effects of Using Nintendo Wii™ Exergames in Older Adults: A Review of the Literature. *Journal of Aging and Health*, *27*(3), 379–402.

Chemtob, K., Caron, J. G., Fortier, M. S., Latimer-Cheung, A. E., Zelaya, W., & Sweet, S. N. (2018). Exploring the peer mentorship experiences of adults with spinal cord injury. *Rehabilitation Psychology*, *63*(4), 542–552.

Chen, Y., Zhang, Y., Guo, Z., Bao, D., & Zhou, J. (2021). Comparison between the effects of exergame intervention and traditional physical training on improving balance and fall prevention in healthy older adults: A systematic review and meta-analysis. *Journal of NeuroEngineering and Rehabilitation*, *18*(1), 164.

Choi, S. D., Guo, L., Kang, D., & Xiong, S. (2017). Exergame technology and interactive interventions for elderly fall prevention: A systematic literature review. *Applied Ergonomics*, *65*, 570–581.

Clarke, P. J., Yan, T., Keusch, F., & Gallagher, N. A. (2015). The Impact of Weather on Mobility and Participation in Older US Adults. *American Journal of Public Health*, *105*(7), 1489–1494.

Collin, C., Wade, D. T., Davies, S., & Horne, V. (1988). The Barthel ADL Index: A reliability study. *International Disability Studies*, *10*(2), 61–63.

Copeland, J. L., Good, J., & Dogra, S. (2019). Strength training is associated with better functional fitness and perceived healthy aging among physically active older adults: A cross-sectional analysis of the Canadian Longitudinal Study on Aging. *Aging Clinical and Experimental Research*, *31*(9), 1257–1263.

Cotten, S. R., Anderson, W. A., & McCullough, B. M. (2013). Impact of Internet Use on Loneliness and Contact with Others Among Older Adults: Cross-Sectional Analysis. *Journal of Medical Internet Research*, *15*(2), e39.

Cresci, M. K., Yarandi, H. N., & Morrell, R. W. (2010). Pro-Nets Versus No-Nets: Differences in Urban Older Adults' Predilections for Internet Use. *Educational Gerontology*, *36*(6), 500–520.

Cunningham, C., Sullivan, R. O., Caserotti, P., & Tully, M. A. (2020). Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scandinavian Journal of Medicine & Science in Sports*, *30*(5), 816–827.

de Labra, C., Guimaraes-Pinheiro, C., Maseda, A., Lorenzo, T., & Millán-Calenti, J. C. (2015). Effects of physical exercise interventions in frail older adults: A systematic review of randomized controlled trials. *BMC Geriatrics*, *15*.

Deandrea, S., Lucenteforte, E., Bravi, F., Foschi, R., La Vecchia, C., & Negri, E. (2010). Risk Factors for Falls in Community-dwelling Older People: A Systematic Review and Meta-analysis. *Epidemiology*, *21*(5), 658–668.

Delbaere, K., Valenzuela, T., Lord, S. R., Clemson, L., Zijlstra, G. A. R., Close, J. C. T., Lung, T., Woodbury, A., Chow, J., McInerney, G., Miles, L., Toson, B., Briggs, N., & van Schooten, K. S. (2021). E-health Standing Tall balance exercise for fall prevention in older people: Results of a two year randomized controlled trial. *The BMJ*, *373*, n740.

Dorgo, S., King, G. A., Bader, J. O., & Limon, J. S. (2013). Outcomes of a Peer Mentor Implemented Fitness Program in Older Adults: A Quasi-Randomized Controlled Trial. *International Journal of Nursing Studies*, *50*(9), 1156–1165.

dos Santos, R. B., Lago, G. N., Jencius, M. C., Barbosa, B. A., Lima, C. A., Paschoal, S. M., Hill, K. D., Leme, L. E. G., & Perracini, M. R. (2021). Older adults' views on barriers and facilitators to participate in a multifactorial falls prevention program: Results from Prevquedas Brasil. *Archives of Gerontology and Geriatrics*, *92*, 104287.

Edemekong, P. F., Bomgaars, D. L., Sukumaran, S., & Levy, S. B. (2021). Activities of Daily Living. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK470404/

El-Khoury, F., Cassou, B., Charles, M.-A., & Dargent-Molina, P. (2013). The effect of fall prevention exercise programs on fall induced injuries in community dwelling older adults: Systematic review and meta-analysis of randomized controlled trials. *The BMJ*, Fleg, J. L., Morrell, C. H., Bos, A. G., Brant, L. J., Talbot, L. A., Wright, J. G., & Lakatta, E. G. (2005). Accelerated Longitudinal Decline of Aerobic Capacity in Healthy Older Adults. *Circulation*, *112*(5), 674–682.

Franco, O. H. (2005). Effects of Physical Activity on Life Expectancy With Cardiovascular Disease. *Archives of Internal Medicine*, *165*(20), 2355.

Friedman, B., Jiang, H. J., & Elixhauser, A. (2008). Costly hospital readmissions and complex chronic illness. *Inquiry: A Journal of Medical Care Organization, Provision and Financing*, *45*(4), 408–421.

Friedmann, P. D., Jin, L., Karrison, T. G., Hayley, D. C., Mulliken, R., Walter, J., & Chin, M. H. (2001). Early revisit, hospitalization, or death among older persons discharged from the ED. *The American Journal of Emergency Medicine*, *19*(2), 125–129.

Gao, Z., Lee, J. E., McDonough, D. J., & Albers, C. (2020). Virtual Reality Exercise as a Coping Strategy for Health and Wellness Promotion in Older Adults during the COVID-19 Pandemic. *Journal of Clinical Medicine, 9*(6), 1986.

Gibbard, R. (July 2018). *Meeting the Care Needs of Canada's Aging Population*. Retrieved April 26, 2022 from: https://www.cma.ca/meeting-care-needs-canadas-aging-population

Gillespie, L. D., Robertson, M. C., Gillespie, W. J., Sherrington, C., Gates, S., Clemson, L., & Lamb, S. E. (2012). Interventions for preventing falls in older people living in the community. *The Cochrane Database of Systematic Reviews*, *2012*(9), CD007146.

Giné-Garriga, M., Roqué-Fíguls, M., Coll-Planas, L., Sitjà-Rabert, M., & Salvà, A. (2014). Physical Exercise Interventions for Improving Performance-Based

Measures of Physical Function in Community-Dwelling, Frail Older Adults: A Systematic Review and Meta-Analysis. *Archives of Physical Medicine and Rehabilitation*, *95*(4), 753-769.e3.

Government of Canada. (2008, July 1). *Impacts of the aging of the Canadian population on housing and communities* Retrieved on April 26, 2022 from: https://publications.gc.ca/site/eng/9.564228/publication.html

Government of Canada. (2021a, June 24). *Internet use and COVID-19: How the pandemic increased the amount of time Canadians spend online*. Retrieved on April 26, 2022 from: https://www150.statcan.gc.ca/n1/pub/45-28-0001/2021001/article/00027-eng.htm

Government of Canada, S. C. (2019a, July 10). *Evolving Internet Use Among Canadian Seniors*. Retrieved on April 26, 2022, from: https://www150.statcan.gc.ca/n1/pub/11f0019m/11f0019m2019015-eng.htm

Government of Canada, S. C. (2019b, August 14). *Section 2 – Results at the Canada level, 2018 to 2068*. Retrieved on April 26, 2022 from: https://www150.statcan.gc.ca/n1/pub/91-520-x/2019001/sect02-eng.htm

Government of Canada, S. C. (2021b, September 1). *The Daily — Canadian Health Measures Survey: Activity monitor data, 2018-2019*. Retrieved on April 26, 2022 from: https://www150.statcan.gc.ca/n1/daily-quotidien/210901/dq210901c-eng.htm

Granacher, U. (2012). Effects of balance and resistance training in children, adolescents, and seniors. *Sportwissenschaft*, *42*(1), 17–29.

Grant, P., Dall, P., & Kerr, A. (2011). Daily and hourly frequency of the sit to stand movement in older adults: A comparison of day hospital, rehabilitation ward and community living groups. *Aging Clinical and Experimental Research*, *23*, 437–444.

Guralnik, J. M., Ferrucci, L., Simonsick, E. M., Salive, M. E., & Wallace, R. B. (1995, March 2). *Lower-Extremity Function in Persons over the Age of 70 Years as a Predictor of Subsequent Disability,* Massachusetts Medical Society.

Hauer, K., Lamb, S. E., Jorstad, E. C., Todd, C., Becker, C. (2006). Systematic review of definitions and methods of measuring falls in randomised controlled fall prevention trials. *Age and Ageing*, *35*(1), 5–10.

Herold, F., Törpel, A., Schega, L., & Müller, N. G. (2019). Functional and/or structural brain changes in response to resistance exercises and resistance training lead to cognitive improvements – a systematic review. *European Review of Aging and Physical Activity*, *16*(1), 1–33.

Hoffman, G. J., Hays, R. D., Shapiro, M. F., Wallace, S. P., & Ettner, S. L. (2017). The Costs of Fall-Related Injuries among Older Adults: Annual Per-Faller, Service Component, and Patient Out-of-Pocket Costs. *Health Services Research*, *52*(5), 1794–1816.

Irvine, A. B., Gelatt, V. A., Seeley, J. R., Macfarlane, P., & Gau, J. M. (2013). Web-based Intervention to Promote Physical Activity by Sedentary Older Adults: Randomized Controlled Trial. *Journal of Medical Internet Research*, *15*(2), e2158.

Izutsu, K., Arima, K., Abe, Y., Okabe, T., Tomita, Y., Mizukami, S., Kanagae, M., Nishimura, T., & Aoyagi, K. (2017). Exercise intervention implemented by trained volunteers improves health-related quality of life among Japanese community-dwelling older females: An intervention study. *Journal of Physical Therapy Science*, *29*(12), 2126–2132.

Jette, A. M., Davies, A. R., Cleary, P. D., Calkins, D. R., Rubenstein, L. V., Fink, A., Kosecoff, J., Young, R. T., Brook, R. H., & Delbanco, T. L. (1986). The functional status questionnaire: Reliability and validity when used in primary care. *Journal of General Internal Medicine*, *1*(3), 143–149.

Jin, B., Lee, J., & Baumgartner, L. M. (2019). Perceptions of peer-led learning among older adults in a community-based aquatic exercise program. *Educational Gerontology*, *45*(4), 297–308.

Katz, S. (1983). Assessing self-maintenance: Activities of daily living, mobility, and instrumental activities of daily living. *Journal of the American Geriatrics Society*, *31*(12), 721–727.

Kiami, S. R., Sky, R., & Goodgold, S. (2019). Facilitators and barriers to enrolling in falls prevention programming among community dwelling older adults. *Archives of Gerontology and Geriatrics*, *82*, 106–113.

Kirkwood, T. B. L., & Austad, S. N. (2000). Why do we age? *Nature*, *408*(6809), 233–238.

Kovacevic, A., Fenesi, B., Paolucci, E., & Heisz, J. J. (2019). The effects of aerobic exercise intensity on memory in older adults. *Applied Physiology, Nutrition, and Metabolism*.

LaMonica, H. M., Davenport, T. A., Roberts, A. E., & Hickie, I. B. (2021). Understanding Technology Preferences and Requirements for Health Information Technologies Designed to Improve and Maintain the Mental Health and Well-Being of Older Adults: Participatory Design Study. *JMIR Aging*, *4*(1), e21461.

Latham, N. K., Mehta, V., Nguyen, A. M., Jette, A. M., Olarsch, S., Papanicolaou, D., & Chandler, J. (2008). Performance-Based or Self-Report Measures of Physical Function: Which Should Be Used in Clinical Trials of Hip Fracture Patients? *Archives of Physical Medicine and Rehabilitation*, *89*(11), 2146–2155.

Lee, J. W., Kim, S. B., & Kim, S. W. (2018). Effects of elastic band exercises on physical ability and muscular topography of elderlyfemales. *Journal of Physical Therapy Science*, *30*(2), 248–251.

Lee, Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., & Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *The Lancet*, *380*(9838), 219–229.

Lepkowsky, C. M. (2017). Functional assessment of comfort employing technology scale (facets): A brief intake instrument to facilitate treatment planning and communication with patients. *Psychology Behavioral Medicine Open Access Journal*, *0*(0), 9–13.

Lin, Y.-H., Chen, Y.-C., Tseng, Y.-C., Tsai, S., & Tseng, Y.-H. (2020). Physical activity and successful aging among middle-aged and older adults: A systematic review and meta-analysis of cohort studies. *Aging (Albany NY)*, *12*(9), 7704–7716.

Liu, C., & Latham, N. K. (2009). Progressive resistance strength training for improving physical function in older adults. *The Cochrane Database of Systematic Reviews*, *2009*(3).

Lloréns, R., Noé, E., Colomer, C., & Alcañiz, M. (2015). Effectiveness, Usability, and Cost-Benefit of a Virtual Reality–Based Telerehabilitation Program for Balance Recovery After Stroke: A Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*, *96*(3), 418-425.e2.

López-Otín, C., Blasco, M. A., Partridge, L., Serrano, M., & Kroemer, G. (2013). The Hallmarks of Aging. *Cell*, *153*(6), 1194–1217.

Ludyga, S., Gerber, M., Brand, S., Holsboer-Trachsler, E., & Pühse, U. (2016). Acute effects of moderate aerobic exercise on specific aspects of executive function in different age and fitness groups: A meta-analysis. *Psychophysiology*, *53*(11), 1611–1626.

Marengoni, A., Angleman, S., Melis, R., Mangialasche, F., Karp, A., Garmen, A., Meinow, B., & Fratiglioni, L. (2011). Aging with multimorbidity: A systematic review of the literature. *Ageing Research Reviews*, *10*(4), 430–439.

Merom, D., Pye, V., Macniven, R., van der Ploeg, H., Milat, A., Sherrington, C., Lord, S., & Bauman, A. (2012). Prevalence and correlates of participation in fall prevention exercise/physical activity by older adults. *Preventive Medicine*, *55*(6), 613–617.

Murtagh, E. M., Murphy, M. H., Murphy, N. M., Woods, C., Nevill, A. M., & Lane, A. (2015). Prevalence and Correlates of Physical Inactivity in Community-Dwelling Older Adults in Ireland. *PLOS ONE*, *10*(2), e0118293.

National Council on Aging. (2021, January 1). *Evidence-Based Falls Prevention Programs for Older Adults*. Retrieved on April 26, 2022 from: https://ncoa.org/article/evidence-based-falls-prevention-programs

New Brunswick Health Council. (2021). *Life expectancy is getting shorter in New Brunswick | New Brunswick Health Council*. Retrieved on April 26, 2022 from: https://nbhc.ca/news/life-expectancy-getting-shorter-new-brunswick

Page, P., & Lee. (2010). Standing Strong: Bringing Evidence to Practice for a Community-Based Fall Prevention Exercise Program. *Topics in Geriatric Rehabilitation*, *26*(4), 335–352.

Pang, M. Y. C., Charlesworth, S. A., Lau, R. W. K., & Chung, R. C. K. (2013). Using Aerobic Exercise to Improve Health Outcomes and Quality of Life in Stroke: Evidence-Based Exercise Prescription Recommendations. *Cerebrovascular Diseases*, *35*(1), 7–22.

Paterson, D. H., & Warburton, D. E. (2010). Physical activity and functional limitations in older adults: A systematic review related to Canada's Physical Activity Guidelines. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 38.

Peterson, M. D., Rhea, M. R., Sen, A., & Gordon, P. M. (2010). Resistance Exercise for Muscular Strength in Older Adults: A Meta-Analysis. *Ageing Research Reviews*, *9*(3), 226–237.

Petigara, T., & Anderson, G. (2009). *Program of All-Inclusive Care for the Elderly*. Retrieved on April 26, 2022 from: https://docplayer.net/14871527-Program-of-all-inclusive-care-for-the-elderly.html

Phu, S., Vogrin, S., Al Saedi, A., & Duque, G. (2019). Balance training using virtual reality improves balance and physical performance in older adults at high risk of falls. *Clinical Interventions in Aging*, *14*, 1567–1577.

Pietrzak, E., Cotea, C., & Pullman, S. (2014). Using Commercial Video Games for Falls Prevention in Older Adults: The Way for the Future? *Journal of Geriatric Physical Therapy*, *37*(4), 166–177.

Pressler, A., Knebel, U., Esch, S., Kölbl, D., Esefeld, K., Scherr, J., Haller, B., Schmidt-Trucksäss, A., Krcmar, H., Halle, M., & Leimeister, J. M. (2010). An internet-delivered exercise intervention for workplace health promotion in overweight sedentary employees: A randomized trial. *Preventive Medicine*, *51*(3), 234–239.

Public Health Agency of Canada. (2014). *Seniors' falls in Canada: Second report.* Retrieved on April 26, 2022 from: http://epe.lac-bac.gc.ca/100/201/301/weekly_checklist/2014/internet/w14-36-U-E.html/collections/collection_2014/aspc-phac/HP25-1-2014-eng.pdf

Reiman, M. P., & Manske, R. C. (2011). The assessment of function: How is it measured? A clinical perspective. *The Journal of Manual & Manipulative Therapy*, *19*(2), 91–99.

Rikli, R. E., & Jones, C. J. (1999). Functional Fitness Normative Scores for Community-Residing Older Adults, Ages 60-94. *Journal of Aging and Physical Activity*, *7*(2), 162–181.

Robertson, & Campbell. (2003). *Otago exercise programme to prevent falls in older adults*. ACC Think safe.

Robertson, L., Hale, B., Waters, D., Hale, L., & Andrew, A. (2014). *Community Peer-Led Exercise Groups: Reasons for Success*. 11.

Robitaille, Y., Laforest, S., Fournier, M., Gauvin, L., Parisien, M., Corriveau, H., Trickey, F., & Damestoy, N. (2005). Moving Forward in Fall Prevention: An

Intervention to Improve Balance Among Older Adults in Real-World Settings. *American Journal of Public Health*, *95*(11), 2049–2056.

Rubenstein, L. Z., & Josephson, K. R. (2006). Falls and Their Prevention in Elderly People: What Does the Evidence Show? *Medical Clinics of North America*, *90*(5), 807–824.

Ruggieri, M., Palmisano, B., Fratocchi, G., Santilli, V., Mollica, R., Berardi, A., & Galeoto, G. (2018). Validated Fall Risk Assessment Tools for Use with Older Adults: A Systematic Review. *Physical & Occupational Therapy In Geriatrics*, *36*(4), 331–353.

Ryan, R. M., & Deci, E. L. (Eds.). (2017). *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. Guilford Press.

Sanchez-Villagomez, P., Zurlini, C., Wimmer, M., Roberts, L., Trieu, B., McGrath, B., Wiesel, R., Ologhobo, T., Goldsmith, S., & Robbins, L. (2021). Shift to Virtual Self-Management Programs During COVID-19: Ensuring Access and Efficacy for Older Adults. *Frontiers in Public Health, 9*, 663875.

Savard, J., Labossière, S., Cardinal, D., Pinet, B., & Borris, C. (2018). Évaluation de Marche vers le futur, un programme novateur de prévention des chutes offert par videoconference. *Canadian Journal on Aging / La Revue Canadienne Du Vieillissement*, *37*(4), 363–376.

Schepens, S., Sen, A., Painter, J. A., & Murphy, S. L. (2012). Relationship Between Fall-Related Efficacy and Activity Engagement in Community-Dwelling Older Adults: A Meta-Analytic Review. *The American Journal of Occupational Therapy*, *66*(2), 137–148.

Schumacher, S., & Kent, N. (2020, April 2). 8 charts on internet use around the world as countries grapple with COVID-19. *Pew Research Center*. Retrieved on April 26, 2022 from: https://www.pewresearch.org/fact-tank/2020/04/02/8-charts-on-internet-use-around-the-world-as-countries-grapple-with-covid-19/

Schwartz, H., Har-Nir, I., Wenhoda, T., & Halperin, I. (2021). Staying physically active during the COVID-19 quarantine: Exploring the feasibility of live, online, group training sessions among older adults. *Translational Behavioral Medicine*, *11*(2), 314–322.

Schwenk, M., Lauenroth, A., Stock, C., Moreno, R. R., Oster, P., McHugh, G., Todd, C., & Hauer, K. (2012). Definitions and methods of measuring and reporting on injurious falls in randomised controlled fall prevention trials: A systematic review. *BMC Medical Research Methodology*, *12*, 50.

Shephard, R. J. (2009). Maximal oxygen intake and independence in old age. *British Journal of Sports Medicine*, *43*(5), 342.

Sherrington, C., Fairhall, N., Wallbank, G., & Tiedemann, A. (2019, January 31). *Exercise for preventing falls in older people living in the community*.

Sherrington, Michaleff, Z. A., Fairhall, N., Paul, S. S., Tiedemann, A., Whitney, J., Cumming, R. G., Herbert, R. D., Close, J. C. T., & Lord, S. R. (2017). Exercise to prevent falls in older adults: An updated systematic review and meta-analysis. *British Journal of Sports Medicine*, *51*(24), 1750–1758.

Sibley, K. M., Thomas, S. M., Veroniki, A. A., Rodrigues, M., Hamid, J. S., Lachance, C. C., Cogo, E., Khan, P. A., Riva, J. J., Thavorn, K., MacDonald, H., Holroyd-Leduc, J., Feldman, F., Kerr, G. D., Jaglal, S. B., Straus, S. E., & Tricco, A. C. (2021). Comparative effectiveness of exercise interventions for preventing falls in older adults: A secondary analysis of a systematic review with network meta-analysis. *Experimental Gerontology*, *143*, 111151.

Sinclair, J., Hingston, P., & Masek, M. (2007). Considerations for the design of exergames. *Proceedings of the 5th International Conference on Computer Graphics and Interactive Techniques in Australia and Southeast Asia*, 289–295.

Soares, W. J. S., Lopes, A. D., Nogueira, E., Candido, V., Moraes, S. A. de, & Perracini, M. R. (2019). Physical Activity Level and Risk of Falling in Community-Dwelling Older Adults: Systematic Review and Meta-Analysis. *Journal of Aging and Physical Activity*, *27*(1), 34–43.

Sobestiansky, S., Michaelsson, K., & Cederholm, T. (2019). Sarcopenia prevalence and associations with mortality and hospitalisation by various sarcopenia definitions in 85–89 year old community-dwelling men: A report from the ULSAM study. *BMC Geriatrics*, *19*(1), 318.

Sousa, L. M. M., Marques-Vieira, C. M. A., Caldevilla, M. N. G. N. de, Henriques, C. M. A. D., Severino, S. S. P., & Caldeira, S. M. A. (2017). Risk for falls among community-dwelling older people: Systematic literature review. *Revista Gaúcha de Enfermagem*, *37*.

Stathi, A., Withall, J., Agyapong-Badu, S., Barrett, E., Kritz, M., Wills, D., Thogersen-Ntoumani, C., & Fox, K. R. (2021). Mobilising people as assets for active ageing promotion: A multi-stakeholder perspective on peer volunteering initiatives. *BMC Public Health*, *21*(1), 150.

Statistics Canada. (2022, January 24). *Life expectancy and other elements of the complete life table, three-year estimates, Canada, all provinces except Prince*

Edward Island. Retrieved on April 26, 2022 from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid= 1310011401

Stevens, J., Sleet, D., & Rubenstein, L. (2017). The Influence of Older Adults' Beliefs and Attitudes on Adopting Fall Prevention Behaviors. *American Journal of Lifestyle Medicine*, *12*, 155982761668726.

Stillman, C. M., Cohen, J., Lehman, M. E., & Erickson, K. I. (2016). Mediators of Physical Activity on Neurocognitive Function: A Review at Multiple Levels of Analysis. *Frontiers in Human Neuroscience*, *10*, 626.

Studenski, S., Perera, S., Wallace, D., Chandler, J. M., Duncan, P. W., Rooney, E., Fox, M., & Guralnik, J. M. (2003). Physical Performance Measures in the Clinical Setting. *Journal of the American Geriatrics Society*, *51*(3), 314–322.

Sun, F., Norman, I. J., & While, A. E. (2013). Physical activity in older people: A systematic review. *BMC Public Health*, *13*, 449.

Tallner, A., Streber, R., Hentschke, C., Morgott, M., Geidl, W., Mäurer, M., & Pfeifer, K. (2016). Internet-Supported Physical Exercise Training for Persons with Multiple Sclerosis—A Randomised, Controlled Study. *International Journal of Molecular Sciences*, *17*(10).

Tanhamira, L., Randhawa, G., & Hewson, D. (2021). *Remotely-Delivered Mind-Body Physical Activity Improves Physical Function in Older Adults*.

Thomas, S., Mackintosh, S., & Halbert, J. (2010). Does the 'Otago exercise programme' reduce mortality and falls in older adults?: A systematic review and meta-analysis. *Age and Ageing*, *39*(6), 681–687.

Tomey, K. M., & Sowers, M. R. (2009). Assessment of Physical Functioning: A Conceptual Model Encompassing Environmental Factors and Individual Compensation Strategies. *Physical Therapy*, *89*(7), 705–714.

Touchette, A. J., Oates, A. R., Menec, V. H., & Sibley, K. M. (2021). Design characteristics and inclusion of evidence-based exercise recommendation in fall prevention community exercise programs for older adults in Canada: A national descriptive self-report study. *BMC Geriatrics*, *21*(1), 33.

Tricco, A. C., Thomas, S. M., Veroniki, A. A., Hamid, J. S., Cogo, E., Strifler, L., Khan, P. A., Robson, R., Sibley, K. M., MacDonald, H., Riva, J. J., Thavorn, K., Wilson, C., Holroyd-Leduc, J., Kerr, G. D., Feldman, F., Majumdar, S. R., Jaglal, S. B., Hui, W., & Straus, S. E. (2017). Comparisons of Interventions for Preventing Falls in Older Adults: A Systematic Review and Meta-analysis. *JAMA*, *318*(17), 1687.

United Nations. (2019). *World Population Ageing 2019: Highlights*. 46.

Valenzuela, T., Okubo, Y., Woodbury, A., Lord, S. R., & Delbaere, K. (2018). Adherence to Technology-Based Exercise Programs in Older Adults: A Systematic Review. *Journal of Geriatric Physical Therapy*, *41*(1), 49–61.

von Bonsdorff, M. B., & Rantanen, T. (2011). Benefits of formal voluntary work among older people. A review. *Aging Clinical and Experimental Research*, *23*(3), 162–169.

Vroman, K. G., Arthanat, S., & Lysack, C. (2015). “Who over 65 is online?” Older adults’ dispositions toward information communication technology. *Computers in Human Behavior*, *43*, 156–166.

Washburn, L. T., Cornell, C. E., Phillips, M., Felix, H., & Traywick, L. (2014). Strength Training in Community Settings: Impact of Lay Leaders on Program Access and Sustainability for Rural Older Adults. *Journal of Physical Activity and Health*, *11*(7), 1408–1414.

Waters, D. L., Hale, L. A., Robertson, L., Hale, B. A., & Herbison, P. (2011). Evaluation of a Peer-Led Falls Prevention Program for Older Adults. *Archives of Physical Medicine and Rehabilitation*, *92*(10), 1581–1586.

Webster, J., Courtney, M., O'Rourke, P., Marsh, N., Gale, C., Abbott, B., McRae, P., & Mason, K. (2008). Should elderly patients be screened for their 'falls risk'? Validity of the STRATIFY falls screening tool and predictors of falls in a large acute hospital. *Age and Ageing*, *37*(6), 702–706.

Werner, D., Teufel, J., & Brown, S. L. (2014). Evaluation of a Peer-Led, Low-Intensity Physical Activity Program for Older Adults. *American Journal of Health Education*, *45*(3), 133–141.

Winser, S. J., Chan, H. T. F., Ho, L., Chung, L. S., Ching, L. T., Felix, T. K. L., & Kannan, P. (2020). Dosage for cost-effective exercise-based falls prevention programs for older people: A systematic review of economic evaluations. *Annals of Physical and Rehabilitation Medicine, 63*(1), 69–80.

Withall, J., Thompson, J. L., Fox, K. R., Davis, M., Gray, S., de Koning, J., Lloyd, L., Parkhurst, G., & Stathi, A. (2018). Participant and Public Involvement in Refining a Peer-Volunteering Active Aging Intervention: Project ACE (Active, Connected, Engaged). *The Gerontologist*, *58*(2), 362–375.

World Health Organization (Ed.). (2009). *Global health risks: Mortality and burden of disease attributable to selected major risks*. World Health Organization.

World Health Organization. (2014, November 6). *"Ageing well" must be a global priority*. Retrieved on April 26, 2022 from: https://www.who.int/news/item/06-11-2014--ageing-well-must-be-a-global-priority

World Health Organization. (2018, February 5). *Ageing and health*. Retrieved on April 26, 2022 from: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

World Health Organization. (2020a). *Decade of healthy ageing: Baseline report*. Retrieved on April 26, 2022 from: https://www.who.int/publications-detail-redirect/9789240017900

World Health Organization. (2020b). *WHO guidelines on physical activity and sedentary behaviour*. Retrieved on April 26, 2022 from: https://www.who.int/publications-detail-redirect/9789240015128

World Health Organization. (2021). *Falls*. Retrieved on April 26, 2022 from: https://www.who.int/news-room/fact-sheets/detail/falls

Wurzer, B., Waters, D. L., Hale, L. A., & Leon de la Barra, S. (2014). Long-Term Participation in Peer-Led Fall Prevention Classes Predicts Lower Fall Incidence. *Archives of Physical Medicine and Rehabilitation*, *95*(6), 1060–1066.

Yardley, L., Beyer, N., Hauer, K., Kempen, G., Piot-Ziegler, C., & Todd, C. (2005). Development and initial validation of the Falls Efficacy Scale-International (FES-I). *Age and Ageing*, *34*(6), 614–619.

Chapter 3: Article

Comparing Online and In-Person Delivery of a Fall Prevention Exercise Program for Older Adults.

To be Submitted at: The Journal of the American Geriatrics Society

Corresponding author:

Danielle Bouchard, Ph.D.
90 Mackay Drive
Faculty of Kinesiology
University of New Brunswick
Fredericton, New Brunswick
E3B 4J9
dboucha1@unb.ca

Author Contributions

Pitre, V: Acquisition of subjects, data collection, data interpretations and manuscript preparation.

Funding Sources: Healthy Seniors Pilot Project- Public Health Agency of Canada, New Brunswick Health Research Foundation

Abstract

Comparing Online and In-person Delivery of a Fall Prevention Exercise Program for Aging Adults

Background: The COVID-19 pandemic forced many exercise programs to stop or shift to online delivery. Online delivery increases accessibility, however, the health and functional benefits for older adults are unknown. It is important to test the benefits of online delivery before permanently offering programs online. The purpose of this study was to determine if online and in-person delivery of an exercise program led to different functional and self-perceived benefits as well as attendance and dropout rates.

Methods: The Zoomers on the Go program is a peer-led exercise program offered for 12 weeks, 2x/week to adults 50+. The program was offered to 103 people online and 95 people in person. To be eligible participants needed to be new to the program. The program includes resistance exercise, aerobic activities, balance, and flexibility. The main outcome was lower body strength as measured by the 30-second chair stand test. Other outcomes included dropout, attendance, balance (one leg stance), cardiorespiratory fitness (2-minute step test or 6-minute walk test), perceived health (36 item Short Form Health Survey), and mental health (Depression Anxiety Stress Scale).

Results: Dropout rate was 27.1% and 11.5% in the online and the in-person group respectively ($p<0.001$). Attendance was 19.6 ± 4.8 sessions for the online group and 16.7 ± 2.9 sessions for the in-person group ($p<0.001$) out of 24. A total of 74 participants (66.3 ± 7.1 years old) in the online group and 84 participants in the in-person group (67.3± 7.2% years old) completed the program. Both groups improved significantly (all $p <0.001$) their 30 seconds chair stand (14.4 ± 2.7 to 17.0 ± 4.2) vs. (14.1 ± 4.2 to 17.5 ± 5.1) for online and in-person respectively, cardiorespiratory fitness, and balance without any difference between groups. In-person group improved values from the SF-36 questionnaire and significantly reduced the level of stress and depression following the program.

Conclusions: Online delivery is associated with a greater attendance, with no difference in functional benefits between delivery modes. However, in-person delivery could offer more health-related benefits reported by participants.

Key Words: Older adults, Online, Fall Prevention, Exercise Program.

Introduction

The number of older adults in our population is steadily increasing. By 2034, 23.4% of the population is expected to be 65 years or older (Vespa, 2019). With an increased older population comes an increased rate of falls (World Health Organization, 2021). Falls cause up to 85% of all injury-related hospitalizations in older adults and over one third of older adults are admitted to long-term care homes after being hospitalized for a fall. (Public Health Agency of Canada, 2014). There is a clear need for strategies to reduce the risk of falls.

Many studies have found that exercise is the most effective method to reduce the risk of falls (Bryant et al., 2015; Tricco et al., 2017). It is for this reason that many communities offer exercise programs for older adults. One of the programs offered to older adults is the Zoomers on the Go program. Zoomers on the Go is a peer-led, fall prevention exercise program offered to adults aged 50 years and older by peers in 12-weeks sessions. Each week includes two classes of 60 minutes including aerobic exercises, resistance training, balance, and flexibility activities. This program has been evaluated by our team, and we have found that the program leads to improvements in physical function in older adults when delivered in-person. (Bouchard et al., 2021)

The COVID-19 pandemic has caused many programs to move to online delivery including the Zoomers on the Go program. Online delivery allows for a greater reach with more than 20% of older adults living in rural areas in the United States (Symens Smith & Trevelyan, 2019). For example, Sanchez-Villagomez et al. (2021) found that once they switched the delivery of their program from in-person to online they were able to increase their reach from 3,931 participants in the in-person program to 428,766 participants with the largest increase in the 60-69 age group.

Online delivery can remove barriers to regular exercise program participation such as transportation, environmental elements (e.g., parking, unsafe location, and sidewalks), bad weather, dislike of group exercise (Bethancourt et al., 2014; Kiami et al., 2019). In addition, research shows that more and more older adults use the internet with many reporting use on a daily basis (Anderson & Perrin, 2017).

Online exercise program delivery has been shown to be a feasible way to reduce fall and increase physical activity levels in older adults (Li et al., 2021; Schwartz et al., 2021). Hong et al. (2018) found a significant improvement in 30-second chair stand, Berg Balance Scale, and a reduced fear of falling when offering a web-based one-on-one exercise program to women aged 65 years and older who were considered at a high risk of falls. Online group exercise programs have also been shown to have higher adherence rates to one-on-one online programs (Beauchamp et al., 2021).

There is limited research testing online exercise for falls prevention for older adults. Given the high prevalence of falls, the demographic of the population, the increase of internet usage for older adults it is important to explore strategies to reduce the risks of falls for older adults using alternate delivery. The main outcome of this study was to test if the improvements in lower body strength, measure by the 30-second chair stand, were different when the program is delivered online compared to when it in delivered in-person. Secondary outcomes included other physical function tests, demographics, self-perceived benefits, dropout, and attendance.

Methods

A quasi-experimental study was used to compare online delivery to in-person delivery of the Zoomers on the Go program. The study was conducted over a 12-week duration. The project was reviewed and approved by the University of New Brunswick Research Ethics Board (REB 2019-153).

To be eligible to participate in the program, participants had to be 50 years and older, cleared to exercise determined by the Canadian Society for Exercise Physiology - Get Active Questionnaire (Canadian Society for Exercise Physiology, 2017). For the in-person group, participants had to be able to physically come to the class location. Participants in the online group had to have access to internet, have a device compatible with Microsoft Teams and able to exercise with minimal supervision. Participants were excluded if they previously participated in the Zoomers on the Go program. Participants were recruited through radio advertisements, newspapers, posters, and social media.

The Zoomers on the Go in-person exercise program was offered at indoor community locations (e.g., community centres, church basements) at no cost to the participants by peer-leaders aged 50+ for a period of 12 weeks in March 2019. The program was offered twice a week for 60 minutes per session. Each session consisted of 10-minute warm-up, 10 minutes of aerobic, balance and flexibility exercises and 15 minutes of muscle strengthening exercises followed by a 5-minute cool-down. TheraBand's band, a 9-inch ball, and a chair (if needed) were used to deliver the program. More details on the exercises offered can be found elsewhere (Bouchard et al., 2021).

The Zoomers on the Go online exercise program was offered through Microsoft Teams from September 2020 to April 2021 (two sessions of 12-weeks) with adaptations for the aerobic portion because of limited space, and equipment (ball and band) was mailed to the participant. Everything else remained the same. Classes were offered in the morning or evening depending on participants preference. Each class had around 20-25 participants.

Data were collected by research staff. The first visit consisted of confirmation of eligibility, consent form signature, and baseline testing. After the 12-week session participants were invited for a second visit for post-testing. Testing included objective measures of physical functions: 30-second chair stand test, the 6-minute walk test both following the Senior Fitness Test protocol (Rikli & Jones, 1999a) and the eyes opened single leg stance test following the Canadian Society for Exercise Physiology protocol (Canadian Society for Exercise Physiology, 2019). Although the validity of online testing of physical function testing is not available, it has been shown to be reliable (Russell et al., 2013). Other questionnaires also collected during the visits were a demographics questionnaire, the Depression, Anxiety, Stress Scale (DASS-21); where depression is scored from 0-14, anxiety from 0-10 and stress from 0-17 with lower scores indicating lower severity, and the 36-item Short-Form Health Survey (SF-36) scored from 0-100 with higher scores indicating better self-reported health.

The same protocol was followed online with minor changes. The 6-minute walk test was replaced by the 2-minute step test and the comfort with technology was assessed with the Functional Assessment of Comfort Employing Technology Scale (FACETS). The FACETS questionnaire is a 10-item questionnaire assessing 5 domains each scored out of 10 for a total score out of 50 (Lepkowsky & Arndt, 2018). Questionnaires were either filled using Google forms, by email, or on paper and mailed back. When participant agreed to take part in the project, they were contacted by the research staff to book a 20-minute testing session to collect baseline data prior to the start of the program. The testing was done virtually using Microsoft Teams.

For the 30-second sit-to-stand test, participants were instructed to place a sturdy chair against the wall while remaining given the research staff. They were then required to sit on the chair with arms crossed at the chest and feet on the floor and completely stand and sit down as many times as possible in 30-seconds without using the rebound to stand. The research staff counted each repetition and kept time. Once the 30-seconds were completed, the number of repetitions was written in the participant chart.

For the 2-minute step test, participants were instructed to stand at a distance from their electronic devices so that the research staff could see their full bodies. Participants were then required to step in place for two minutes, making sure that their knee was lifted to the midpoint of their thigh. The participant was allowed to take a break or hold onto a chair or a wall if needed, but time was not stopped. The research staff recorded the number of times that the right knee passed the midpoint of the thigh in the 2-minute time frame in the participant chart.

Participants were asked to stand with a chair or a wall near them for the single-leg stance for safety. The participant was instructed that the test ends if the lifted foot touched the ground, if the arms left the crossed at the chest position or if 45-seconds had elapsed. They were then asked to cross their arms on their chest and lift one foot off the ground for as long as they could or until 45-seconds had passed. The test was repeated on the other leg. The time in seconds that the participant stood on one leg was recorded in their participant chart.

Statistical Analysis

A power calculation was performed to determine the appropriate sample size to test the non-difference hypothesis between online and in-person delivery on the 30-

second chair stand test using R software with the *magrittr*, *tidyerse*, and *pwr* packages (RStudio Inc., 2021). The 30-second chair stand test was used for sample size calculation because lower body strength plays an important role in fall prevention (Warburton et al., 2001). The sample size was calculated using the observed change for the in-person delivery in the intervention group participating in the RCT (Bouchard et al., 2021) with an expected effect size of 3.8 and a standard deviation of 3.2 for both groups on the 30 seconds chair stand test, $\alpha= 0.05$ and a power of 95%. The total sample size required per group was 29. It has been reported that exercise programs for older adults have a dropout rate of 30% (Stiggelbout et al., 2005); therefore, we aimed to recruit an additional 8 participants for the online delivery and thus a minimum of 37 participants per group.

Differences between groups on descriptive variables outcomes at baseline was tested via T-tests and Chi-square tests depending on the variable's nature. Changes in physical function were tested using paired T-tests for both online and in-person groups. For the balance test with eyes open, only those who did not score 45 seconds (maximum time) on baseline test were included in the analysis. To identify if the group was associated with any changes in the measured outcomes, post values were tested using linear regression models adjusting for baseline value, group (online or in-person) as well as age, sex, and attendance. Changes between groups in balance were tested using logistic regression adjusted for the same confounders. Logistic regression was used instead of linear regression for balance because the assumptions of linear regression were not met. Balance results were divided in two groups, 0 being score reduced (22.5%) and 1 being score improved or no change (77.5%). Effect sizes were tested using the Cohen's d score for all T-tests where 0.50 indicating a medium effect and 0.80

indicating a large effect (Lakens, 2013). Finally, intention to treat analysis were completed for all physical function tests by dragging values from baseline for participants for which post-testing values were not available.

Results

A total of 198 participants took part in the study (103 online, 95 in-person). Thirty nine participants (20%; 28 online and 11 in-person) dropped out during the program leaving 159 completers for analysis (75 online and 84 in-person). Significantly more participants dropped out of the online group (27%) compared to the in-person group (11.6%) ($p=0.004$). Participants reported dropping out because the program's intensity was not fitting their need (N=2), technology issues (N=5), and health issues (N=7). Other participants did not want to attend post-testing (N=20) or did not provide any reason but stopped attending the program (N=6) (Figure 1).

No significant difference was observed in participant characteristics at baseline for participants who completed the trial (Table 1). For example, the average age of participants was 66.3 years and 67.3 years for online and in-person participants respectively. Of those participants, women made up 86.6% of the online group and 84.5% of the in-person group. No difference was also observed on baseline characteristics between completers (n=159) and non-completers (n=40).

Out of a maximum of 24 sessions, the total attendance was significantly higher in the online group 19 ± 2 (79%) and 16 ± 4 (66%) for the in-person ($p<0.001$). In addition, weekly attendance was always higher for the online group (Figure 2).

In both settings, completers (75 online and 84 in-person) improved significantly during the program for all physical function tests ($p<0.001$; Table 2). The equivalent effect sizes were between 0.5 and 1.05. Even when completing an intention to treat analysis, the results all remained significant with effect sizes ranging from 0.21 and 0.93. No group effect was found for the change in any of the variables when models adjusted for baseline value, age, sex, and attendance.

Participants who had 45 seconds at baseline for balance were excluded for the balance analysis (N=47 for online and N=24 for in person). Even when including all completers, the balance scores were still significant between pre and post values without any difference between groups.

For self-perceived benefits (Table 3), the level of depression and stress improved significantly in the in-person group only ($p<0.05$). For the responses on the Short Form Health, half of the domains (i.e., emotional, social functioning, general health, and energy) improved significantly for the in-person group ($p<0.05$), but no domain improved for the online group.

Finally, in terms of comfort with technology (Figure 3), the online group did not significantly improve their total score (35.6 ± 9.9 to 35.8 ± 9.2), but the home domain improved significantly (8.5 ± 1.8 for pre and 8.9 ± 1.3 for post, $p=0.05$).

Discussion

This study shows that online and in-person delivery of the Zoomers on the Go program improved physical functions with no significant advantage for one or the other setting. Online delivery was associated with more drop-out, but more attendance from those who complete the program. However, this study suggests that in-person delivery might be superior to online delivery due to increased self-perceived health outcomes observed in this group.

While dropout rates were higher in the online group (27%) than in the in-person group (11%), the dropout rate in the online group aligned with other studies reporting dropouts (~30%) for exercise programs for older adults (Schwartz et al., 2021; Stiggelbout et al., 2005). Attendance was significantly higher in the online group than the in-person group. This is supported by a systematic review by Valenzuela et al. (2018) comparing traditional exercise programs to technology-based exercise programs (e.g., exergames, virtual reality, applications, websites) for older adults. They found that technology-based programs had 8% higher adherence compared to traditional exercise programs. This is not surprising since online delivery reduces commonly reported barriers for regular exercise such as lack of time and transportation (Bethancourt et al., 2014; dos Santos et al., 2021; Kiami et al., 2019) and it has been shown that there is an interest in web-based programs in the older adult population (Cohen-Mansfield et al., 2021).

Contrary to popular belief, no difference was observed between the measured characteristics (e.g., age, socio-economic status) of the participants registering online or in-person. It confirms that despite the perception that older adults are not interested in technology, or not able to use it appropriately, this study confirms that this is changing. With up to 67% of adults aged 65 years and older using the internet and 76% of them using it on a daily basis (Anderson & Perrin, 2017), online delivery of services for seniors could expand in the future.

Despite a greater effect size observed for the improvement of physical function in the group of participants receiving the in-person format, this study showed that physical function was improved in both settings without any significant difference between groups. While there is limited research comparing online and in-person exercise programs for older adults, Tanhamira et al. (2021) found that an 8-week videoconference delivered exercise programs for adults aged 65 years and older was effective at increasing sit to stand time. Similar to this study, programs using virtual reality have also been shown to improve static and dynamic balance as well as physical performance in older adults (Gao et al., 2020; Phu et al., 2019). When referring to principles of fitness, specificity and overload are key for physical improvements (Paterson et al., 2007). It is suggested that the stimulus -intensity and volume of exercises could be as high in both settings. One study conducted with older adults reported a minimal clinically important difference (MCID) for the 30 second sit to stand of two repetitions (Zanini et al., 2018). The change observed in this study was 2.6 repetitions for online and 3.4 repetitions for in-person. MCID for the 6-minute walk test was found to be 17.8m in frail older adults (Kwok et al., 2013). We saw an average change of 56.8 m in this study. MCID for other tests and questionnaires were not found in the literature therefore opening avenues for future research.

Our findings suggest that only participants who had in-person delivery improved their self-perceived benefits. For this group, improvements were reported in the emotional, general health, social functioning, energy stress, and depression. These improvements were reported by multiple studies when delivered in-person (Mikkelsen et al., 2017; Rethorst et al., 2009). The fact that the group receiving the program online did not improve these outcomes could be due to the fact that the intervention was offered online during the global COVID-19 pandemic where the in-person group received the intervention before the pandemic began. Therefore, it is possible that mental and physical health of participants online was affected by the pandemic rather than the delivery method as suggested elsewhere (Bailey et al., 2021; Capaldi et al., 2022; Tyler et al., 2021). It is important to note that mental and physical health did not reduce significantly in participants receiving the program online. Despite no significant improvements for this group, perhaps the online delivery permitted a coping mechanism for the pandemic as suggested by others (Beauchamp et al., 2021).

Comfort with technology was only assessed in the online group. Although the average score was 35/50 and thus considered frequent users on average, the score ranged from 2 to 50 meaning that some participants receiving the online program were not comfortable with technology. However, for some of the participants, online delivery was their option to participate in exercise classes, meaning that this score could be even higher if the program was offered when people have access to the in-person option. For example, a participant who does not have access to in-person classes and is not comfortable with technology may choose to participate in the online program anyways because they have no other exercise program options. Older adults living in rural areas may not have access to other exercise programs and online exercise could be the only way for them to access such program. It is thus possible that online delivery may increase in popularity. Sanchez-Villagomez et al. (2021) saw a 12.1% increase in participation in the 60-69 age group when the program switched to online because participants did not have to live in the city where the program was offered in order to participate.

Despite the novelty of this study, some limitations are worth noting. First, sessions were not held in the same season (in-person was in the spring, online was in the fall and winter). In North America every season brings different weather conditions which could impact the participants' willingness to participate and attend each session (Aspvik et al., 2018; Clarke et al., 2015). Second, participants did not get to choose or were not randomised to their mode of delivery since the online option was not available when the in-person intervention was offered, and vice versa and the lack of a control group. Third, the online sessions were conducted during the COVID-19 pandemic while the in-person sessions were done before the pandemic. Fourth, there was an imbalance in the number of participants in both groups therefore influencing statistical analysis. Finally, exercise performed outside the program was not controlled, therefore it is unknown if some of the outcomes could be associated with other activities.

In summary, online delivery is associated with a greater attendance, with no difference in functional benefits between delivery modes. However, in-person delivery could offer more health-related benefits reported by participants. This study also suggests an appetite for online exercise program for aging adults that could remain after the pandemic.

References

Adams, J. M., & White, M. (2004). Biological ageing: A fundamental, biological link between socio-economic status and health? *European Journal of Public Health, 14*(3), 331–334.

AGE-WELL National Innovation Hub APPTA inc. (2021). *The Benefits and Challenges of Virtual Geriatric Care in New Brunswick*.

Alasfour, M., & Almarwani, M. (2020). The effect of innovative smartphone application on adherence to a home-based exercise programs for female older adults with knee osteoarthritis in Saudi Arabia: A randomized controlled trial. *Disability and Rehabilitation*, 1–8.

Alemayehu, B., & Warner, K. E. (2004). The Lifetime Distribution of Health Care Costs. *Health Services Research*, *39*(3), 627–642.

Ambrose, A. F., Paul, G., & Hausdorff, J. M. (2013). Risk factors for falls among older adults: A review of the literature. *Maturitas*, *75*(1), 51–61.

Anderson, M., & Perrin, A. (2017, May 17). Technology use among seniors. *Pew Research Center: Internet, Science & Tech*. Retrieved on April 26, 2022 from: https://www.pewresearch.org/internet/2017/05/17/technology-use-among-seniors/

Bailey, L., Ward, M., DiCosimo, A., Baunta, S., Cunningham, C., Romero-Ortuno, R., Kenny, R. A., Purcell, R., Lannon, R., McCarroll, K., Nee, R., Robinson, D., Lavan, A., & Briggs, R. (2021). Physical and mental health of older people while cocooning during the COVID-19 pandemic. *QJM: An International Journal of Medicine*, *114*(9), 648–653.

Bandura, A. (2004). Health Promotion by Social Cognitive Means. *Health Education & Behavior*, *31*(2), 143–164.

Bean, J. F., Vora, A., & Frontera, W. R. (2004). Benefits of exercise for community-dwelling older adults. *Archives of Physical Medicine and Rehabilitation, 85,* 31–42.

Beard, J. R., Officer, A., de Carvalho, I. A., Sadana, R., Pot, A. M., Michel, J.-P., Lloyd-Sherlock, P., Epping-Jordan, J. E., Peeters, G. M. E. E. (Geeske), Mahanani, W. R., Thiyagarajan, J. A., & Chatterji, S. (2016). The World report on ageing and health: A policy framework for healthy ageing. *Lancet (London, England), 387*(10033), 2145–2154.

Beauchamp, M. R., Hulteen, R. M., Ruissen, G. R., Liu, Y., Rhodes, R. E., Wierts, C. M., Waldhauser, K. J., Harden, S. H., & Puterman, E. (2021). Online-Delivered Group and Personal Exercise Programs to Support Low Active Older Adults' Mental Health During the COVID-19 Pandemic: Randomized Controlled Trial. *Journal of Medical Internet Research*, *23*(7), e30709.

Beaudart, C., Zaaria, M., Pasleau, F., Reginster, J.-Y., & Bruyère, O. (2017). Health Outcomes of Sarcopenia: A Systematic Review and Meta-Analysis. *PLoS ONE*, *12*(1).

Belsky, D. W., Caspi, A., Houts, R., Cohen, H. J., Corcoran, D. L., Danese, A., Harrington, H., Israel, S., Levine, M. E., Schaefer, J. D., Sugden, K., Williams, B., Yashin, A. I., Poulton, R., & Moffitt, T. E. (2015). Quantification of biological aging in young adults. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(30), E4104–E4110.

Bennie, J. A., De Cocker, K., Teychenne, M. J., Brown, W. J., & Biddle, S. J. H. (2019). The epidemiology of aerobic physical activity and muscle-strengthening activity guideline adherence among 383,928 U.S. adults. *International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 34.

Bennie, J. A., Pedisic, Z., Uffelen, J. G. Z. van, Charity, M. J., Harvey, J. T., Banting, L. K., Vergeer, I., Biddle, S. J. H., & Eime, R. M. (2016). Pumping Iron in Australia: Prevalence, Trends and Sociodemographic Correlates of Muscle Strengthening Activity Participation from a National Sample of 195,926 Adults. *PLOS ONE*, *11*(4), e0153225.

Bethancourt, H. J., Rosenberg, D. E., Beatty, T., & Arterburn, D. E. (2014). Barriers to and Facilitators of Physical Activity Program Use Among Older Adults. *Clinical Medicine & Research*, *12*(1–2), 10–20.

Bodenheimer, T. S., & Berry-Millett, R. (2009). Care management of patients with complex health care needs. *The Synthesis Project. Research Synthesis Report*, *19*, 52372.

Bohannon, R. W. (1995). Sit-to-Stand Test for Measuring Performance of Lower Extremity Muscles. *Perceptual and Motor Skills*, *80*(1), 163–166.

Bohannon, R. W. (2015). Daily sit-to-stands performed by adults: A systematic review. *Journal of Physical Therapy Science*, *27*(3), 939–942.

Borde, R., Hortobágyi, T., & Granacher, U. (2015). Dose–Response Relationships of Resistance Training in Healthy Old Adults: A Systematic Review and Meta-Analysis. *Sports Medicine (Auckland, N.z.)*, *45*(12), 1693–1720.

Bouchard, D. R., Olthuis, J. V., Bouffard-Levasseur, V., Shannon, C., McDonald, T., & Sénéchal, M. (2021). Peer-led exercise program for ageing adults to improve physical functions—A randomized trial. *European Review of Aging and Physical Activity*, *18*(1), 2.

Bowden Davies, K. A., Pickles, S., Sprung, V. S., Kemp, G. J., Alam, U., Moore, D. R., Tahrani, A. A., & Cuthbertson, D. J. (2019). Reduced physical activity in young and older adults: Metabolic and musculoskeletal implications. *Therapeutic Advances in Endocrinology and Metabolism*, *10*, 2042018819888824.

Boyne, P., Welge, J., Kissela, B., & Dunning, K. (2017). Factors Influencing the Efficacy of Aerobic Exercise for Improving Fitness and Walking Capacity After Stroke: A Meta-Analysis With Meta-Regression. *Archives of Physical Medicine and Rehabilitation*, *98*(3), 581–595.

Bryant, M. S., Rintala, D. H., Hou, J.-G., & Protas, E. J. (2015). Relationship of Falls and Fear of Falling to Activity Limitations and Physical Inactivity in Parkinson's Disease. *Journal of Aging and Physical Activity*, *23*(2), 187–193.

Buchner, D. M., Rillamas-Sun, E., Di, C., LaMonte, M. J., Marshall, S. W., Hunt, J., Zhang, Y., Rosenberg, D. E., Lee, I.-M., Evenson, K. R., Herring, A. H., Lewis, C. E., Stefanick, M. L., & LaCroix, A. Z. (2017). Accelerometer-Measured Moderate to Vigorous Physical Activity and Incidence Rates of Falls in Older Women. *Journal of the American Geriatrics Society*, *65*(11), 2480–2487.

Buford, T. W., Anton, S. D., Clark, D. J., Higgins, T. J., & Cooke, M. B. (2014). Optimizing the Benefits of Exercise on Physical Function in Older Adults. *PM & R : The Journal of Injury, Function, and Rehabilitation*, *6*(6), 528–543.

Burton, E., Farrier, K., Hill, K. D., Codde, J., Airey, P., & Hill, A.-M. (2018). Effectiveness of peers in delivering programs or motivating older people to increase their participation in physical activity: Systematic review and meta-analysis. *Journal of Sports Sciences*, *36*(6), 666–678.

Cadore, E. L., Rodríguez-Mañas, L., Sinclair, A., & Izquierdo, M. (2013). Effects of Different Exercise Interventions on Risk of Falls, Gait Ability, and Balance in Physically Frail Older Adults: A Systematic Review. *Rejuvenation Research*, *16*(2), 105–114.

Cameron, K. A. (2019). Chronic Conditions, from A to Z: Life expectancy is lower in America than in other developed nations, mainly due to the toll of chronic conditions, many of which are preventable. *Generations*, 8–12.

Canada. (2016, October 3). *Government of Canada—Action for Seniors report*. Retrieved on April 26, 2022 from: https://www.canada.ca/en/employment-social-development/programs/seniors-action-report.html

Canadian Society for Exercise Physiology. (2017). CSEP Get Active Questionnaire. *Canadian Society for Exercise Physiology (CSEP)*. Retrieved on April 26, 2022 from: https://csep.ca/2021/01/20/pre-screening-for-physical-activity/

Canadian Society for Exercise Physiology. (2019). *CSEP Physical Activity Training for Health® (CSEP-PATH®) Resource Manual* (2nd ed.). Canadian Society for Exercise Physiology. Retrieved on April 26, 2022 from: https://store.csep.ca/products/csep-path_resource_manual_second_edition_english

Cano Porras, D., Sharon, H., Inzelberg, R., Ziv-Ner, Y., Zeilig, G., & Plotnik, M. (2019). Advanced virtual reality-based rehabilitation of balance and gait in clinical practice. *Therapeutic Advances in Chronic Disease*, *10*, 2040622319868379. https://doi.org/10.1177/2040622319868379

Capaldi, C. A., Liu, L., Ooi, L. L., & Roberts, K. C. (2022, February 16). Self-rated mental health, community belonging, life satisfaction and perceived change in mental health among adults during the second and third waves of the COVID-19 pandemic in Canada. Retrieved on April 26, 2022 from: https://www.canada.ca/en/public-health/services/reports-publications/health-promotion-chronic-disease-prevention-canada-research-policy-practice/vol-42-no-5-2022/self-rated-mental-health-community-belonging-life-satisfaction-perceived-change-mental-health-adults-COVID-19-pandemic-canada.html

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126–131.

Chao, Y.-Y., Scherer, Y. K., & Montgomery, C. A. (2015). Effects of Using Nintendo Wii™ Exergames in Older Adults: A Review of the Literature. *Journal of Aging and Health*, *27*(3), 379–402.

Chemtob, K., Caron, J. G., Fortier, M. S., Latimer-Cheung, A. E., Zelaya, W., & Sweet, S. N. (2018). Exploring the peer mentorship experiences of adults with spinal cord injury. *Rehabilitation Psychology*, *63*(4), 542–552.

Chen, Y., Zhang, Y., Guo, Z., Bao, D., & Zhou, J. (2021). Comparison between the effects of exergame intervention and traditional physical training on improving balance and fall prevention in healthy older adults: A systematic review and meta-analysis. *Journal of NeuroEngineering and Rehabilitation*, *18*(1), 164.

Choi, S. D., Guo, L., Kang, D., & Xiong, S. (2017). Exergame technology and interactive interventions for elderly fall prevention: A systematic literature review. *Applied Ergonomics*, *65*, 570–581.

Cohen-Mansfield, J., Muff, A., Meschiany, G., & Lev-Ari, S. (2021). Adequacy of Web-Based Activities as a Substitute for In-Person Activities for Older Persons During the COVID-19 Pandemic: Survey Study. *Journal of Medical Internet Research*, *23*(1), e25848.

Collin, C., Wade, D. T., Davies, S., & Horne, V. (1988). The Barthel ADL Index: A reliability study. *International Disability Studies*, *10*(2), 61–63.

Copeland, J. L., Good, J., & Dogra, S. (2019). Strength training is associated with better functional fitness and perceived healthy aging among physically active older adults: A cross-sectional analysis of the Canadian Longitudinal Study on Aging. *Aging Clinical and Experimental Research*, *31*(9), 1257–1263.

Cotten, S. R., Anderson, W. A., & McCullough, B. M. (2013). Impact of Internet Use on Loneliness and Contact with Others Among Older Adults: Cross-Sectional Analysis. *Journal of Medical Internet Research*, *15*(2), e39.

Cresci, M. K., Yarandi, H. N., & Morrell, R. W. (2010). Pro-Nets Versus No-Nets: Differences in Urban Older Adults' Predilections for Internet Use. *Educational Gerontology*, *36*(6), 500–520.

Cunningham, C., Sullivan, R. O., Caserotti, P., & Tully, M. A. (2020). Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scandinavian Journal of Medicine & Science in Sports*, *30*(5), 816–827.

de Labra, C., Guimaraes-Pinheiro, C., Maseda, A., Lorenzo, T., & Millán-Calenti, J. C. (2015). Effects of physical exercise interventions in frail older adults: A systematic review of randomized controlled trials. *BMC Geriatrics, 15*.

Deandrea, S., Lucenteforte, E., Bravi, F., Foschi, R., La Vecchia, C., & Negri, E. (2010). Risk Factors for Falls in Community-dwelling Older People: A Systematic Review and Meta-analysis. *Epidemiology*, *21*(5), 658–668.

Delbaere, K., Valenzuela, T., Lord, S. R., Clemson, L., Zijlstra, G. A. R., Close, J. C. T., Lung, T., Woodbury, A., Chow, J., McInerney, G., Miles, L., Toson, B., Briggs, N., & van Schooten, K. S. (2021). E-health StandingTall balance exercise for fall prevention in older people: Results of a two year randomised controlled trial. *The BMJ*, *373*, n740.

Dorgo, S., King, G. A., Bader, J. O., & Limon, J. S. (2013). Outcomes of a Peer Mentor Implemented Fitness Program in Older Adults: A Quasi-Randomized Controlled Trial. *International Journal of Nursing Studies*, *50*(9), 1156–1165.

dos Santos, R. B., Lago, G. N., Jencius, M. C., Barbosa, B. A., Lima, C. A., Paschoal, S. M., Hill, K. D., Leme, L. E. G., & Perracini, M. R. (2021). Older adults' views on barriers and facilitators to participate in a multifactorial falls prevention program: Results from Prevquedas Brasil. *Archives of Gerontology and Geriatrics*, *92*, 104287.

Edemekong, P. F., Bomgaars, D. L., Sukumaran, S., & Levy, S. B. (2021). Activities of Daily Living. In *StatPearls*. StatPearls Publishing. Retrieved on April 26, 2022 from: http://www.ncbi.nlm.nih.gov/books/NBK470404/

El-Khoury, F., Cassou, B., Charles, M.-A., & Dargent-Molina, P. (2013). The effect of fall prevention exercise programmes on fall induced injuries in community dwelling older adults: Systematic review and meta-analysis of randomised controlled trials. *The BMJ*, *347*, f6234.

Fleg, J. L., Morrell, C. H., Bos, A. G., Brant, L. J., Talbot, L. A., Wright, J. G., & Lakatta, E. G. (2005). Accelerated Longitudinal Decline of Aerobic Capacity in Healthy Older Adults. *Circulation*, *112*(5), 674–682.

Franco, O. H. (2005). Effects of Physical Activity on Life Expectancy With Cardiovascular Disease. *Archives of Internal Medicine*, *165*(20), 2355.

Friedman, B., Jiang, H. J., & Elixhauser, A. (2008). Costly hospital readmissions and complex chronic illness. *Inquiry: A Journal of Medical Care Organization, Provision and Financing*, *45*(4), 408–421.

Friedmann, P. D., Jin, L., Karrison, T. G., Hayley, D. C., Mulliken, R., Walter, J., & Chin, M. H. (2001). Early revisit, hospitalization, or death among older persons discharged from the ED. *The American Journal of Emergency Medicine*, *19*(2), 125–129.

Gao, Z., Lee, J. E., McDonough, D. J., & Albers, C. (2020). Virtual Reality Exercise as a Coping Strategy for Health and Wellness Promotion in Older Adults during the COVID-19 Pandemic. *Journal of Clinical Medicine*, *9*(6), 1986.

Gibbard, R. (July 2018). *Meeting the Care Needs of Canada's Aging Population*. Retrieved April 26, 2022 from: https://www.cma.ca/meeting-care-needs-canadas-aging-population

Gillespie, L. D., Robertson, M. C., Gillespie, W. J., Sherrington, C., Gates, S., Clemson, L., & Lamb, S. E. (2012). Interventions for preventing falls in older people living in the community. *The Cochrane Database of Systematic Reviews*, *2012*(9), CD007146.

Giné-Garriga, M., Roqué-Fíguls, M., Coll-Planas, L., Sitjà-Rabert, M., & Salvà, A. (2014). Physical Exercise Interventions for Improving Performance-Based Measures of Physical Function in Community-Dwelling, Frail Older Adults: A Systematic Review and Meta-Analysis. *Archives of Physical Medicine and Rehabilitation*, *95*(4), 753-769.e3.

Government of Canada. (2008, July 1). *Impacts of the aging of the Canadian population on housing and communities*. Retrieved April 26, 2022 from: https://publications.gc.ca/site/eng/9.564228/publication.html

Government of Canada. (2021a, June 24). *Internet use and COVID-19: How the pandemic increased the amount of time Canadians spend online*. Retrieved April 26, 2022 from: https://www150.statcan.gc.ca/n1/pub/45-28-0001/2021001/article/00027-eng.htm

Government of Canada, S. C. (2019a, July 10). *Evolving Internet Use Among Canadian Seniors*. Retrieved April 26, 2022 from: https://www150.statcan.gc.ca/n1/pub/11f0019m/11f0019m2019015-eng.htm

Government of Canada, S. C. (2019b, August 14). *Section 2 – Results at the Canada level, 2018 to 2068*. Retrieved April 26, 2022 from: https://www150.statcan.gc.ca/n1/pub/91-520-x/2019001/sect02-eng.htm

Government of Canada, S. C. (2021b, September 1). *The Daily — Canadian Health Measures Survey: Activity monitor data, 2018-2019*. Retrieved April 26, 2022 from: https://www150.statcan.gc.ca/n1/daily-quotidien/210901/dq210901c-eng.htm

Granacher, U. (2012). Effects of balance and resistance training in children, adolescents, and seniors. *Sportwissenschaft*, *42*(1), 17–29.

Grant, P., Dall, P., & Kerr, A. (2011). Daily and hourly frequency of the sit to stand movement in older adults: A comparison of day hospital, rehabilitation ward and community living groups. *Aging Clinical and Experimental Research*, *23*, 437–444.

Guralnik, J. M., Ferrucci, L., Simonsick, E. M., Salive, M. E., & Wallace, R. B. (1995, March 2). *Lower-Extremity Function in Persons over the Age of 70 Years as a Predictor of Subsequent Disability.* Massachusetts Medical Society.

Hauer, K., Lamb, S. E., Jorstad, E. C., Todd, C., Becker, C. (2006). Systematic review of definitions and methods of measuring falls in randomised controlled fall prevention trials. *Age and Ageing*, *35*(1), 5–10.

Herold, F., Törpel, A., Schega, L., & Müller, N. G. (2019). Functional and/or structural brain changes in response to resistance exercises and resistance training lead to cognitive improvements – a systematic review. *European Review of Aging and Physical Activity*, *16*(1), 1–33.

Hoffman, G. J., Hays, R. D., Shapiro, M. F., Wallace, S. P., & Ettner, S. L. (2017). The Costs of Fall-Related Injuries among Older Adults: Annual Per-Faller, Service Component, and Patient Out-of-Pocket Costs. *Health Services Research*, *52*(5), 1794–1816.

Hong, J., Kong, H.-J., & Yoon, H.-J. (2018). Web-Based Telepresence Exercise Program for Community-Dwelling Elderly Women With a High Risk of Falling: Randomized Controlled Trial. *JMIR MHealth and UHealth*, *6*(5), e132.

Irvine, A. B., Gelatt, V. A., Seeley, J. R., Macfarlane, P., & Gau, J. M. (2013). Web-based Intervention to Promote Physical Activity by Sedentary Older Adults: Randomized Controlled Trial. *Journal of Medical Internet Research*, *15*(2), e2158.

Izutsu, K., Arima, K., Abe, Y., Okabe, T., Tomita, Y., Mizukami, S., Kanagae, M., Nishimura, T., & Aoyagi, K. (2017). Exercise intervention implemented by trained volunteers improves health-related quality of life among Japanese community-dwelling older females: An intervention study. *Journal of Physical Therapy Science*, *29*(12), 2126–2132.

Jette, A. M., Davies, A. R., Cleary, P. D., Calkins, D. R., Rubenstein, L. V., Fink, A., Kosecoff, J., Young, R. T., Brook, R. H., & Delbanco, T. L. (1986). The functional status questionnaire: Reliability and validity when used in primary care. *Journal of General Internal Medicine*, *1*(3), 143–149.

Jin, B., Lee, J., & Baumgartner, L. M. (2019). Perceptions of peer-led learning among older adults in a community-based aquatic exercise program. *Educational Gerontology*, *45*(4), 297–308.

Katz, S. (1983). Assessing self-maintenance: Activities of daily living, mobility, and instrumental activities of daily living. *Journal of the American Geriatrics Society*, *31*(12), 721–727.

Kiami, S. R., Sky, R., & Goodgold, S. (2019). Facilitators and barriers to enrolling in falls prevention programming among community dwelling older adults. *Archives of Gerontology and Geriatrics, 82*, 106–113.

Kirkwood, T. B. L., & Austad, S. N. (2000). Why do we age? *Nature*, *408*(6809), 233–238.

Kovacevic, A., Fenesi, B., Paolucci, E., & Heisz, J. J. (2019). The effects of aerobic exercise intensity on memory in older adults. *Applied Physiology, Nutrition, and Metabolism*.

Kwok, B. C., Pua, Y. H., Mamun, K., & Wong, W. P. (2013). The minimal clinically important difference of six-minute walk in Asian older adults. *BMC Geriatrics*, *13*(1), 23.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4*.

LaMonica, H. M., Davenport, T. A., Roberts, A. E., & Hickie, I. B. (2021). Understanding Technology Preferences and Requirements for Health Information Technologies Designed to Improve and Maintain the Mental Health and Well-Being of Older Adults: Participatory Design Study. *JMIR Aging*, *4*(1), e21461.

Lamoureux, E. L., Sparrow, W. A., Murphy, A., & Newton, R. U. (2002). The Relationship Between Lower Body Strength and Obstructed Gait in Community-Dwelling Older Adults. *Journal of the American Geriatrics Society*, *50*(3), 468–473.

Latham, N. K., Mehta, V., Nguyen, A. M., Jette, A. M., Olarsch, S., Papanicolaou, D., & Chandler, J. (2008). Performance-Based or Self-Report Measures of Physical

Function: Which Should Be Used in Clinical Trials of Hip Fracture Patients? *Archives of Physical Medicine and Rehabilitation*, *89*(11), 2146–2155.

Lee, J. W., Kim, S. B., & Kim, S. W. (2018). Effects of elastic band exercises on physical ability and muscular topography of elderlyfemales. *Journal of Physical Therapy Science*, *30*(2), 248–251.

Lee, Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., & Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *The Lancet*, *380*(9838), 219–229.

Lepkowsky, C. M., & Arndt, S. (2018). Functional Assessment of Currently Employed Technology Scale (FACETS): Reliability and Validity. *International Journal of Medical Science and Clinical Invention*, *5*(9), 4064–4068.

Li, F., Harmer, P., Voit, J., & Chou, L.-S. (2021). Implementing an Online Virtual Falls Prevention Intervention During a Public Health Pandemic for Older Adults with Mild Cognitive Impairment: A Feasibility Trial. *Clinical Interventions in Aging*, *16*, 973–983.

Lin, Y.-H., Chen, Y.-C., Tseng, Y.-C., Tsai, S., & Tseng, Y.-H. (2020). Physical activity and successful aging among middle-aged and older adults: A systematic review and meta-analysis of cohort studies. *Aging (Albany NY)*, *12*(9), 7704–7716.

Liu, C., & Latham, N. K. (2009). Progressive resistance strength training for improving physical function in older adults. *The Cochrane Database of Systematic Reviews*, *2009*(3).

Lloréns, R., Noé, E., Colomer, C., & Alcañiz, M. (2015). Effectiveness, Usability, and Cost-Benefit of a Virtual Reality–Based Telerehabilitation Program for Balance

Recovery After Stroke: A Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*, *96*(3), 418-425.e2.

López-Otín, C., Blasco, M. A., Partridge, L., Serrano, M., & Kroemer, G. (2013). The Hallmarks of Aging. *Cell*, *153*(6), 1194–1217.

Ludyga, S., Gerber, M., Brand, S., Holsboer-Trachsler, E., & Pühse, U. (2016). Acute effects of moderate aerobic exercise on specific aspects of executive function in different age and fitness groups: A meta-analysis. *Psychophysiology*, *53*(11), 1611–1626.

Marengoni, A., Angleman, S., Melis, R., Mangialasche, F., Karp, A., Garmen, A., Meinow, B., & Fratiglioni, L. (2011). Aging with multimorbidity: A systematic review of the literature. *Ageing Research Reviews*, *10*(4), 430–439.

Merom, D., Pye, V., Macniven, R., van der Ploeg, H., Milat, A., Sherrington, C., Lord, S., & Bauman, A. (2012). Prevalence and correlates of participation in fall prevention exercise/physical activity by older adults. *Preventive Medicine*, *55*(6), 613–617.

Mikkelsen, K., Stojanovska, L., Polenakovic, M., Bosevski, M., & Apostolopoulos, V. (2017). Exercise and mental health. *Maturitas*, *106*, 48–56.

Murtagh, E. M., Murphy, M. H., Murphy, N. M., Woods, C., Nevill, A. M., & Lane, A. (2015). Prevalence and Correlates of Physical Inactivity in Community-Dwelling Older Adults in Ireland. *PLOS ONE*, *10*(2), e0118293.

National Council on Aging. (2021, January 1). *Evidence-Based Falls Prevention Programs for Older Adults*. Retrieved April 26, 2022 from: https://ncoa.org/article/evidence-based-falls-prevention-programs

Page, P. (2010). Standing Strong: Bringing Evidence to Practice for a Community-Based Fall Prevention Exercise Program. *Topics in Geriatric Rehabilitation*, *26*(4), 335–352.

Pang, M. Y. C., Charlesworth, S. A., Lau, R. W. K., & Chung, R. C. K. (2013). Using Aerobic Exercise to Improve Health Outcomes and Quality of Life in Stroke: Evidence-Based Exercise Prescription Recommendations. *Cerebrovascular Diseases*, *35*(1), 7–22.

Paterson, D. H., Jones, G. R., & Rice, C. L. (2007). Ageing and physical activity: Evidence to develop exercise recommendations for older adults. *Canadian Journal of Public Health / Revue Canadienne de Sante'e Publique*, *98*, S69–S108.

Paterson, D. H., & Warburton, D. E. (2010). Physical activity and functional limitations in older adults: A systematic review related to Canada's Physical Activity Guidelines. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 38.

Peterson, M. D., Rhea, M. R., Sen, A., & Gordon, P. M. (2010). Resistance Exercise for Muscular Strength in Older Adults: A Meta-Analysis. *Ageing Research Reviews*, *9*(3), 226–237.

Petigara, T., & Anderson, G. (2009). *Program of All-Inclusive Care for the Elderly*. Retrieved April 26, 2022 from: https://docplayer.net/14871527-Program-of-all-inclusive-care-for-the-elderly.html

Phu, S., Vogrin, S., Al Saedi, A., & Duque, G. (2019). Balance training using virtual reality improves balance and physical performance in older adults at high risk of falls. *Clinical Interventions in Aging*, *14*, 1567–1577.

Pietrzak, E., Cotea, C., & Pullman, S. (2014). Using Commercial Video Games for Falls Prevention in Older Adults: The Way for the Future? *Journal of Geriatric Physical Therapy*, *37*(4), 166–177.

Pressler, A., Knebel, U., Esch, S., Kölbl, D., Esefeld, K., Scherr, J., Haller, B., Schmidt-Trucksäss, A., Krcmar, H., Halle, M., & Leimeister, J. M. (2010). An internet-delivered exercise intervention for workplace health promotion in overweight sedentary employees: A randomized trial. *Preventive Medicine*, *51*(3), 234–239.

Public Health Agency of Canada. (2014). *Seniors' falls in Canada: Second report.* Retrieved April 26, 2022 from: http://epe.lac-bac.gc.ca/100/201/301/weekly_checklist/2014/internet/w14-36-U-E.html/collections/collection_2014/aspc-phac/HP25-1-2014-eng.pdf

R Core Team. (2021). *R: A language and environment for statistical computing*. Retrieved April 26, 2022 from: https://scholar.google.ca/citations?view_op=view_citation&hl=en&user=yvS1QUEAAAAJ&citation_for_view=yvS1QUEAAAAJ:t6usbXjVLHcC

Reiman, M. P., & Manske, R. C. (2011). The assessment of function: How is it measured? A clinical perspective. *The Journal of Manual & Manipulative Therapy*, *19*(2), 91–99.

Rethorst, C. D., Wipfli, B. M., & Landers, D. M. (2009). The Antidepressive Effects of Exercise. *Sports Medicine*, *39*(6), 491–511.

Rikli, R. E., & Jones, C. J. (1999a). Development and Validation of a Functional Fitness Test for Community-Residing Older Adults. *Journal of Aging and Physical Activity*, *7*(2), 129–161.

Rikli, R. E., & Jones, C. J. (1999b). Functional Fitness Normative Scores for Community-Residing Older Adults, Ages 60-94. *Journal of Aging and Physical Activity*, *7*(2), 162–181.

Robertson, L., Hale, B., Waters, D., Hale, L., & Andrew, A. (2014). *Community Peer-Led Exercise Groups: Reasons for Success*. 11.

Robertson, M. C., & Campbell, A. J. (2003). *Otago exercise programme to prevent falls in older adults*. ACC Thinksafe.

Robitaille, Y., Laforest, S., Fournier, M., Gauvin, L., Parisien, M., Corriveau, H., Trickey, F., & Damestoy, N. (2005). Moving Forward in Fall Prevention: An Intervention to Improve Balance Among Older Adults in Real-World Settings. *American Journal of Public Health*, *95*(11), 2049–2056.

Rubenstein, L. Z., & Josephson, K. R. (2006). Falls and Their Prevention in Elderly People: What Does the Evidence Show? *Medical Clinics of North America*, *90*(5), 807–824.

Ruggieri, M., Palmisano, B., Fratocchi, G., Santilli, V., Mollica, R., Berardi, A., & Galeoto, G. (2018). Validated Fall Risk Assessment Tools for Use with Older Adults: A Systematic Review. *Physical & Occupational Therapy In Geriatrics*, *36*(4), 331–353.

Russell, T., Hoffmann, T., Nelson, M., Thompson, L., Vincent, A., Vincent, A., Russell, T. G., Tammy, P., Hoffmann, C., Nelson, P. M., Thompson, B. L., & Vincent, B. (hons) A. (2013). *Internet-based physical assessment of people with Parkinson disease is accurate and reliable: A pilot study*.

Ryan, R. M., & Deci, E. L. (Eds.). (2017). *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. Guilford Press.

Sanchez-Villagomez, P., Zurlini, C., Wimmer, M., Roberts, L., Trieu, B., McGrath, B., Wiesel, R., Ologhobo, T., Goldsmith, S., & Robbins, L. (2021). Shift to Virtual Self-Management Programs During COVID-19: Ensuring Access and Efficacy for Older Adults. *Frontiers in Public Health*, *9*, 663875.

Savard, J., Labossière, S., Cardinal, D., Pinet, B., & Borris, C. (2018). Évaluation de Marche vers le futur, un programme novateur de prévention des chutes offert par videoconference. *Canadian Journal on Aging / La Revue Canadienne Du Vieillissement*, *37*(4), 363–376.

Schepens, S., Goldberg, A., & Wallace, M. (2010). The short version of the Activities-specific Balance Confidence (ABC) scale: Its validity, reliability, and relationship to balance impairment and falls in older adults. *Archives of Gerontology and Geriatrics*, *51*(1), 9–12.

Schumacher, S., & Kent, N. (2020, April 2). 8 charts on internet use around the world as countries grapple with COVID-19. *Pew Research Center*. Retrieved April 26, 2022 from: https://www.pewresearch.org/fact-tank/2020/04/02/8-charts-on-internet-use-around-the-world-as-countries-grapple-with-COVID-19/

Schwartz, H., Har-Nir, I., Wenhoda, T., & Halperin, I. (2021). Staying physically active during the COVID-19 quarantine: Exploring the feasibility of live, online, group training sessions among older adults. *Translational Behavioral Medicine*, *11*(2), 314–322.

Schwenk, M., Lauenroth, A., Stock, C., Moreno, R. R., Oster, P., McHugh, G., Todd, C., & Hauer, K. (2012). Definitions and methods of measuring and reporting on injurious falls in randomised controlled fall prevention trials: A systematic review. *BMC Medical Research Methodology*, *12*, 50.

Shephard, R. J. (2009). Maximal oxygen intake and independence in old age. *British Journal of Sports Medicine*, *43*(5), 342.

Sherrington, C., Fairhall, N., Wallbank, G., & Tiedemann, A. (2019, January 31). *Exercise for preventing falls in older people living in the community*.

Sherrington, Michaleff, Z. A., Fairhall, N., Paul, S. S., Tiedemann, A., Whitney, J., Cumming, R. G., Herbert, R. D., Close, J. C. T., & Lord, S. R. (2017). Exercise to prevent falls in older adults: An updated systematic review and meta-analysis. *British Journal of Sports Medicine*, *51*(24), 1750–1758.

Sibley, K. M., Thomas, S. M., Veroniki, A. A., Rodrigues, M., Hamid, J. S., Lachance, C. C., Cogo, E., Khan, P. A., Riva, J. J., Thavorn, K., MacDonald, H., Holroyd-Leduc, J., Feldman, F., Kerr, G. D., Jaglal, S. B., Straus, S. E., & Tricco, A. C. (2021). Comparative effectiveness of exercise interventions for preventing falls in older adults: A secondary analysis of a systematic review with network meta-analysis. *Experimental Gerontology*, *143*, 111151.

Sinclair, J., Hingston, P., & Masek, M. (2007). Considerations for the design of exergames. *Proceedings of the 5th International Conference on Computer Graphics and Interactive Techniques in Australia and Southeast Asia*, 289–295.

Soares, W. J. S., Lopes, A. D., Nogueira, E., Candido, V., Moraes, S. A. de, & Perracini, M. R. (2019). Physical Activity Level and Risk of Falling in Community-Dwelling Older Adults: Systematic Review and Meta-Analysis. *Journal of Aging and Physical Activity*, *27*(1), 34–43.

Sobestiansky, S., Michaelsson, K., & Cederholm, T. (2019). Sarcopenia prevalence and associations with mortality and hospitalisation by various sarcopenia definitions in 85–89 year old community-dwelling men: A report from the ULSAM study. *BMC Geriatrics*, *19*(1), 318.

Sousa, L. M. M., Marques-Vieira, C. M. A., Caldevilla, M. N. G. N. de, Henriques, C. M. A. D., Severino, S. S. P., & Caldeira, S. M. A. (2017). Risk for falls among community-dwelling older people: Systematic literature review. *Revista Gaúcha de Enfermagem*, *37*.

Stathi, A., Withall, J., Agyapong-Badu, S., Barrett, E., Kritz, M., Wills, D., Thogersen-Ntoumani, C., & Fox, K. R. (2021). Mobilising people as assets for active ageing promotion: A multi-stakeholder perspective on peer volunteering initiatives. *BMC Public Health*, *21*(1), 150.

Statistics Canada. (2022, January 24). *Life expectancy and other elements of the complete life table, three-year estimates, Canada, all provinces except Prince Edward Island*. Retrieved April 26, 2022 from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310011401

Stevens, J., Sleet, D., & Rubenstein, L. (2017). The Influence of Older Adults' Beliefs and Attitudes on Adopting Fall Prevention Behaviors. *American Journal of Lifestyle Medicine*, *12*, 155982761668726.

Stiggelbout, M., Hopman-Rock, M., Tak, E., Lechner, L., & Mechelen, W. van. (2005). Dropout from Exercise Programs for Seniors: A Prospective Cohort Study. *Journal of Aging and Physical Activity*, *13*(4), 409–421.

Stillman, C. M., Cohen, J., Lehman, M. E., & Erickson, K. I. (2016). Mediators of Physical Activity on Neurocognitive Function: A Review at Multiple Levels of Analysis. *Frontiers in Human Neuroscience*, *10*, 626.

Studenski, S., Perera, S., Wallace, D., Chandler, J. M., Duncan, P. W., Rooney, E., Fox, M., & Guralnik, J. M. (2003). Physical Performance Measures in the Clinical Setting. *Journal of the American Geriatrics Society*, *51*(3), 314–322.

Sun, F., Norman, I. J., & While, A. E. (2013). Physical activity in older people: A systematic review. *BMC Public Health*, *13*, 449.

Symens Smith, A., & Trevelyan, E. (2019, October 22). *In Some States, More Than Half of Older Residents Live In Rural Areas*. Census.Gov. Retrieved April 26, 2022 from: https://www.census.gov/library/stories/2019/10/older-population-in-rural-america.html

Tallner, A., Streber, R., Hentschke, C., Morgott, M., Geidl, W., Mäurer, M., & Pfeifer, K. (2016). Internet-Supported Physical Exercise Training for Persons with Multiple Sclerosis—A Randomised, Controlled Study. *International Journal of Molecular Sciences*, *17*(10).

Tanhamira, L., Randhawa, G., & Hewson, D. (2021). *Remotely-Delivered Mind-Body Physical Activity Improves Physical Function in Older Adults*.

Thomas, S., Mackintosh, S., & Halbert, J. (2010). Does the 'Otago exercise programme' reduce mortality and falls in older adults?: A systematic review and meta-analysis. *Age and Ageing*, *39*(6), 681–687.

Tomey, K. M., & Sowers, M. R. (2009). Assessment of Physical Functioning: A Conceptual Model Encompassing Environmental Factors and Individual Compensation Strategies. *Physical Therapy*, *89*(7), 705–714.

Touchette, A. J., Oates, A. R., Menec, V. H., & Sibley, K. M. (2021). Design characteristics and inclusion of evidence-based exercise recommendation in fall prevention community exercise programs for older adults in Canada: A national descriptive self-report study. *BMC Geriatrics*, *21*(1), 33.

Tricco, A. C., Thomas, S. M., Veroniki, A. A., Hamid, J. S., Cogo, E., Strifler, L., Khan, P. A., Robson, R., Sibley, K. M., MacDonald, H., Riva, J. J., Thavorn, K., Wilson, C., Holroyd-Leduc, J., Kerr, G. D., Feldman, F., Majumdar, S. R., Jaglal, S. B., Hui, W., & Straus, S. E. (2017). Comparisons of Interventions for Preventing Falls in Older Adults: A Systematic Review and Meta-analysis. *JAMA*, *318*(17), 1687.

Tyler, C. M., McKee, G. B., Alzueta, E., Perrin, P. B., Kingsley, K., Baker, F. C., & Arango-Lasprilla, J. C. (2021). A Study of Older Adults' Mental Health across 33 Countries during the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, *18*(10),

United Nations. (2019). *World Population Ageing 2019: Highlights*. 46. Retrieved April 26, 2022 from: https://www.un.org/development/desa/pd/news/world-population-ageing-2019-0

Valenzuela, T., Okubo, Y., Woodbury, A., Lord, S. R., & Delbaere, K. (2018). Adherence to Technology-Based Exercise Programs in Older Adults: A Systematic Review. *Journal of Geriatric Physical Therapy*, *41*(1), 49–61.

Vespa, J. (2019, October 8). *The U.S. Joins Other Countries With Large Aging Populations*. Census.Gov. Retrieved April 26, 2022 from: https://www.census.gov/library
/stories/2018/03/graying-america.html

von Bonsdorff, M. B., & Rantanen, T. (2011). Benefits of formal voluntary work among older people. A review. *Aging Clinical and Experimental Research*, *23*(3), 162–169.

Vroman, K. G., Arthanat, S., & Lysack, C. (2015). “Who over 65 is online?” Older adults’ dispositions toward information communication technology. *Computers in Human Behavior*, *43,* 156–166.

Warburton, D. E. R., Gledhill, N., & Quinney, A. (2001). The effects of changes in musculoskeletal fitness on health. *Canadian Journal of Applied Physiology*, *26*(2), 161–216.

Washburn, L. T., Cornell, C. E., Phillips, M., Felix, H., & Traywick, L. (2014). Strength Training in Community Settings: Impact of Lay Leaders on Program Access and Sustainability for Rural Older Adults. *Journal of Physical Activity and Health*, *11*(7), 1408–1414.

Waters, D. L., Hale, L. A., Robertson, L., Hale, B. A., & Herbison, P. (2011). Evaluation of a Peer-Led Falls Prevention Program for Older Adults. *Archives of Physical Medicine and Rehabilitation*, *92*(10), 1581–1586.

Watson, K. B. (2016). Physical Inactivity Among Adults Aged 50 Years and Older—United States, 2014. *MMWR. Morbidity and Mortality Weekly Report*, *65*.

Webster, J., Courtney, M., O’Rourke, P., Marsh, N., Gale, C., Abbott, B., McRae, P., & Mason, K. (2008). Should elderly patients be screened for their ‘falls risk’? Validity of the STRATIFY falls screening tool and predictors of falls in a large acute hospital. *Age and Ageing*, *37*(6), 702–706.

Winser, S. J., Chan, H. T. F., Ho, L., Chung, L. S., Ching, L. T., Felix, T. K. L., & Kannan, P. (2020). Dosage for cost-effective exercise-based falls prevention programs for older people: A systematic review of economic evaluations. *Annals of Physical and Rehabilitation Medicine, 63*(1), 69–80.

Withall, J., Thompson, J. L., Fox, K. R., Davis, M., Gray, S., de Koning, J., Lloyd, L., Parkhurst, G., & Stathi, A. (2018). Participant and Public Involvement in Refining a Peer-Volunteering Active Aging Intervention: Project ACE (Active, Connected, Engaged). *The Gerontologist*, *58*(2), 362–375.

World Health Organization (Ed.). (2009). *Global health risks: Mortality and burden of disease attributable to selected major risks*. World Health Organization.

World Health Organization. (2014, November 6). *"Ageing well" must be a global priority*. Retrieved April 26, 2022 from: https://www.who.int/news/item/06-11-2014--ageing-well-must-be-a-global-priority

World Health Organization. (2018, February 5). *Ageing and health*. Retrieved April 26, 2022 from: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

World Health Organization. (2020a). *Decade of healthy ageing: Baseline report*. Retrieved April 26, 2022 from: https://www.who.int/publications-detail-redirect/9789240017900

World Health Organization. (2020b). *WHO guidelines on physical activity and sedentary behaviour*. Retrieved April 26, 2022 from: https://www.who.int/publications-detail-redirect/9789240015128

World Health Organization. (2021). *Falls*. Retrieved April 26, 2022 from: https://www.who.int/news-room/fact-sheets/detail/falls

Wurzer, B., Waters, D. L., Hale, L. A., & Leon de la Barra, S. (2014). Long-Term Participation in Peer-Led Fall Prevention Classes Predicts Lower Fall Incidence. *Archives of Physical Medicine and Rehabilitation*, *95*(6), 1060–1066.

Yardley, L., Beyer, N., Hauer, K., Kempen, G., Piot-Ziegler, C., & Todd, C. (2005). Development and initial validation of the Falls Efficacy Scale-International (FES-I). *Age and Ageing*, *34*(6), 614–619.

Zanini, A., Crisafulli, E., D'Andria, M., Gregorini, C., Cherubino, F., Zampogna, E., Azzola, A., Spanevello, A., & Chetta, A. (2018). Minimal clinically important difference in 30 second sit-to-stand test after pulmonary rehabilitation in patients with COPD. *European Respiratory Journal*, *52*(suppl 62).

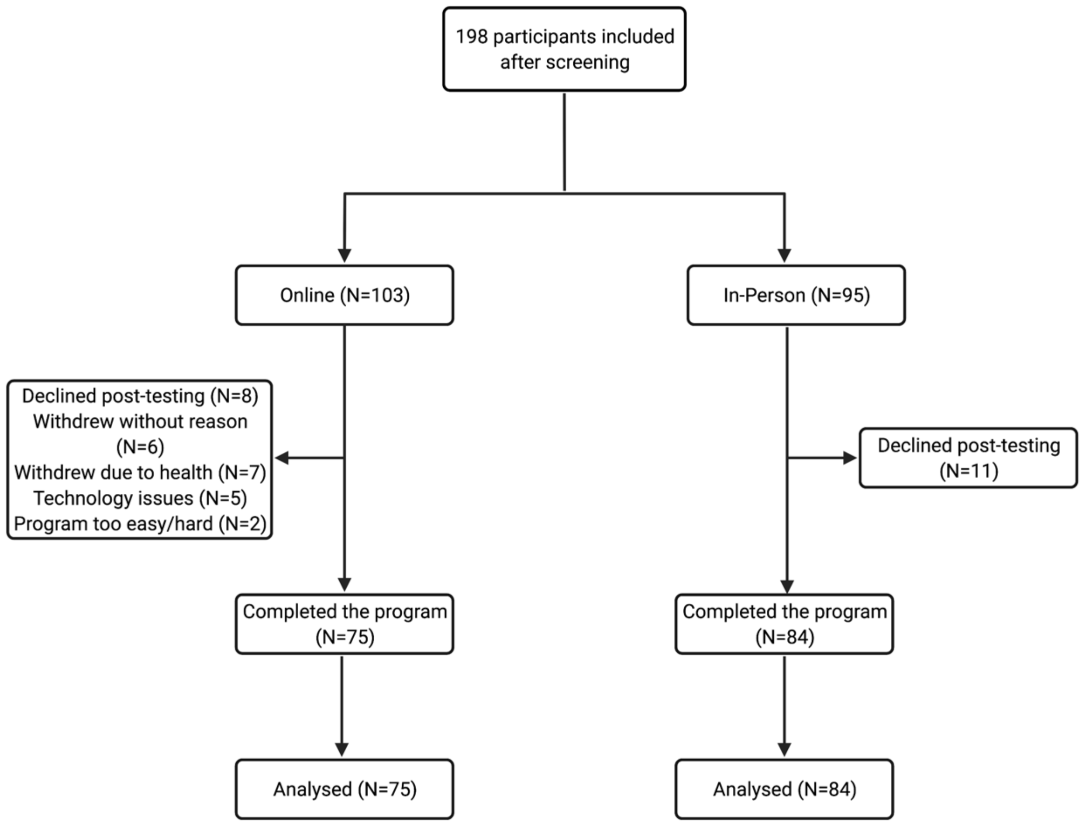

Figure 1: Flow Chart of Enrollment

Table 1: Participant Characteristics

	Online (N= 75)	In-Person (N= 84)
Age	66.3 ± 7.1	67.3 ± 7.2
Sex (Female)	65 (86.6)	71 (84.5)
Marital Status (Married)	47 (73.4)	53 (65.8)
Occupation (Retired)	47 (73.4)	58 (69.8)
Income ($30,000-100,000)	45 (72.5)	56 (66.6)

Data Presented as mean ± SD or N (%)

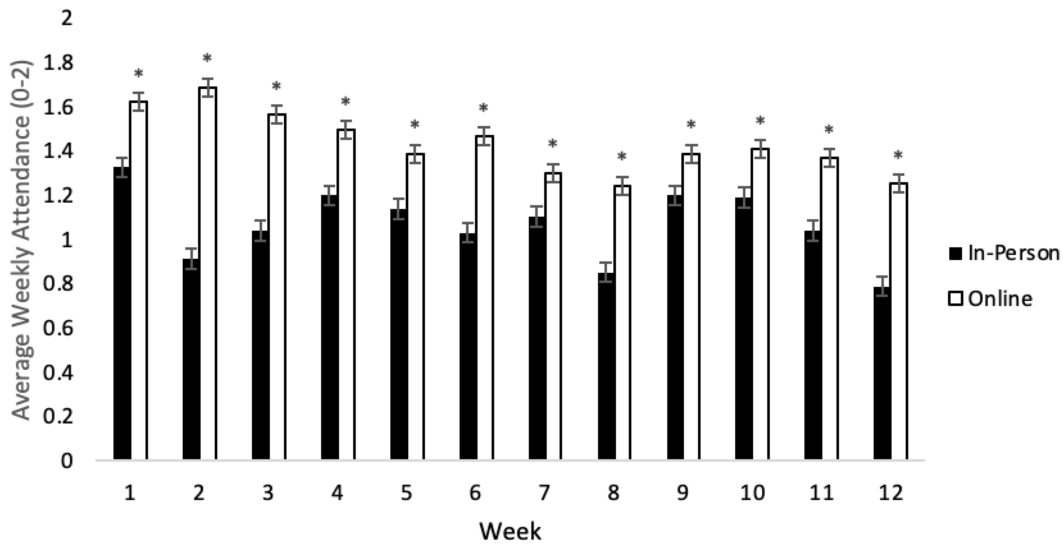

Figure 2: Average (SE) Weekly Attendance for Online and In-Person

*Significant difference between groups

Table 2: Changes in Physical Function Tests

	Online (N=75)			In-Person (N=84)		
	Pre	Post	Effect size	Pre	Post	Effect size
6-min walk test (meters)	-	-	-	468.8± 86.7	525.6± 93.9*	0.89 (0.63-1.15)
2-minute steps test (#steps)	129.3± 27.3	140.8± 25.9*	0.50 (0.25-0.74)	-	-	-
Power (#stands /30 seconds)	14.4± 2.7	17.0± 4.1*	0.79 (0.52-1.04)	14.1± 4.2	17.5± 5.0*	1.05 (0.78-1.32)
†Balance (seconds/45 seconds)	22.7± 13.5	29.4± 14.9*	0.71 (0.28-1.13)	19.7± 11.07	28.7± 15.1*	0.85 (0.54-1.15)

*Significant difference between pre and post testing
†Excluded participants that got 45 seconds at baseline (N=47 for online and N=24 for in person).
Data presented as mean ± SD and the effect size as the Cohen's d value (95% CI)

Table 3: Self-Perceived Benefits

	Online (N=38)		In-Person (N=80)	
	Pre	Post	Pre	Post
Depression Anxiety Stress Scale				
Stress (0-17)	7.1±6.9	7.9±5.4	6.4±6.0	5.0±4.9*
Depression (0-14)	4.6±5.3	5.5±5.3	5.1±6.8	3.1±4.9*
Anxiety (0-10)	3.5±4.6	3.2±3.4	3.6±4.7	3.1±3.5
Short Form Health Survey (0-100 where higher is better)				
Physical functions (0-100)	85.4±12.3	85.0±11.0	78.2±18.6	77.6±21.4
Emotional Problems (0-100)	82.4±30.7	79.8±32.4	79.8±30.2	88.7±23.6*
Pain (0-100)	79.1±17.9	76.6±17.8	77.9±18.6	74.5±20.8
Social Functioning (0-100)	89.9±18.1	85.2±18.7	88.6±16.3	91.8±14.3*
Physical Health (0-100)	80.4±32.8	76.3±37.2	80.1±33.5	85.8±25.4
General Health (0-100)	71.6±17.1	72.0±13.7	69.6±19.4	73.6±16.5*
Emotional Wellbeing (0-100)	81.1±15.9	81.8±12.8	80.5±14.3	83.2±10.6
Energy (0-100)	66.5±17.1	67.5±17.2	63.7±17.9	67.8±16.1*

*Significant difference pre-post
Data presented as mean ± SD

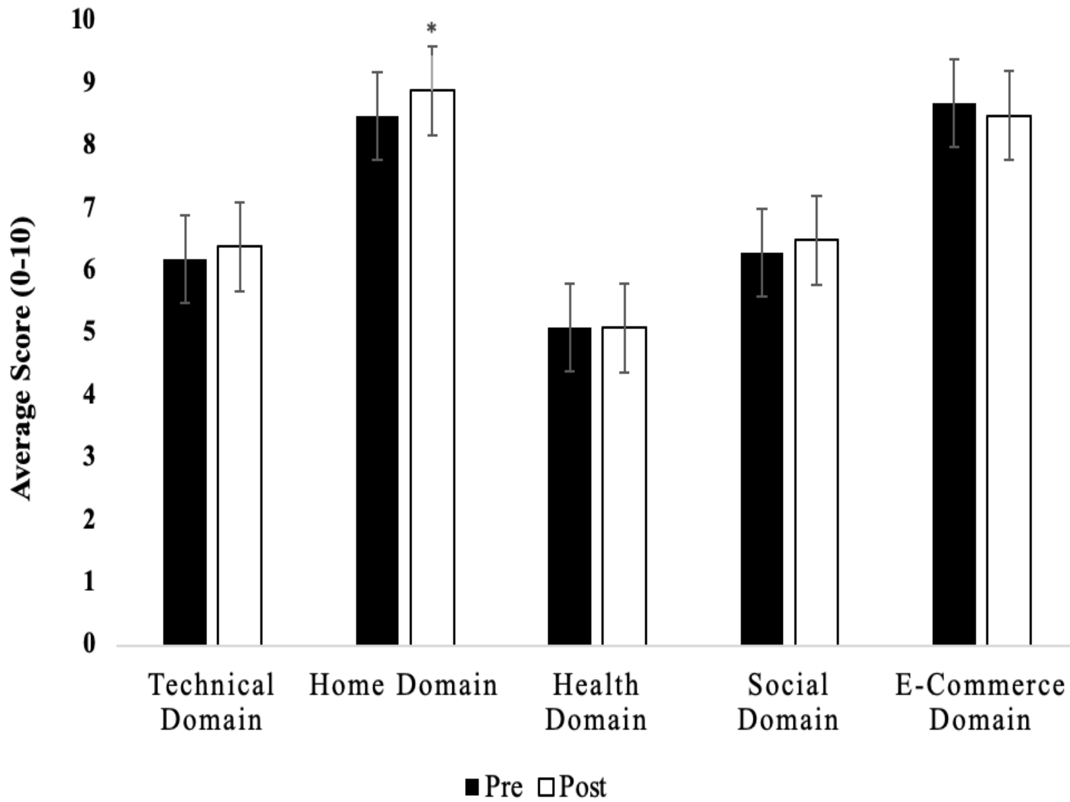

Figure 3: FACETS Scores by Domain for the Online Group

*p=0.05 Difference pre and post testing

Curriculum Vitae

Candidate's full name: Vanessa Pitre

Universities attended (with dates and degrees obtained):
Bachelor of Science in Kinesiology, University of New Brunswick 2020

Conference Presentations:

Zoom Online: An Exercise Program to Reduce Risks of Falls, Atlantic Provinces Exercise and Scientists and Socioculturalists (APES+), 2021

Potential Benefits of Online Delivery of a Fall Prevention Program in Aging Adults, International Society for Physical Activity Congress (ISPAH), 2021

Zoomers on the Go Online: Is Comfort with Technology Associated with more Benefits?, New Brunswick Health Research Foundation Health Research Week 2021, 2021