Combined cognitive and exercise training for community-dwelling adults and older adults: A feasibility study

by

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Author’s Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Statement of Contributions

The qualitative interview methods, analyses, and data results (for phase 1 only of the study) included in this thesis has also been reported as part of Catherine Lee's undergraduate research thesis.

Abstract

Older adults show cognitive improvements after taking part in exercise training or cognitive training. A number of studies suggest that combining these two types of interventions may lead to greater cognitive gains. However, trials that have done so have occurred in controlled experimental settings, so the effectiveness when translated to real-world settings is unclear. This study evaluated the feasibility of combining a cognitive training regimen (shown efficacious in trials) with a community exercise program for adults and older adults at augmented risk for dementia. The study was conducted in two phases. Phase 1 was a single-arm trial of 3-months of cognitive and exercise training (CET). Phase 2 was a quasi-experimental parallel-group trial where program times (Monday/Wednesday or Tuesday/Thursday) were randomized to either 3-month CET or exercise only (ExO) interventions. Community-dwelling adults and older adults eligible for the study and for the YMCA Move for Health exercise program were recruited. The feasibility outcomes were recruitment rate, study retention, adherence to intervention (attendance and completion of exercise diaries), and participant and instructor program acceptance (based on a satisfaction questionnaire). Exploratory outcomes including cognitive function, physical function, exercise-related self-efficacy and perceived well-being were also measured. Eleven participants were recruited to phase 1 of the study and 32 participants (16/group) were recruited to phase 2 of the study. The study met most *a priori* feasibility criteria, with the exception of recruitment rate and phase 2 retention. Recruitment rate was 1.8 participants/week in phase 1 and 3.2 participants/week in phase 2, well short of the 6 participants/week target. The most frequent reason for ineligibility was lack of willingness or ability to participate at designated program times. Retention rate was 91% in phase 1 and 72% in phase 2 (69% for CET and 75% ExO) (criterion for success was ≥ 75%). Adherence (attendance) rate was 79% for phase 1 and 73% for phase 2 (73% for CET and for ExO), respectively (criterion for success was ≥ 70%). Participant satisfaction was 4.5 of 5 in phase 1 and in phase 2 (4.5 for CET and 4.4 for ExO). Instructor satisfaction rating was 4.7 for phase 1 and 4.0 for phase 2 (3.9 for CET and 4.1 for ExO instructors) (criterion was ≥ 4 out of 5). No feasibility outcomes differed between the intervention groups. However, participants that were older, had more chronic health conditions, poorer baseline global cognition, and lower baseline physical activity were more likely to withdraw from the study, and had poorer adherence to study protocols, suggesting a need for additional supports for individuals with these traits. In addition, the lowest satisfaction rating was for the difficulty of cognitive and exercise training; for the cognitive training, many of those with high baseline global cognitive function did not feel sufficiently challenged. Though correlations in this small sample were not significant and likely driven by outliers, trends in this study suggest that having fewer chronic conditions may be associated with better cognitive outcomes and should be investigated in a future trial. The results of this study suggest that a pragmatic trial of CET may

be feasible in a community setting, provided adjustments to recruitment strategies. This could include opening additional program timeslots, as lack of ability or willingness to participate at the set program time was the primary reason for participants not being recruited.

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List of Abbreviations

ADLs	…	Activities of daily living
BDNF	…	Brain-derived neurotrophic factor
CET	…	Cognitive and exercise training
ExO	…	Exercise only
IGF-1	…	Insulin-like growth factor-1
MCI	…	Mild cognitive impairment
RCT(s)	…	Randomized controlled trial(s)

1. Introduction

Due to advances in medicine and technology, human life expectancy has significantly increased in the last 100 years. Consequently, the worldwide population of older adults is growing at an accelerating rate (Wilson et al., 2019). By the year 2029, the entire baby boom cohort (birth years 1946-1965) will be 65 years or older and, thus, 25% or more of adults in most developed countries will be older adults (World Health Organization, 2015). Currently, in Canada, there are approximately 8.9 million baby boomers and 2.7 million older adults, which makes up 25.9% of the total Canadian population (Statistics Canada, 2019).

Cognitive decline is very common with aging (Deary et al., 2009; Harada et al., 2013). Age-associated (i.e. non-pathological) decline in some mental capabilities can begin as early as 30 years old (Park & Reuter-Lorenz, 2009). However, the rate and extent of age-related decline in cognition varies by cognitive domain and across individuals due to demographic, biological, and psychosocial factors (Deary et al., 2009). Executive functions—including selective attention (attending to specific stimuli and inhibiting irrelevant information), divided attention (attending to multiple tasks simultaneously), shifting between tasks or mental sets, and updating and monitoring working memory—are especially susceptible to senescence (van Dam & Aleman, 2004; Deary et al., 2009; Harada et al., 2013). More optimistically, executive functions are often a focus of exercise and cognitive interventions which aim to improve cognition, and have been shown to be sensitive to both exercise and cognitive training (Dahlin et al., 2008; Baker et al., 2010a, 2010b; Best et al., 2015).

While age-associated cognitive decline is common with aging, approximately 10% of people aged 65 years or older experience greater-than-expected (i.e. pathological) cognitive decline, resulting in a diagnosis of mild cognitive impairment (MCI) or dementia (Harada et al., 2013; Alzheimer's Society of Canada, 2016). As of 2016, there are an estimated 564,000 Canadians living with MCI or dementia. Given the growing population of older adults, this number is projected to increase to 937,000 by the year 2031, which will have a significant impact on formal and informal care demands. Combined health care system costs and out-of-pocket caregiver costs are projected to be $16.6 billion by the year 2031(Alzheimer Society of Canada, 2016). Therefore, it is clear that there is a need for reliable, cost-effective, and accessible interventions to prevent the onset and slow the progression of dementia.

If current interventions could delay or prevent the onset and progression of dementia by a modest 1 year, there would be nearly 9.2 million fewer cases of the disease worldwide in 2050 (Brookmeyer et al., 2007). However, there is currently no disease modifying agent or cure for dementia, while pharmacological therapies alleviate symptoms but fail to appreciably modify disease progression (Versijpt, 2014). Therefore, it is essential to identify alternate preventative and therapeutic approaches. The 2018 guidelines for the clinical management of people with MCI, who are at high risk of dementia, supports exercise as one of two effective strategies (the other being cognitive training) to improve cognition (Petersen et al., 2018). Exercise, including both aerobic exercise (Baker et al., 2010a, 2010b) and resistance exercise (Nagamatsu et al., 2012) may improve cognitive function among people with MCI via direct mechanisms (i.e. positive changes in brain structure and function) and/or indirect mechanisms (i.e. reduce the incidence of dementia risk factors such as diabetes and cardiovascular disease) (Nokia et al., 2016; Booth et al., 2000). The clinical guidelines for MCI also supported cognitive training as a potential intervention to improve cognitive function in this population (Kramer et al., 2004; Jean et al., 2010; Petersen et al., 2018). Recommendations for cognitive training were not as strong as for physical exercise primarily due to limited availability of evidenced-based cognitive training interventions.

Preliminary evidence from our ongoing randomized clinical trial (Montero-Odasso et al., 2018b) suggests that combined cognitive and exercise training (CET) may have clinically meaningful benefits to cognition in people at risk for dementia, superior to either alone, which is in line with other recent findings (Zhu et al., 2016; Karssemeijer et al., 2017; Gheysen et al., 2018). To implement these emergent findings, older Canadians at risk for dementia need access to combined exercise and cognitive training programs. Though exercise programs for older adults are available in many Canadian communities, combined exercise and cognitive training programs are not. Access to cognitive training is typically restricted to clinical trials and a few (generally unproven) computer programs or smart phone apps. As far as we are aware, this study is the first to examine the feasibility and acceptability of a CET program for older adults at higher risk for dementia in a community-setting. The results from this study will provide evidence for the feasibility of a future clinical trial, as well as community programming. A secondary objective is to describe changes in cognitive function, physical function, self-efficacy, and well-being in a CET program and in an exercise only (ExO) program. If shown to be feasible, the combined exercise and cognitive training program has the potential for broader investigation and, eventually, wide-scale implementation to benefit the health of older Canadians.

2. Literature Review

2.1 Age-Related Cognitive Changes in Late Life

Cognition refers to the mental process of obtaining knowledge (Arwert et al., 2005) and is a strong predictor of well-being (Wilson et al., 2013), falls (Muir et al., 2012), and mobility (Buchman et al., 2011). In addition, people with low cognitive performance are at higher risk of incident dementia (Wilson et al., 2012), functional dependence (Wang et al., 2002), and mortality (Dewey & Saz, 2001).

Studies assessing global cognitive function have reported significant decline with age in some cognitive domains. For example, one cross-sectional study found a small yet significant decrease in global cognition with an increase in age starting as early at 30 years of age, and that this decrease in performance was greater in those with lower education (12 years or less) (Rossetti et al., 2011). Additionally, community-dwelling healthy older adults have demonstrated cognitive decline at varying rates in longitudinal cohorts (Lyketsos et al., 1999; Brayne et al., 1999; Unger et al., 1999; Park et al. 2003). Studies of the oldest old (i.e. older than 85 years) typically show greater rates of decline in global cognitive function (Brayne et al., 1999; Park et al., 2003).There is some variation in observed rates of decline across studies, which may be explained by study design (Hultsch et al., 1992; Unger et al., 1999; Cooley et al., 2015). For instance, selective attrition in longitudinal studies (when individuals more likely to exhibit cognitive decline drop out from the study at higher rates) can result in an underestimation of cognitive decline in older adults (Hultsch et al., 1992). Furthermore, longitudinal studies often have repeated measures of global cognition which can lead to practice effects. Several studies have reported significant improvements in global cognitive scores among healthy older adults with repeated assessments, likely as a result of practice (Unger et al., 1999; Cooley et al., 2015). It has been suggested, that longer test-retest intervals and utilizing different versions of the test may minimize such effects (Cooley et al., 2015; Krishnan et al., 2017). However, cross-sectional studies are confounded by cohort effects, where people of different age groups often have different education levels and different life experiences (health care, nutrition, major life events), which may exaggerate age-related effects (Sliwinski & Busche, 1999).

In addition to age-related changes in cognition, some older adults experience a larger cognitive decline than anticipated given their age and education and are diagnosed with either MCI or dementia. Both MCI and dementia can be characterized by cognitive decline and/or changes in behaviour from a previous level of functioning (Alzheimer's Disease International, 2015). Those with MCI experience cognitive decline without notable interference in activities of daily living (ADLs) (Gauthier et al., 2006), while those with dementia have sufficiently severe cognitive decline to impact ADLs. MCI is considered a high risk state for dementia (Petersen et al., 1999), and some even consider it an early stage of dementia (Morris et al., 2001).

While some decline with age is universal (Park et al., 2003), the extent and rate of age-related decline in global cognition and incidence of MCI and dementia can vary based on individual characteristics. In addition to age and education, those with chronic diseases or risk factors for chronic diseases are often at an increased risk. For example, people with cardiovascular disease (Newman et al., 2005), metabolic conditions (Cooper et al., 2015), and osteoarthritis (Huang et al., 2015) are all at increased risk of developing MCI and/or dementia. While some risk factors for MCI and dementia are not modifiable, there are other risk factors that can be modified and thus should be targeted by preventative interventions.

2.1.1 Modifiable Risk Factors for Cognitive Decline, MCI, and Dementia

Although cognitive decline is common with aging, the incidence, rate and extent of age-related and pathological decline in cognition varies across people depending on several factors. Some of these factors are not modifiable. For instance, people who possess the E4 allele for the apolipoprotein E gene have an increased risk of MCI and dementia and perform worse on global and domain-specific cognitive measures (Skoog et al., 1998; Liu et al., 2013). As mentioned previously, age-related cognitive decline is more pronounced in late life. So, it is not surprising that the majority of MCI and dementia cases occur in those 75 years or older (Carone et al., 2014; Niu et al., 2017). While age is among the greatest risk factors for dementia and is unmodifiable, it is a less powerful risk factor when other lifestyle elements and comorbidities are taken into account (Livingston et al., 2017).

Various lifestyle factors can also alter an individual’s risk for developing MCI and dementia. Social isolation (Santini et al., 2015), poor sleep (Livingston et al., 2017), sedentary behaviour (Fratiglioni et al., 2004; Kramer et al., 2004), and low levels of Vitamin D (Cao et al., 2016) have all been suggested to increase risk of MCI and dementia. Furthermore, these risk factors can exacerbate other conditions associated with increased dementia risk such as obesity, depression and hypertension (Santini et al., 2015; Livingston et al., 2017). Fortunately, many of these risk factors can be directly mitigated through lifestyle changes such as increased physical activity (Hamer & Chida, 2009; Sofi et al., 2011), dietary modifications (Van Dyk & Sano, 2007; Deary et al., 2009), increased sleep quantity and quality (Livingston et al., 2017), and intellectual stimulation such as social interaction or cognitive activities (Larson, 2010; Borenstein & Mortimer, 2016). Positive lifestyle changes may also decrease an individual’s risk indirectly by encouraging adoption of additional health behaviours (Almeida et al., 2014; Cooper et al., 2015). Therefore, identification and implementation of lifestyle strategies that prevent or reduce the likelihood of cognitive decline and dementia are of particular interest to researchers, clinicians and the public. The lifestyle factors investigated provide opportunities to deliver and take part in cost-effective interventions, such as physical exercise and cognitive training, to improve cognition and/or reduce the impact of age-related and pathological cognitive decline (Deary et al., 2009).

2.2 The Effects of Exercise on Cognition

Some researchers have suggested that there is more evidence to support physical exercise than other lifestyle factors for its role as a protective agent against age-related cognitive decline (Kramer et al., 2004; Hertzog et al., 2008). Cross-sectional studies suggest that the age-related differences in cognition observed between younger and older adults are reduced among higher-fit older adults (Hillman et al., 2002; Renaud et al., 2010). Evidence from clinical trials supports benefits across a number of exercise modalities (Northey et al., 2018).

2.2.1 The Effects of Aerobic Exercise

Participation in aerobic exercise programs has resulted in improvements in measures of global cognition (Bherer et al., 2013) and memory (Chapman et al., 2013) in healthy older adults compared to those who did not exercise. However, conclusions of meta-analyses and systematic reviews are not entirely consistent, with some supporting benefits (Angevaren et al., 2008; Sanders et al., 2019) and others not (Gates et al., 2013; Young et al., 2015), though the most recent and comprehensive reviews have generally supported cognitive benefits from exercise (Zhu et al., 2016; Northey et al., 2018; Wu et al., 2019). One of the most recent and inclusive meta-analyses reported small-to-moderate significant effects of aerobic exercise on cognition (SMD = 0.29; 95% CI 0.17 to 0.41; $p<0.01$), among other exercise interventions (Northey et al., 2018). The contradictory findings across other reviews could be due to restrictive inclusion criteria (i.e. requiring a maximal aerobic fitness test, considering only one exercise mode, or a narrow range of publication years).

In addition to enhancing global cognition, several studies have suggested that aerobic training can also enhance specific domains of cognition, including executive functioning. For example, 33 older adults with MCI completed a six-month aerobic exercise intervention in a randomized clinical trial (Baker et al., 2010a). Results demonstrated significant improvements in several cognitive tasks, including assessments that targeted speed of processing and executive functioning (Baker et al., 2010a). Similar results have also been reported following aerobic training in healthy older adults (Dustman et al., 1984; Hawkins et al., 1992; Barenberg et al., 2011; Predovan et al., 2012), older adults with dementia (Heyn et al., 2004) and older adults with glucose intolerance (Baker et al., 2010b) – a known risk factor for cognitive impairment

(Baquer et al., 2009; Luchsinger, 2010). Furthermore, individual studies and meta-analyses have reported that aerobic training programs may induce greater benefits in executive functions compared to other cognitive domains (Colcombe & Kramer, 2003; Bherer et al., 2013; Northey et al., 2018). Together these findings highlight the global and domain-specific cognitive gains following aerobic training, and also suggest that greater benefits may be demonstrated in measures of executive function.

The optimal dose of aerobic exercise on cognitive function in older adults has not been well-established. Several studies indicate that light and moderate aerobic exercise are sufficient to observe cognitive gains (Deary et al., 2009; Erickson & Kramer, 2009). However, positive effects on cognition have also been observed with high intensity aerobic training (i.e. 75 – 85% of heart rate reserve) (Baker et al., 2010a). Though, in a population of older adults who have age-related and/or pathological comorbidities, light-to-moderate aerobic exercise may be better enjoyed and tolerated (Cassilhas et al., 2007; Deary et al., 2009), and so positive effects elicited by higher intensity aerobic exercise may be less feasible in the long term for older adults. Furthermore, most intervention studies that have shown significant cognitive gains with aerobic exercise sessions lasted between 20 and 60 minutes, 2 – 4 days per week for 3-12 months. It has generally been concluded that 6 months of aerobic training is sufficient to induce improvements in cognitive performance (Erickson & Kramer, 2009).

The type of movements involved in the exercise prescription could also alter the cognitive effects. For example, aerobic exercise that consists of movement sequences and/or coordination (e.g. dancing or water aerobics) has shown to result in greater improvements on task switching compared to inactive control and other forms of physical exercise (i.e. on-land fall prevention training and Tai Chi), possibly as a result of engaging higher order cognitive brain regions during the exercise (Coubard et al., 2011; Predovan et al., 2012). Additional moderators of these aerobic exercise-induced effects include individual characteristics such as sex (Baker et al., 2010a), baseline cognitive function (Heyn et al., 2004; Erickson & Kramer, 2009), and cognitive assessment (Predovan et al., 2012).

In addition to improvements in cognitive assessments, aerobic exercise is associated with improvements in neural and cerebrovascular structure and brain activity. Cardiorespiratory fitness (i.e. maximal oxygen consumption) was strongly associated with reduced brain atrophy in healthy older adults (Colcombe et al., 2003) and older adults living with dementia (Burns et al., 2008). Even a relatively short aerobic exercise intervention (6 months) has shown to increase grey matter volume in the frontal and superior temporal lobe, hippocampus and increase white matter volume in the genu of the corpus callosum, thereby promoting neuroplasticity through structural changes (Colcombe et al., 2006; Erickson et al., 2011). In addition, Voss et al. (2010) reported significant increases in connectivity within the frontal executive network, specifically in the frontal and temporal cortices, in older adults following a 12 month aerobic (walking) training program. Increased connectivity was behaviourally relevant as it was also associated with significant improvements on cognitive tasks that challenged working memory, inhibition, and task-switching (Voss et al., 2010). Altogether, these findings support the notion that aerobic exercise can lead to positive structural and functional changes within the brain that translate to improved cognitive performance.

The mechanisms underlying the benefits of aerobic exercise on cognitive performance and brain structure and function are still unclear. However, both direct and indirect mechanisms have been proposed to explain these effects (Spirduso et al., 1995; Bherer et al., 2013). The proposed direct mechanisms involve changes in growth factors such as brain-derived neurotrophic factor (BDNF) (Bherer et al., 2013), insulin-like growth factor-1 (IGF-1) (Baker et al., 2010b; Bherer et al., 2013), and vascular endothelial growth factor (Zhang et al., 2011; Zhang et al,. 2013). Exercise-induced increases in BDNF production were significantly associated with promoting angiogenesis and neurogenesis (Zhang et al., 2011; Zhang et al., 2013; Santin et al., 2011), and with increases in hippocampal volume and memory improvements (Erickson et al., 2011). Chronic aerobic exercise can also decrease inflammatory cytokines and oxidative stress (Santin et al., 2011) and have anti-inflammatory and antioxidant effects on the brain. The indirect effects of aerobic training involve improving cognitive function by decreasing depression, anxiety, stress, and even the risk of cardiovascular and metabolic diseases (Spirduso et al., 2008). Further, aerobic training can benefit cognitive function through improvements in self-efficacy and sleep (Spirduso et al., 2008; Vitiello, 2008). While the literature is not entirely consistent, there is sufficient evidence to suggest that aerobic exercise can induce positive behavioural changes in cognitive function, and that these improvements may be caused by neural changes in cognitive brain regions.

2.2.2 The Effects of Resistance Exercise

Resistance training may also improve cognitive function in older adults. Cassilhas et al. (2007) investigated the effects of resistance training on cognitive function in 62 healthy older men. Participants completed three 1-hour sessions each week of whole-body resistance exercises for 24 weeks, and completed tests that assessed executive functioning and memory before and after the program (Cassilhas et al., 2007). Compared to controls, participants in the resistance training group had significantly improved cognition on all cognitive outcomes (Cassilhas et al., 2007). Similar beneficial effects of resistance training on cognitive performance, including performance on the Trail Making test Part B

(Trails B) and Stroop task incongruent trials, have been reported for healthy older women (Liu-Ambrose et al., 2010; Best et al., 2015) and for older women with probable MCI (Nagamatsu et al., 2012).

There is little evidence of dose-related moderators of the cognitive changes induced by resistance training. For instance, one study compared the effects of resistance training at two different intensities (50% 1-repetition max and 80% 1-repetition max) on cognitive functions in sedentary healthy older adults (Cassilhas et al., 2007). After a 24-week program consisting of three 1-hour sessions per week, there were no significant differences in cognitive function between the two resistance exercise groups, suggesting that moderate-intensity resistance training equally enhances cognitive performance in the elderly as high-intensity resistance training (Cassilhas et al., 2007). Further, resistance training programs lasting between 6 months (Cassilhas et al., 2007) and 12 months (Best et al., 2015) have resulted in significantly improved cognitive performance and neural structural enhancements in older participants. While few studies have investigated frequency of resistance training exercise on cognitive function, Liu-Ambrose et al. (2012) compared the effects of once-weekly versus twice-weekly resistance training on cognitive function in healthy older women. Positive results were revealed for cognitive performance after 12 months of training for both groups compared to control. However, only the twice-weekly resistance training group showed positive changes in neural areas (functional magnetic resonance imaging data) associated with inhibitory processes (Liu-Ambrose et al., 2012). This aligns with the American College of Sports Medicine 2016 recommendations of at least 2 days of whole-body resistance exercise per week (Riebe et al., 2016).

Research regarding the structural and neural changes as a result of chronic resistance exercise is relatively scarce compared to aerobic exercise. In one functional magnetic resonance imaging study, 155 community-dwelling senior women were randomized to either the control group (balance and toning) or experimental group (resistance training) for 52 weeks, and cognitive assessments and brain scans were collected before and after the interventions (Liu-Ambrose et al., 2010). Participants in the resistance training group demonstrated significant reductions in whole-brain volumes compared to active control (who showed no change) (Liu-Ambrose et al., 2010). While this was an unexpected finding, a previous beta-amyloid immunization trial in those with probable Alzheimer’s disease led to reduced beta-amyloid load and reduced brain volume (Fox et al., 2005). Therefore, it is possible that resistance exercise contributed to the removal of beta-amyloid and other protein constituents from brain tissue that could have resulted in reduced whole brain values (Liu-Ambrose et al., 2010). Contrary to the findings of Liu-Ambrose et al. (2010), no significant changes were observed in cortical grey matter or hippocampal volume in healthy older adults 1 year after a 52-week resistance training program (Best et al., 2015). In this study, significant increases in cortical white matter were found 1 year-post-intervention in addition to significant improvements on executive function measures, including the Stroop task and the Trail Making test (Best et al., 2015). In addition, compared to once weekly, twice-weekly resistance training can lead to significant improvements in functional plasticity of inhibitory neural areas in healthy older adults (Liu-Ambrose et al., 2012). Altogether, these findings tentatively suggest that resistance exercise can lead to significant improvements in both cognitive performance and brain structure and function, and that these changes can last long after the cessation of the exercise program.

One potential mechanism underlying the improved neural activity and cognitive performance following resistance training is an increase in IGF-1, which is involved in the modulation of BDNF, neurogenesis and angiogenesis (Lindvall et al., 1994, Cassilhas et al., 2007). IGF-1 can pass through the blood brain barrier and have neuroprotective effects by promoting neuronal growth and myelination, neuronal survival following injury, and differentiation; all of which can reduce the impact of or prevent age-related decline in cognition and thus translate to better cognitive performance (Cotman & Berchtold, 2002; Cassilhas et al., 2007). It has been hypothesized that resistance training-related cognitive changes are primarily IGF-1 dependent, while those observed with aerobic training are primarily BDNF-dependent. The fact that the mechanisms underpinning aerobic and resistance training may be different could explain the reported additive effects of combing resistance and aerobic training on cognitive performance (Colcombe & Kramer, 2003; Liu-Ambrose & Donaldson, 2009). In addition, resistance exercise has shown to reduce serum homocysteine levels (Vincent et al., 2003) and thereby reduce the risk of coronary artery disease (a risk factor for cognitive impairment) (Nygård et al., 1997) and Alzheimer’s Disease (Seshadri et al., 2002). Resistance exercise may also boost the activity of antioxidant enzymes within skeletal muscle and the central nervous system, thus enhance the defense against damage caused by oxygen-reactive specimens that can contribute to age-related cognitive decline (Radak et al., 2001). Therefore, there is evidence supporting the effectiveness of resistance training on cognitive performance via chemical and structural neural changes. However, combining aerobic and resistance training may be more beneficial than either type of exercise alone.

2.2.3 The Effects of Aerobic versus Resistance Exercise

There are few studies that have compared the effects of aerobic training to resistance training. One study had 36 people aged 60 – 85 years do 9 weeks of physical exercise (resistance training or aerobic training). Both groups improved cognition relative to control, with no significant differences between them (Özkaya et al., 2005). These results indicate that either type can improve cognitive performance in older adults (Özkaya et al., 2005). In contrast, Nagamatsu et al. (2012) found that resistance training led to significantly enhanced cognitive performance on measures of memory and inhibition, and improved functional changes in hemodynamic activity of neural regions involved with associative memory; whereas those in the aerobic training group only showed significant improvements on measures of physical function, such as balance and mobility. While this highlights the cognitive benefits of resistance training, it contradicts other research supporting the cognitive gains associated with aerobic training (Heyn et al., 2004; Bherer et al., 2013). However, these conflicting findings could be attributed to differences in frequency and/or intensity of aerobic training, where the latter study was only twice per week (Nagamatsu et al., 2012). Furthermore, a meta-analysis revealed that the greatest benefits of aerobic exercise on cognitive performance in older adults occurred when it was paired with resistance exercise (Colcombe & Kramer, 2003). Therefore, it is possible that combining resistance and aerobic training may have an additive effect and thus may be optimal for cognitive benefits compared to either intervention alone.

2.3 The Effects of Cognitive Training on Cognition

Cognitive training can be described as specifically designed programs that provide guided practice on a standard set of cognitive tasks aimed to improve performance on one or more cognitive domains (Martin et al., 2011). Such programs vary from study to study, but typically contain redesigns of cognitive assessments (i.e. n-back, Stroop task) in the form of written, verbal, or computerized games or activities (Double & Birney, 2016). Interest in cognitive training interventions for older adults has risen dramatically over the last decade, following evidence from a number of studies that have established strong links between engagement in cognitively stimulating activities throughout life and enhanced late-life cognition, and reduced risk of cognitive impairment and dementia (Wilson et al., 2002; Verghese et al., 2003; Marioni et al., 2012). Increasing evidence also suggests that late-life cognitive training can improve cognitive functions in the short term (Kelly et al., 2014).

Cognitive training targeted to various cognitive domains —including memory, reasoning, processing speed, working memory, and multiple cognitive domains—can lead to significant improvements in executive functioning (specifically working memory), processing speed, attention, and global cognition in older adults (Kelly et al., 2014; Reijnders et al., 2013). These findings are consistent across healthy older adults (Tardif & Simard, 2011) and those at high risk for cognitive decline (Coyle et al., 2015). However, one meta-analysis (Jean et al., 2010) reported improvements for objective and subjective measures of memory but not for other domains following cognitive training, though it should be noted that the authors only analyzed articles that investigated the effects of cognitive training on those with amnestic type MCI, a subcategory of MCI where memory loss is predominant (Csukly et al., 2016). Not surprisingly, most of the included studies investigated memory-dominant cognitive training, likely the reason for the lack of benefits observed for cognitive domains other than memory (i.e. executive function).

Computerized cognitive training has become a focus of cognitive training research due to its efficient and easy delivery, as well as the ability to individualize and adapt training content and difficulty over time (Clare & Woods, 2003; Kueider et al., 2012; Jak et al., 2013). Computerized cognitive training involves structured practice on standardized and cognitively challenging tasks (Clare & Woods, 2003), and is a potentially more cost-effective alternative to traditional training programs (Kueider et al., 2012). A recent meta-analysis analyzed the results of 52 randomized controlled trials (RCTs) of computerized cognitive training on cognition in healthy older adults (Lampit et al., 2014). Results demonstrated small positive effects of computerized cognitive training on some cognitive domains including working memory, processing speed, non-verbal memory, and visuospatial skills; while no significant effects were observed for verbal memory, executive function (specifically inhibition and task switching) or attention outcomes (Lampit et al., 2014). However, the domains that improved generally aligned with those that were trained, where less than half of the studies used multi-domain training and the others used either working memory training (9 studies), speed of processing training (9 studies), attention training (6 studies), or video games (4 studies) (Lampit et al., 2014). These findings are in agreement with other studies, suggesting little transfer of cognitive training effects to untrained cognitive abilities (Verhaeghen et al., 1992; Ball et al., 2002; Rebok et al., 2007; Lauenroth et al., 2016).

In contrast, there are some studies that have demonstrated a certain degree of generalizability to other cognitive abilities. For instance, transfer effects to non-trained activities have been observed in older adults following dual task (Bherer et al., 2008), attention (Mozolic et al., 2011), and memory training (Buschkuehl et al., 2008; Li et al., 2008). Therefore, computerized cognitive training may be a viable and cost-effective alternative to traditional cognitive training to improve several cognitive abilities.

Characteristics of the cognitive training and of the individual may influence cognitive training effects on cognition. For instance, one meta-analysis revealed significant cognitive improvements for studies that required training 2 – 3 times per week, but not in studies that had once-weekly training or training that occurred more than 3 times per week (Lampit et al., 2014). This suggests that there may be an inverted-U relationship between training frequency and observed cognitive benefits in older adults, and that factors such as cognitive fatigue may interfere with training gains (Holtzer et al., 2010). Additionally, the effects of training sessions that were shorter than 30 minutes were weaker compared to those that were longer than 30 minutes (Lampit et al., 2014). It has been postulated that this is because synaptic plasticity is more likely to occur after 30 – 60 minutes of stimulation (Lüscher et al., 2000). This meta-analysis also reported that home-based administration was less effective at improving cognitive performance in older adults compared to group-based cognitive training (Lampit et al., 2014). Furthermore, in the same way that individual characteristics can mediate exercise-induced cognitive changes, this may also be true for cognitive training. For instance, following 12 weeks of a multi-domain computerized cognitive training, participants with lower baseline cognitive function benefited more from the training compared to those with higher baseline cognitive function (Peretz et al., 2011). Baseline cognitive performance should be considered when evaluating intervention effects. Therefore, depending on the characteristics of the person and the program, cognitive training – and specifically computerized cognitive training – may be an appropriate intervention to enhance cognitive performance in healthy and cognitively impaired adults and older adults. Though, adding cognitive training to exercise may demonstrate additional health benefits.

2.4 The Effects of Combined Cognitive and Exercise Training on Cognition

The cognitive benefits elicited by physical activity may be enhanced by exposure to cognitively challenging activities or environments (Fabel et al., 2009; Langdon & Corbett, 2012). Several studies have reported that combining physical activity with various types of cognitive training may lead to significant improvements in measures of general cognitive function, memory, executive function, visuospatial ability, and attention among healthy older adults (Nishiguchi et al., 2015; Zhu et al., 2016) and older adults with MCI (Kounti et al., 2011; Law et al., 2014). In addition, combining physical exercise and cognitive training has shown to enhance neural efficiency and increase connectivity between several cortices in healthy older adults (Nishiguchi et al., 2015) and adults with cognitive impairment (Maffei et al., 2017; Klados et al., 2016).

Most studies that have reported beneficial cognitive effects following combined interventions used inactive controls as their comparator groups. One study did compare the effects of combined training to an active control (Desjardins-Crépeau et al., 2016). The combined training group completed 12 weeks of aerobic and resistance exercise and computerized dual task training, while the active control group completed 12 weeks of stretching and toning sessions and computer lessons. Although the combined training group showed improvements in speed of processing, inhibition, and task-switching compared to baseline, these improvements were not significantly different from those seen in the active control group, suggesting a placebo effect (Desjardins-Crépeau et al., 2016). These same findings have been demonstrated by other studies investigating the cognitive benefits of similar interventions in older adults with cognitive complaints; citing practice effects and the vulnerability of this population to significant positive effects of light exercise as possible reasons for the lack of significant differences between the groups (Barnes et al., 2013; Middleton et al., 2018). Zhu and colleagues (2016) extended these findings by concluding that the cognitive effects of combined training, while significantly greater than inactive control and physical activity alone, did not significantly differ from cognitive training alone. The fact that combined cognitive and exercise training resulted in better cognitive effects compared to exercise alone, but not cognitive training alone, is consistent with a more recent meta-analysis comparing the cognitive effects of combined interventions to exercise alone and cognitive training alone in cognitively intact and mildly impaired older adults (Gheysen et al., 2018). Therefore, while more recent findings suggest that combined cognitive and exercise training may be more beneficial cognitively than exercise alone, it may not result in greater cognitive gains compared to cognitive training alone.

Though there are many possible explanations, one reason for the null results of the comparison between cognitive training alone and combined interventions could be that cognitive training alone demands more cognitive efforts with fewer or shorter sessions. It is therefore possible that this optimal level of intensity, frequency, and duration of cognitive training maximizes cognitive improvements without inducing excessive fatigue (Gheysen et al., 2018). However, these results do not promote cognitive training alone over a combined intervention due to the well-established and broad benefits of physical exercise (Zhu et a., 2016; Gheysen et al., 2018). A recent meta-analysis showed that combined cognitive and physical exercise interventions resulted in moderate-large effects (SMD = 0.65; 95% CI 0.09 to 1.21; $p<0.01$) on ADLs in older adults with MCI or dementia. These improvements in ADLs suggest that combining interventions may have functional and clinical relevance (Karssemeijer et al., 2017). It is possible that the broader health benefits from the physical exercise combined with the specific cognitive gains from the cognitive training may be an advantageous combination for older adults with and without cognitive impairment.

Participant characteristics and study design may moderate cognitive effects. Cognitive gains may be greater when participants are older (Heyn et al., 2004; Erickson & Kramer, 2009; Zhu et al., 2016). In addition, benefits may be greater when combined programs occur less than 5 times per week (Li et al., 2011; Zhu et al., 2016). Additionally, one review concluded that 1 – 3 hours per week for 12 – 16 weeks (or more) of a combined regimen that is sufficiently demanding and progressively increases in difficulty is more likely to elicit detectable cognitive improvements; though it was recommended to avoid excessive intensity (Lauenroth et al., 2016). It is possible that very high cognitive and physical loads lead to cognitive fatigue (Holtzer et al., 2010; Lampit et al., 2014), excessive stress, and less engagement in the activities (Singh et al., 2014). The presence of a certified trainer may also enhance benefits, perhaps due to improved adherence and motivation or social engagement (Amieva et al., 2010). Lastly, the timing of each intervention in relation to each other may influence cognitive performance. It has been proposed that simultaneous cognitive and physical intervention may be most beneficial for mechanistic interactions

(Fissler et al., 2013; Gheysen et al., 2018). However, one review revealed no significant difference in the efficacy of simultaneous versus sequential combined interventions on cognitive function (Zhu et al., 2016). Furthermore, the evidence supporting a specific ordering of sequential cognitive training and exercise training has been inconsistent, with some proposing that doing cognitive training before or after exercise may be more effective (Legault et al., 2011; Langdon & Corbett, 2012; Lauenroth et al. 2016) while others have found no effect of intervention order (Oswald et al., 2006).

The underlying mechanism of the combined effects of physical exercise and cognitive training remains unclear. However, it has been postulated that the additive effects observed are likely due to distinct yet related training-induced physiological processes. It has been proposed that physical exercise and cognitive training induce plastic changes through different means: physical exercise enhances cell proliferation and synaptic plasticity, while cognitive training "guides" plasticity by increasing the number of new neurons and integrating new neurons and synapses into pre-existing neural networks (Curlik & Shors, 2013; Fissler et al., 2013; Bamidis et al., 2014). Combined physical and cognitive training has shown to increase cerebral blood flow in specific neural regions, including the parahippocampal region, which could explain the observed increases in neural efficiency and connectivity across cognitive networks (Maffei et al., 2017). Animal studies have shown that physical activity and environmental enrichment induced hippocampal neurogenesis via different pathways and that the combination of the two interventions resulted in greater structural and behavioural cognitive benefits than either intervention alone (Fabel et al., 2009; Langdon & Corbett, 2012; Smith et al., 2013). Furthermore, it has been shown that CET programs can induce significant increases in peripheral BDNF levels, suggesting that the additive effects may be mediated by neurotrophic growth factors (Anderson-Hanley et al., 2012). This is not surprising given that BDNF likely plays a prominent role in the mechanisms underlying the individual effects of physical exercise and cognitive training (Baker et al., 2010a; Bherer et al., 2013; Staines, 2018). Therefore, through separate but connected neurophysiological mechanisms, combining cognitive training and exercise training may induce greater cognitive gains and more health benefits overall than either intervention alone in older adults. However, there is a need to determine if this kind of intervention can be feasibly implemented and to investigate whether similar findings can be observed in a real-world setting.

2.5 Feasibility and Pilot Studies

RCTs of lifestyle interventions can be difficult due to the challenge of intervention adherence, participant retention, and group allocation blinding (Slade et al., 2016; Eldridge et al., 2016a). Without establishing the characteristics of an effective and efficient trial design beforehand, RCTs can be effortful and waste valuable time and resources. Further, RCTs are often underpowered due to low recruitment and/or retention rates making it difficult to make inferences regarding the efficacy of the intervention (El-Kotob & Giangregorio, 2018). For example, in a recent meta-analysis of combined exercise and cognitive training, the authors explained that adherence to the interventions was rarely reported, and thus it is possible that low adherence could have contributed to the lack of significant findings on executive function, attention, and memory observed in certain studies (Karssemeijer et al., 2017).

Feasibility and pilot studies may be helpful in improving the quality of clinical trials of physical activity and other behavioural and medical interventions (Slade et al., 2016; Eldridge et al., 2016a). A feasibility study is used to determine whether aspects of a future main study can be accomplished (Eldridge et al., 2016b), while a pilot study is a division of a feasibility study that mirrors the clinical trial but has the primary aim of assessing feasibility rather than the efficacy of the intervention (El-Kotob & Giangregorio, 2018). There are four main reasons that a feasibility or pilot study may be conducted: (1) to inform process (i.e. feasibility of recruitment, retention, adherence, etc.); (2) to understand resource requirements (i.e. money and time); (3) to inform management (i.e. personnel challenges, organization, etc.); and (4) to advance scientific inquiry (i.e. intervention dosage, treatment effect, and safety) (Thabane et al., 2010). Therefore, pilot and feasibility studies are useful as they focus on feasibility outcomes rather than outcomes of effectiveness, thereby ensuring that large-scale RCTs can be done successfully.

Criteria for success related to the primary feasibility questions should be determined ahead of time so that other researchers can interpret the meaning of the findings, and take them into consideration when conducting future trials (Thabane et al., 2010). For instance, some studies have made vague claims about what is considered “high adherence”, while others have suggested that acceptable adherence ranges between 60% and 87% (Predovan et al., 2012; El-Kotob & Giangregorio, 2018; Giangregorio et al., 2018). However, adherence as a primary outcome measure has proven to be challenging to analyze, as it is often subject to social desirability bias and non-response bias (El-Kotob & Giangregorio, 2018). Alternatively, researchers can determine *a priori* criteria using previous data for other feasibility outcomes that are not influenced by such biases such as attendance, completion, and recruitment rates (Thabane et al., 2010). While it can be challenging to determine *a priori* criteria, feasibility and pilot studies should aim to use previous literature to develop criteria for success for various feasibility outcomes such as adherence and retention rates. Therefore, a feasibility study with pre-determined criteria for success is necessary to better understand the facilitators and barriers to program implementation, such as the implementation of a CET program.

3. Rationale and Objectives

3.1 Rationale

Evidence suggests that exercise and cognitive training each may improve cognitive and other health outcomes among older adults (Baker et al., 2010a, 2010b; Nagamatsu et al., 2012; Jean et al. 2010). Additionally, there is some evidence that combined programs may lead to more cognitive benefits compared to either training alone (Alzheimer's Disease International, 2015; Montero-Odasso et al., 2018b). To implement these emergent findings, older Canadians at risk for dementia need access to combined exercise and cognitive training programs. Though exercise programs for older adults are available in many Canadian communities, combined exercise and cognitive training programs are not. For most individuals, cognitive training is only accessible through enrolment in clinical trials and a few computer program or smart phone applications – most of which have not been scientifically investigated. Furthermore, there is no research to date evaluating the feasibility of implementing or evaluating a combined training program in a community-based setting. This study will examine the feasibility and acceptability of a CET intervention and program for older adults in a community-setting. If shown to be feasible, it has the potential for further evaluation and wide implementation and, therefore, have a significant impact on the cognitive health of older Canadians.

3.2 Objectives and Hypotheses

The overarching aim of this project was to evaluate the feasibility and acceptability of a cognitive training regimen (Montero-Odasso et al., 2018a, 2018b) in combination with a community exercise program among adults and older adults. To support this aim, we have developed a collaboration with the YMCA of Kitchener-Waterloo, which offers an exercise program (called the "Move for Health" program) that is targeted to adults and older adults living with or at risk for chronic health conditions. The original intent was to address the study's objectives in a single offering of the program. However, due to unanticipated challenges with initial recruitment and facility closure of the YMCA in response to COVID-19, the objectives and hypotheses, study design, and results are presented in two phases.

3.2.1 Phase 1: Objectives and Hypotheses (Fall 2019)

1. To evaluate the feasibility and acceptability of implementing a single-arm 12-week, twice weekly CET program in a community-setting among adults and older adults, and to compare participants by study completion and by adherence status.

    Ha. It was anticipated that this program will be feasible to implement, and will be well accepted by the participants and exercise providers, as indicated by:

i. Intervention attendance of ≥ 70%, which is similar to the average program attendance for the Move for Health program (as of 2015), and is in line with attendance rates in clinical trials of exercise among older adults (Picorelli et al., 2014). Program attendance was defined as the completion of the full intervention in each class (i.e. exercise + cognitive training for CET participants).

ii. Study completion rate of ≥ 75%, which is similar to the completion rates of the Move for Health program (as of 2016) and consistent with previous literature (Picorelli et al., 2014; Giangregorio et al., 2018).

iii. Recruitment of ≥ 24 participants within the month prior to the study (~ 6 participants per week).

iv. Mean participant program satisfaction rating of ≥ 80% (Myers, 2003) on a satisfaction questionnaire consisting of Likert scales (1-5), where the higher the numerical response the greater the satisfaction (group average anticipated to be 4/5 or 80% or higher).

v. Mean instructor program satisfaction rating of ≥ 80 % (Myers, 2003) on a similar satisfaction questionnaire as the participants.

2. To describe changes in cognitive function, physical function, well-being, and exercise related self-efficacy over the 12-weeks of the CET program.

3.2.2 Phase 2: Objectives and Hypotheses (Winter 2020)

1. To evaluate the feasibility and acceptability of a 12-week quasi-experimental, parallel-group trial comparing CET versus ExO in a community-setting among adults and older adults (including an evaluation of the feasibility of participant randomization), and to compare participants by study completion and by adherence status.

   Ha. Hypotheses and criteria for successful feasibility as in phase 1.

   Hb. It was anticipated that participant retention, adherence, and participant and instructor program acceptance would be comparable between the two groups.

2. To describe changes in exploratory outcomes (cognitive function, physical function, well-being, and self-efficacy) between CET and ExO.

4. Methods

4.1 Study Design

This study had two phases. In the fall of 2019, there was a single-arm trial to evaluate the feasibility of CET in a community setting (phase 1). In the winter of 2020, there was a quasi-experimental, parallel-group trial to compare the feasibility of CET versus ExO (phase 2) (ClinicalTrials.gov identifier: NCT04515758). In phase 2, participants were allowed to select a program timeslot, which was then randomly allocated to either CET (cognitive training + Move for Health exercise training) or the active control group (Move for Health exercise training only, ExO) (see Figure 1 for study design).

4.2 Setting

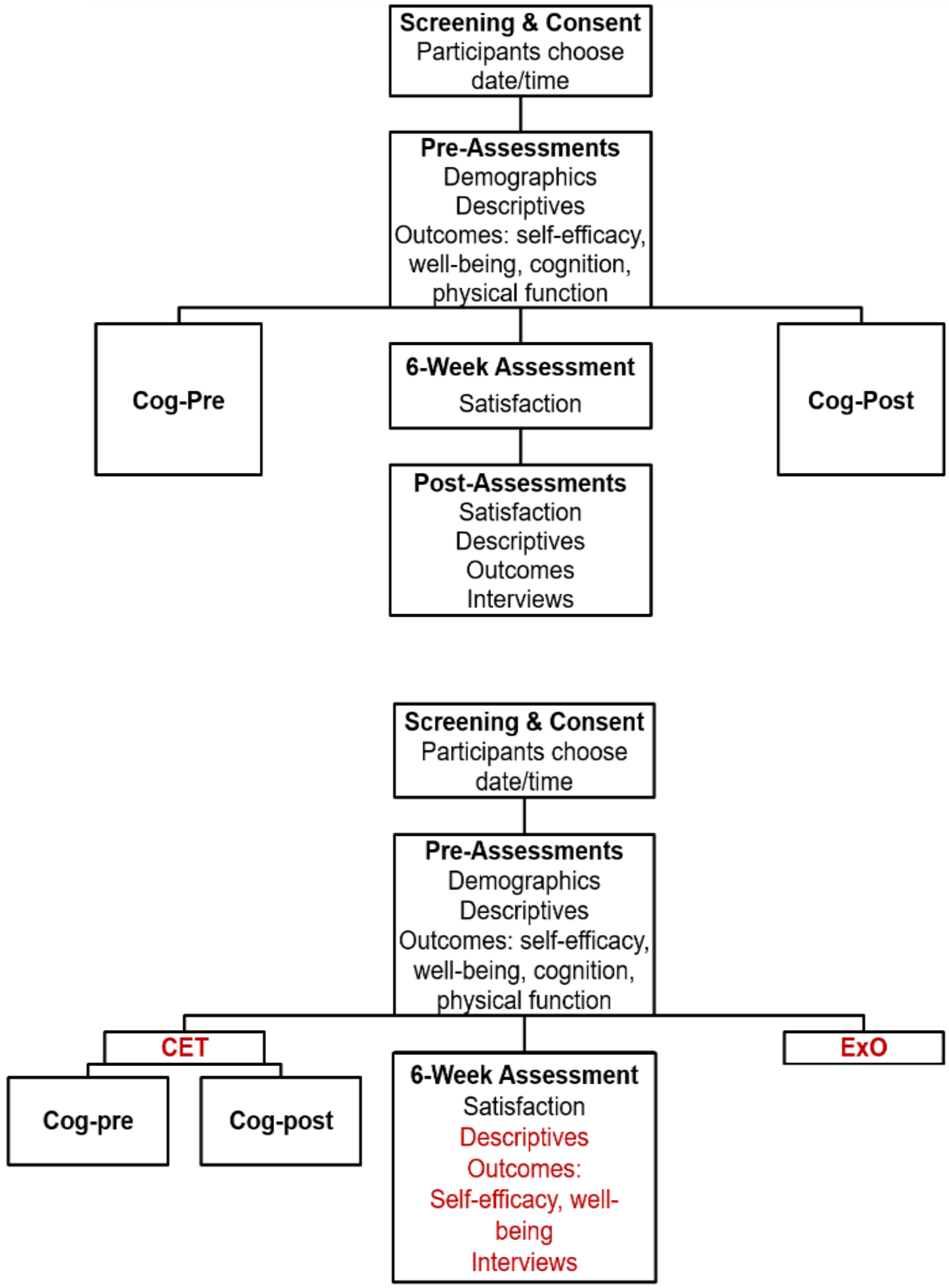
Both interventions in the study were conducted at the A.R. Kaufman Family YMCA (Kitchener) fitness center. The A.R. Kauman Family YMCA is a multi-use building with a fitness centre, meeting rooms, a large gymnasium, a pool, and a café. The fitness centre had a variety of equipment including automated and manual treadmills, stationary or recumbent bikes, ellipticals, stair-masters, rowing machines, and vertical rowing machines. In addition, there was a variety of equipment for resistance training including weight machines, resistance bands, TRX ropes, stability balls, and free weights.

4.3 Participants

Adults and older adults eligible for the Move for Health program at the YMCA were recruited. To be eligible for Move for Health, participants must be dealing with one or more of the following chronic health conditions that are common with ageing:

- Osteoarthritis and/or rheumatoid arthritis
- Osteoporosis
- Pre/post joint replacement
- Fibromyalgia
- Hypertension
- Stable heart conditions (e.g. controlled angina, irregular heart rhythm)
- Chronic obstructive pulmonary disease
- Diabetes (type 1 or type 2) or pre-diabetes
- Obesity

Figure 1. Study design by phase. Phase 1 (top) occurred in the fall of 2019 and was a single-arm trial, while phase 2 (bottom) occurred in the winter of 2020 and was a quasi-experimental parallel group trial.



Typically, Move for Health participants have osteoarthritis or vascular risk factors (e.g. high cholesterol, hypertension), which are both risk factors for dementia (Newman et al., 2005; Huang et al., 2015). YMCA staff screened people who were interested in the Move for Health program for program and study eligibility. Since initial recruitment was slow, the researcher (CE) also assisted with screening. There were two main streams of initial screening: 1) people who had heard of the program and/or study (i.e. via an advertisement, word-of-mouth, etc.) and contacted YMCA staff or the researcher for more information; and 2) people who completed YMCA Smart Start applications (see Appendix A), which were then passed on to recruitment staff or the researcher because they appeared eligible for the study. Once a participant's eligibility and interest for the Move for Health program was confirmed, additional study inclusion and exclusion criteria were reviewed. Study participants had to be screened safe to exercise using the Get Active Questionnaire or approved for exercise by their physician (Petrella et al., 2018). Participants were also required to be available and willing to participate in the program on a set of days and times that the study was being conducted. In addition, participants had to have sufficient written and verbal proficiency in English to understand and respond appropriately to instructions and questions.

Participants were excluded from the study if they had a recent concussion (last 6 months) and/or had any severe and/or untreated cognitive, visual, auditory, or motor impairments that prevented them from being able to complete the exercise and/or cognitive training. Participants were also excluded if they had participated in the Move for Health program within the last year (recent knowledge of the typical program could have impeded the purpose of randomization and blinding). In addition, participants who were currently undergoing any form of cancer treatment were excluded due to the possible treatment side-effects on physical and cognitive function.

4.4 Interventions

4.4.1 ExO Group (Phase 2 only)

The ExO group only occured in the quasi-experimental parallel group trial phase (phase 2). Participants in the ExO group took part in the YMCA Move for Health exercise program only. This program included two 1-hour sessions per week week for 12 weeks.

The Move for Health exercise program was group-based but exercise prescriptions were individualized and progressive. Each exercise session included aerobic training, whole body resistance training, and balance and posture training, as well as approximately 5 minutes of a warm-up and a cool-down (i.e. light aerobic exercise and dynamic stretches). The programs were designed to reach a moderate intensity for both aerobic and resistance training.

Participants were generally advised to complete 15-20 minutes of aerobic exercise each session. The mode of aerobic exercise was participant selected. Moderate intensity was considered achieved when: (1) participants were breathing more heavily, (2) participants self-reported increases in their heart rates, and (3) they were able to carry a conversation and/or speak in full sentences with more effort, but could not sing. If participants were able to sing and/or no longer experienced elevated breathing and heart rates, instructors worked with participants to increase intensity (i.e. by increasing speed, incline, resistance, and/or duration or changed the mode of exercise).

For resistance training, each participant completed 1-2 exercises targeting each of the following muscle groups: back, chest, upper limbs (biceps and/or triceps), lower limbs (quadriceps, hamstrings, and/or calves), and core (abdominal muscles). Again, target intensity was moderate. Moderate intensity of resistance training was defined as achieving 1-2 sets of 10-12 repetitions (reps) of each exercise, with the last 2 reps of each set being difficult or challenging to complete. If participants were able to comfortably complete 2 sets of 12-15 reps of an exercise, instructors worked with participants to increase intensity appropriately (i.e. by adding a 3rd set or increasing weight using ACSM 2016 guidelines) (Riebe et al., 2016). If participants were unable to complete the exercise with proper form or found it too challenging, weight was reduced or a modified or alternative exercise was prescribed. Depending on the participant's specific needs, balance, posture, coordination, and/or agility exercises were also prescribed (see Appendix B for details). Participants were encouraged to dedicate 20 – 25 minutes of the session to resistance training exercises and any other balance, posture, coordination, or agility exercises prescribed.

4.4.2 CET Group (Phase 1 and 2)

Participants in the CET group completed the Move for Health exercise training, as described for the ExO group above. In addition, participants in the CET group completed 30 minutes of cognitive training, either before or after each exercise session (participants were randomized to completing the cognitive training before or after exercise). The cognitive training used was similar to one implemented in previous experimental studies (Bherer et al., 2008; Predovan et al., 2012) and an ongoing clinical trial (Montero-Odasso et al., 2018a), but was implemented on an Android tablet rather than an iPad. The cognitive training focused on dual-task training and required participants to employ higher-order cognitive abilities such as attention (selective/divided attention) and executive function (working memory, task-switching, and inhibition). Each cognitive task required the participants to choose and execute the appropriate hand response (i.e. buttons tapped by their left or right thumbs) for the visual stimuli presented (celestial bodies and animals). Complex response time tasks were completed consecutively or concurrently (two stimuli at once). Some of the concurrent tasks required participants to prioritize hand sequencing (i.e. right responds first, then the left hand and vice versa). Participants had to perform tasks as fast as possible while maintaining accuracy. Online feedback for speed (colour-coded speedometer) and accuracy (colouring of response buttons to indicate correctness) was included in the training. A results report was also provided at the end of each session to encourage improvement.

Following the introductory sessions (first two classes), each person began at the same (easiest) difficulty level. However, each individual's training progressed based on their ongoing performance. Specifically, as participants responded faster, the criteria for achieving each level within the online performance tracking became more demanding (i.e. they had to respond faster to remain in the green-yellow area of the speedometer, which indicated optimal response speed).

All participants completed the training in the same room and at the same time. While it is ideal to have them seated at their own desks, due to limited availability of such equipment, participants completed the training sitting next to each other at one large table. Chairs were arranged so that there was enough space between each participant (to reduce peripheral distractions). Participants were instructed to remain silent during the training and to turn off any electronic devices to minimize distraction for themselves and others.

4.4.3 COVID-19 Closure

In phase 2, both the ExO and the CET programs were ended at 6 weeks due to the COVID-19 shut down. However, program feasibility, acceptability, and adherence were still assessed, as were outcome assessments that could be completed by telephone.

4.5 Randomization and Blinding

In order to support recruitment, participants were allowed to select their program days. As a result, 1:1 participant randomization to CET or ExO was not possible. Instead, quasi-randomization based on program days was performed. Specifically, participants chose their preferred option of program days and then a research assistant independent to the study (AN) used computer-generated random numbers to allocate the program intervention to the program days. Sequence of cognitive training and exercise training was quasi-randomized, whereby LM and AN randomized phase 1 and phase 2 experimental participants individually or in spousal dyads to one of two groups: (1) cognitive training before exercise or (2) cognitive training after exercise. Due to human error, block randomization for gender was done for the phase 1 (fall) CET group but not for the phase 2 (winter) CET group. However, since each pair of spouses in the phase 2 group was male and female, gender was balanced nonetheless. All allocation sequences were concealed using participant ID-labeled Word and/or Excel documents and kept in a password protected computer. Randomization of individuals and of programs was only revealed after baseline assessments.

In this double-blinded study, participants and assesors of the exploratory outcomes were blind to the intervention-day allocation. Partial disclosure was used to keep participants blind by informing them that they will be randomly allocated to either the "regular Move for Health program" or the "augmented version of the Move for Health program". The documents containing the allocation sequences were shared with and revealed by the researcher responsible for collecting feasibility and observational data (CE), as they were unable to be blinded to the group allocations.

4.6 Measures

All participants reported demographic characteristics, health conditions, and physical activity history and completed assessments of cognitive function, physical function, well-being, and self-efficacy before and after the program. Participants and Move for Health instructors also completed program satisfaction questionnaires at the halfway point and at the end of the program (i.e. week 6 and week 12) and most took part in a brief 10-30 minute interview within 2 weeks of the last session. Assessments were planned for the 2 weeks prior to the start of the program (time point 1, T1), at the mid-point of the study (time point, T2), and within 2 weeks after the program (time point, T3). Due to facility closure in response to COVID-19, the phase 2 participants were unable to complete post-program assessments for cognitive and physical function. However, post-program descriptive measures, well-being and self-efficacy measures, and the interviews were completed over the phone. Because of the uncertainty of the situation, the phone-assessments were completed approximately 1 month following facility closure (Figure 1).

4.6.1 Screening and Consent (T1)

We confirmed whether the participants were safe to exercise using the YMCA Smart Start application (Appendix A) in combination with physician screening (if it was necessary, see Appendix C for the YMCA physician screening letter) and the Get Active Questionnaire. Inclusion and exclusion criteria were reviewed over the phone (during recruitment screening) and confirmed in person during the consent process and initial assessment. Eligible participants were provided the study information and consent forms.

4.6.2 Descriptors (T1, T3):

Demographics and baseline cognitive status: At baseline, participant demographics (age, gender, and ethnicity), marital status, education, socioeconomic status and relevant comorbidities and medications were reported by questionnaire (Appendix D). Instructor demographics (age, gender, and ethnicity), education, years of practice providing exercise, certifications, and socioeconomic status were also reported by questionnaire (Appendix E) The Montreal Cognitive Assessment (MoCA) was administered as a screen for cognitive impairment (though participants were not excluded based on their MoCA scores). The MoCA has high sensitivity and specificity for detecting MCI and dementia (Nasreddine et al., 2005).

Physical activity habits: Habitual physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). The IPAQ has moderate validity ($\rho = 0.26 – 0.53$) across several age groups, including older adults (Craig et al., 2003; Tomioka et al., 2011; Van Holle et al., 2015; Cleland et al., 2018). Categorization of physical activity levels were based off the IPAQ scoring protocol (Forde, 2018).

Cognitive activity habits: Habitual cognitive activity was assessed using an adapted version of the Florida Cognitive Activities Scale (see Appendix F) (Schinka et al., 2005). The wording for some of the items on the original scale was adapted for clarity. This has adequate validity in several populations, including older adults with and without cognitive impairment (Schinka et al., 2005; Dotson et al., 2008; Schinka et al., 2010). Participants were required to report how frequently they typically engaged in each cognitive activity item (0 = never or not in the past year; 1 = less than once per month; 2 = one – four times per month; 3 = five or more times per month; 4 = daily). The level of cognitive activity was defined by each participant's average score (0 = very low; 1 = low; 2 = moderate; 3 = moderate-to-high; 4 = high).

Social activity habits: In addition, social activity habits were measured using a scale that was adapted from two scales used in previous studies (see Appendix G). The "groups of people" one could interact with were adapted from the verbal interaction component of a questionnaire utilized by Zuelsdorff et al. (2018). This scale has shown to have substantial reliability, however the response scale was more complex than what was necessary for the purposes of the current study. Therefore a more simplistic response scale was obtained from a questionnaire used by Lee and colleagues (2013). The response items from this source referred to the typical frequency of interactions for each social group (0 = never or not in the past year; 1 = a few times every year or every month; 2 = weekly; 3 = daily).

Additionally, the definition of “interactions” or “contacts” used by Lee et al (2013) better captured all forms of modern day social interaction (i.e. included emails, video calls, and text messages). Each participant’s level of social activity was defined by their average score (0 = very low; 1 = low; 2 = moderate; 3 = high).

Any changes in demographics post-program were reported (i.e. changes in medications or age). In addition, physical, cognitive, and social activity scales were also assessed post-program in attempt to capture changes in activity levels (since joining, but separate from the program) for exploratory purposes. The MoCA was not reassessed post-program.

4.6.3 Measures of Feasibility and Acceptability (primary objective, T1/2/3):

Recruitment rate was calculated as the number of participants recruited per week over the intended recruitment period (4 weeks in phase 1) and over the adjusted recruitment period (6 weeks in phase 1, 10 weeks in phase 2). **Retention rate** was calculated as the percentage of people who were enrolled in the study who completed the study. **Adherence rate** was calculated in two ways: 1) as the portion of classes (whole class, cognitive training, and exercise program); and 2) completion of exercise diaries as a percentage of attended classes. **Participant and instructor satisfaction ratings (T2/T3)** of program enjoyment, staff quality, facility quality, and class structure for each training type (cognitive and exercise) and for the overall program were reported using Likert scales of 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly agreement). Exercise and cognitive training difficulty scales of “optimal” to “too easy/too hard” and open-ended questions were also included in the questionnaires (see Appendices H–K for the CET and ExO participant and instructor satisfactions questionnaires). Strategies were implemented to minimize the impact of social pressures and reporting bias. These included maintaining participant anonymity, having a separate party (CL) distribute the questionnaires, and ensuring program instructors and researchers were out of the room while participants completed the questionnaires.

Participant and instructor interviews inquired about participant and instructors’ experiences throughout the program (T3). Semi-structured interviews were conducted with participants and instructors in-person (phase 1) and over the phone (phase 2). Prior to the interview all interviewees were informed that the purpose of the interview was to provide further insight regarding their experience in the program and research study. Participants and instructors were also reminded of their rights, including the anonymity of their interview (de-identified via numeric ID), option to provide as little or as much information as they wish, and skipping questions or ceasing participation at any point in the interview. All interviews were conducted in a semi-structured manner, generally following the interview guide (see Appendix L for detail). Participants were prompted for further information or for clarity, as necessary. Length of the interviews lasted between 10 and 30 minutes, depending on the natural course of the conversation. With the interviewee's consent, interviews were audio recorded and transcribed verbatim. Protocol and results for the interviews completed in phase 1 were also reported as part of an undergraduate thesis project (Catherine Lee; Appendix M), though this analysis pertained primarily to CET program feasibility as opposed to trial feasibility. Here, we included the additional phase 2 interviews, and focused on emergent themes related to research study feasibility and acceptability. Interviews from phase 1 and phase 2 were integrated for the purpose of the current thesis.

Observational notes were collected for all sessions by the researcher (CE). These notes were based on observations that were relevant to the feasibility, delivery, or effectiveness of the interventions, and included descriptions of instructors' and participants' experiences from the perspective of the observer. Five questions related to perceived program enjoyment, barriers to program delivery or participation, and degree of instructor and participant engagement were used to guide note-taking (Appendix N). In particular, notable successes and failures (and the dates of these incidences) associated with all study protocols (i.e. recruitment, pre- and post-program assessments, and dropouts) were reported as they occurred (usually once or twice a week). See Appendix O for a sample report (no data included). No participant or instructor names were recorded in notes or reports.

4.6.4 Measures of Effectiveness (secondary objective, T1/3):

Cognitive Function: Two tests were used to evaluate cognitive changes: **1)** ***Stroop Colour Word Interference Test:*** The Stroop Task is a valid assessment of selective attention and inhibition (Houx et al., 1993). Participants completed three conditions, naming (i) the colour name written; (ii) the colour of a box; and (iii) the colour of the ink in which a colour name is written. Scores were calculated in the time (seconds) to complete each condition, and errors were also noted. **2)** ***Trail Making Test (TMT):*** This two part assessment provides as a valid measure of executive control (visuoperceptual abilities, working memory, and task-switching) (Sánchez-Cubillo et al., 2009). In Part A (Trails A), participants had to draw a line connecting numbered circles in ascending order. In Part B (Trails B), participants drew a line connecting lettered and numbered circles in ascending order (alternating from number to letter). The time to complete the task was the score, and errors were also noted.

The Stroop and Trail Making tests were chosen because both require speed in addition to accuracy. Both assessments measure aspects of executive functioning – a cognitive subdivision particularly susceptible to ageing and impaired in those with MCI/dementia (van Dam & Aleman, 2004; Deary et al., 2009; Harada et al., 2013). Further, tasks that require executive functions have shown to be sensitive to both exercise and cognitive training (Dahlin et al., 2008; Baker et al., 2010a, 2010b; Best et al., 2015).

Physical Function: Tests of physical function were selected to align with the standard pre- and post-program YMCA assessments (Appendix P). These included: **1)** ***6 Minute Walk:*** Participants were asked to walk as far as possible along an indoor track in 6 minutes (distance recorded in number of laps). It has shown to be a valid and reliable measure of functional fitness (Enright, 2003). ***2) Grip strength:*** Participants were required to grip a hand dynamometer as hard as possible with their arm straight and abducted at 45 degrees (the results in lbs from two trials for each hand were recorded). This is the simplest method for muscle function assessment in clinical practice and is a valid measure of whole-body muscle strength and functional mobility limitations (Schaubert & Bohannon, 2005). **3)** ***Five-Time-Sit-to-Stand:*** Participants were asked to complete five sit-to-stands as fast as possible (time recorded in seconds). The sit-to-stand test is a reliable and valid measure of lower limb strength, dynamic balance, and functional mobility (Goldberg et al., 2012). **4)** ***Four Square Step Test:*** This test required participants to step quickly and safely clockwise then counter-clockwise into four squares created by objects (i.e. rods). Their time to complete the step sequence was recorded. This test has been shown to be a valid measure of dynamic balance (McKee & Hackney, 2014). **5)** ***Timed Up-and-Go:*** Participants were required to stand up from a chair, walk to a line on the floor three meters away at their normal pace, turn, walk back to the chair at their normal pace, and sit down (completion time for two trials were recorded). This has shown to be a valid and reliable test to assess functional mobility, dynamic balance, lower limb strength, and fall risk (Podsiadlo et al., 1991; Nordin et al., 2008).

Well-being: The Vitality Plus Scale was used to report changes in well-being. It was developed to capture elements of well-being thought to be sensitive to exercise, including sleep, energy level, mood, and other psychological aspects of "feeling good" (Myers et al., 1999).

Self-Efficacy: Exercise-related self-efficacy was reported using the Bandura Self-Efficacy for Exercise Scale, which has been validated among older adults (Resnick & Jenkins, 2000).

4.7 Analysis

All reporting was in accordance with the 2010 CONSORT statement for randomised pilot and feasbility trials (Eldridge et al., 2010). All data analyses were computed using Microsoft Excel (2013) and RStudio Desktop version 3.6.3 (RStudio 2020, Inc., Boston, MA). Statistical significance was set at an alpha of 0.05.

4.7.1 Phase 1: Quantitative Analysis

Participant and instructor demographic data was described and presented as mean and standard deviation for continuous normally-distributed data, count and percent for categorical data, and median and range for continuous skewed data. Recruitment rate, adherence rate, and completion rate were described as a percent and number of participants. Participant and instructor satisfaction ratings were presented as the mean score on the satisfaction questionnaire (with the score of negatively worded phrases reversed). In addition, the lowest and highest scoring phrases were noted.

Characteristics of completers versus withdrawals and adherent (attendance of ≥ 80%) versus non-adherent participants were compared post-hoc with the Mann Whitney-U test for continuous data and Fisher's Exact test for categorical data.

Outcome measures were also described and presented as mean and standard deviation for continuous normally-distributed data, count and percent for categorical data, and median and range for continuous skewed data. In addition to describing pre- and post-program scores for all efficacy outcome measures, a post-hoc analyses described age, number of chronic conditions, baseline MoCA and IPAQ scores between those that showed better scores post-program (compared to pre-program) on the Stroop incongruent task (colour-word task) and Trails B task and those that did not. In addition, these characteristics were graphed against change in the Stroop colour-word task and the Trails B times and the associations were also analyzed post-hoc using the Spearman's rank correlation test.

4.7.2 Phase 2: Quantitative Analysis

Most analyses were conducted as in phase 1. However, feasibility measures (attendance, retention, and overall program satisfaction) were also compared between the CET and ExO groups using independent t-test or (if data is skewed) a non-parametric test (i.e. Mann Whitney-U test).

Pre- and post-assessment scores for outcome measures were also described by group. In phase 2, of outcome measures, only self-efficacy and well-being were collected.

4.7.3 Qualitative Analysis

Inductive thematic analysis was used to identify, analyze, and report patterns of themes within participant and instructor interview transcripts, daily observational notes, and reports of study successes and failures (Attride-Stirling, 2001; Clarke et al., 2015; Ignatow & Mihalcea, 2016). All phase 1 interview transcripts were coded independently by two researchers (CE and CL) for accuracy, while phase 2 interview data, all observational notes, and all reports of study successes and failures were coded by one researcher (CE). To become equally familiar with the content and patterns in the phase 1 interview data, both researchers (CE and CL) immersed themselves into the data (Ignatow & Mihalcea, 2016). To establish a preliminary coding scheme and codebook (see Appendix Q for codebook format), one transcript was coded separately by the two researchers and then reviewed together. A third researcher (LM) was consulted to aid in interpretation and help with any disagreements regarding codes. Following this, a coding scheme was finalized and the two researchers (CE and CL) independently conducted line-by-line coding of the remaining phase 1 transcripts. After every three transcripts, the two researchers discussed their findings together to ensure consistency in coding. With the consultation of another researcher (LM), one researcher (CE) adapted the coding scheme and codebook to accommodate new and additional data that emerged from the observational data and the phase 2 interviews.

Codes were clustered in comprehensive themes and sub-themes with definitions. Relevant quotes for each sub-theme and theme were labelled using the following indications: "CET Participant FP" to denote a CET program participant from phase 1 (fall), "CET Instructor FI" to denote a CET program exercise instructor from phase 1, "CET/ExO Participant WP" to denote to denote a CET or an ExO program participant from phase 2 (winter), and "CET/ExO Instructor WI" to denote a CET or an ExO program instructor from phase 2. In addition, themes were reviewed and revised over the course of phase 1 and phase 2 with the wider research team to ensure that data within themes were cohesive and meaningful, while maintaining clear and identifiable distinctions between individual themes. To maximize credibility of the qualitative data, tactics such as informing the participant of their rights (e.g. their right to participate or not in the post-program interview), iterative questioning (e.g. use of probes and encouragement of honest answers), and frequent debriefing sessions to include fresh perspectives and critical feedback were implemented (Shenton, 2004).

5. Results

5.1 Phase 1

5.1.1 Participants

In phase 1, there were 39 people screened in 6 weeks for the study. Of these, eight were excluded due to an inability to follow up (i.e. initially they showed interest, but then we lost contact with them), leaving 31 people that were assessed for study eligibility. Sixteen people did not meet the inclusion criteria and four were eligible but declined study participation, leaving a total of eleven people in phase 1 of the study. Participants had an average age of 63.7 years (range 48 to 70 years), 3 were men and the majority (7 of 11) identified as Caucasian and most (6 of 11) had more than high school education (ranging from 6 to 20 years of education). The most commonly reported health conditions were arthritis (64%) and hypertension (55%). Although no participants reported a diagnosis related to cognitive impairment, 5 participants scored 25.0 or less which is a positive screen for cognitive impairment (Nasreddine et al., 2005). The IPAQ revealed an overall moderate-to-high physical activity level (median total physical activity score = 2360.0 MET-minutes/week). Participant characteristics are reported in detail in Table 1.

Three staff delivered the exercise program in phase 1 of the study. All were female and 2 of 3 were Caucasian. Average age was 31.0 years (range 24 to 31). All instructors were highly educated in a field relevant to exercise prescription (bachelor's degree or more in kinesiology or exercise physiology), with an average of 19.0 years (ranging from 17 to 22 years) of formal education. The credentials varied across instructors: 1 certified exercise physiologist; 1 registered kinesiologist; and 1 certified personal trainer. Two instructors had 10 or more years of experience prescribing exercise in practice (5 or more years at the YMCA facility), and one participant had 1 year of experience prescribing exercise.

5.1.2 Feasibility Outcomes

<u>Recruitment</u>

Eleven participants were recruited over 6 weeks, with 7 recruited during the planned 4 week recruitment period (1.8 participants/week). Due to slower than expected recruitment in the first 4 weeks, the recruitment period was extended to 6 weeks. An additional 4 participants (2 per week) were recruited. Recruitment rate increased slightly in the last two weeks due, in part, to the implementation of a study advertisement in the YMCA e-newsletter and YMCA Facebook page (yielded two recruits). Study advertisement posters and flyers posted at the YMCA facility and the University of Waterloo campus resulted in few inquiries and zero recruits. Two recruited participants did not reveal how they were informed about the study, while five were recruited via word-of-mouth (i.e. through a friend) and two participants were referred to the YMCA by clinicians and then contacted by a study recruiter. The *a priori* success criteria was to recruit 24 or more participants in one month (6 participants per week), which was not met.

The main drivers of ineligibility were lack of ability or willingness to participate during the pre-determined program days and times (n = 12), completion of the Move for Health program in the past year (n = 2), and an inability to speak and/or write proficiently in English (n = 2). No participants were excluded due to an inability to receive medical clearance. Out of the 15 eligible recruits, four declined to participate; one participant did not provide a reason, one had other commitments (providing care to a family member), and two were not interested in partaking in research.

Table 1. Phase 1 participant characteristics (mean [SD], n [%], or median [min-max], n=11).

Characteristic	**CET**
Age, years	63.7 (6.1)
Gender, male	3 (27%)
Chronic health conditions, number	3 (1)
Education, years	14.0 (3.9)
Annual income, ≤ $60,000	7 (64%)
MoCA	25.4 (3.9)
IPAQ, MET-minutes/wk [a]	2360.0 (219-3087)
Cognitive activity scale [b]	2.7 (1.2)
Social activity scale [c]	2.4 (1.2)

[a] Excluded 3 participants due to over-reporting of total minutes of physical activity per week; [b] Max score of 4; [c] Max score of 3.

Key Issues for Feasibility

There were three primary challenges with recruitment. First, to randomize at an individual level, participants were initially required to be available for all of the program scheduling options (i.e. Monday/Wednesday and Tuesday/Thursday). However, this resulted in fewer potential participants willing to make such a commitment as most had preferred days of the week and time of the day to participate. Additionally, the original timeslots chosen for the study program was early morning which was not well accepted by possible recruits. Thus, the program time was changed to mid-afternoon and eligibility and randomization procedures changed to allow participants a choice of program days. This change necessitated randomization at the group level, rather than the individual level in phase 2. Second, there was some loss of YMCA staff conducting screening and study invitations over time due to competing responsibilities, which led to the researcher conducting recruitment along with one YMCA staff member. In a future study, it is likely that additional research-specific recruitment staff would be required to screen and invite participants. Lastly, the length of time planned for recruitment was too short for this few personnel, which led to the decision to extend the recruitment period by two weeks. It is likely this extended period would be required to achieve the target numbers in future offerings.

Retention

Only one participant withdrew from the study, leaving a completion rate of 91% for phase 1, which is above the *a priori* criterion for success (75%). The participant withdrew because they considered the physical exercise to be too difficult. This participant was female, had a high number of chronic conditions (5), was one of the older participants, and had low baseline physical activity.

Key Issues for Feasibility

Retention rate for phase 1 was high. The fact that the one person who withdrew had a high number of comorbidities and found the exercise too difficult warrants further consideration regarding program intensity (i.e. additional modifications – more than what was done – may be needed).

Adherence

The overall adherence (attendance) rate was 79%, which surpasses the *a priori* criterion of 70% overall program adherence. In one session, one participant left halfway through due to a scheduling conflict and attended the cognitive training only. Thus, when breaking down adherence by activity type post-hoc, adherence was 80% for the cognitive training and 79% for the exercise training. Subgroup analyses of adherent (attendance of ≥ 80%) and non-adherent (attendance of < 80%) participants indicated that non-adherent participants were older (67.0 versus 63.0 years, p=0.004), had lower baseline physical activity (IPAQ score 2360.0 versus 2624.8, p=0.008), had lower baseline MoCA scores (20.5 versus 29.0, p=0.004), and reported more chronic health conditions (3.5 versus 2.1, p=0.001). See Table 2 for a more detailed comparison of adherent and non-adherent participants.

Participants' adherence to the Move for Health exercise program component was also captured via daily excise diary entries (see Appendix R for sample diary). Out of the ten participants who completed the study, 4 recorded in their exercise diaries every class that they attended and 6 missed logging exercises on one or two days. Diary entries typically included the duration of aerobic activities but not the associated speed, incline, or resistance. Less than half of the participants (4 of 10) reported achieving the prescribed target of 15 – 20 minutes of aerobic training (the average duration was 10 minutes) in 70% or more of their attended classes; two participants recorded spending more time than what was recommended on aerobic activities (25 – 30 minutes). Resistance training varied between participants (6 – 12 exercises prescribed) and were updated frequently to meet the participants' ongoing needs and preferences. Eight people reported completing the recommended 1 – 2 sets of 10 – 12 reps for each exercise consistently (i.e. 70% or more of their attended classes). One participant consistently completed fewer than 10 reps of each exercise, demonstrating low adherence to the exercise prescription. Six sessions were dedicated to exploring the YMCA facility to allow participants to try other activities and programs that are offered (i.e. 30 minutes of each session doing yoga, exercise circuit, aquatic exercises, etc.). It was during this period of time that exercise diary entries decreased across individuals.

Table 2. Phase 1 participant characteristics, by adherent status (median [min-max] or n [%], n= 7 adherent; 4 non-adherent).

Characteristic	Adherent	Non-adherent
Age, years	**63.0 (48-70)**	**67.0 (63-70)***
Gender, male	2 (29%)	1 (25%)
Chronic health conditions, number	**2 (1-3)**	**4 (1-5)***
Education, years	**16.0 (12-20)**	**11.5 (6-16)***
Annual income, ≤ $60,000	3 (43%)	4 (100%)
MoCA	**29.0 (24-30)**	**20.5 (19-26)***
IPAQ, MET-minutes/wk [a]	**2624.8 (880-3087)**	**2360.0 (219-2802)***
Cognitive activity scale [b]	2.2 (2.0-2.7)	2.2 (1.4-3.0)
Social activity scale [c]	2.0 (1.9-2.4)	1.6 (1.3-2.1)

[a] Excluded 3 adherent participants due to over-reporting of total minutes of physical activity per week; [b] Max score of 4; [c] Max score of 3; * Statistically significant ($p < 0.05$).

Key Issues for Feasibility

Phase 1 adherence met the criterion for success. However, two participants (spouses) missed five classes due to one participant (with 5 comorbidities) needing emergency surgery. This highlights the possibility that the health status of the participant (and their life partner) may be a barrier to adherence. Additionally, it is not clear from the YMCA exercise diaries alone if the target exercise intensity was achieved. A future trial should either adapt the exercise diary or use other measures of exercise adherence (i.e. heart rate monitors) to ensure exercise intensity is captured.

Blinding

While there was no control group in phase 1, participants were under the impression that two groups were running simultaneously on separate days of the week and that they could be assigned to either the intervention or the control. At conclusion of the study, all ten participants reported that they were unaware of what version of the program they received, indicating successful participant blinding.

Acceptance

The overall program satisfaction was 4.6 and 4.5 (out of 5) for T2 and T3, respectively, and thus succeeds the *a priori* criterion of 80% (4 out of 5). Participant's ratings from these two time points were not significantly different ($t = 1.0$, $df = 9$, $p = 0.3$). The program aspects with the highest satisfaction ratings included, but were not limited to, the quality of all program staff and overall enjoyment of the program activities; though two participants did report low ratings for "brain activity enjoyment". While the majority (77.5%) rated high satisfaction for the class structure (i.e. class duration, frequency, organization, and timing), class structure also received the largest number of neutral (i.e. no opinion) and low satisfaction responses (Table 3). Additionally, 80% of participants reported optimal difficulty for the exercise program at T3, while 50% reported optimal difficulty for the cognitive training. The rest of the sample rated the difficulty level of both activities as either somewhat easy or somewhat hard, while only one participant reported that the cognitive training was too easy (Table 4).

The instructors' overall program satisfaction percentage was 4.4 (out of 5) at T2, which increased to 4.7 by the end of the program. Therefore, the instructor's overall rating of the program surpasses the *a priori* criterion for success of 80% (4 out of 5). By the end of the program, all instructors rated overall program satisfaction at a 4 or 5, indicating high overall program satisfaction. In addition, all instructors cited optimal difficulty leading the exercise program by T3.

Key Issues for Feasibility

Participants and instructors were satisfied with the program, indicating that the program may be acceptable in a community setting. However, only 50% of participants rated the difficulty of the brain activity to be optimal. This highlights a potential need to adapt the cognitive training (i.e. adding extra, more challenging levels) to better accommodate participants' cognitive abilities and preferences for level of challenge.

Table 3. Phase 1 participant program satisfaction (T3 questionnaire, n [%] total responses, n=10).

	CET		
Program Satisfaction Categories	**High Satisfaction**	**Neutral/No Opinion**	**Low Satisfaction**
Overall Program			
a. Program enjoyment (1 statement)	10 (100%)	0 (0%)	0 (0%)
b. Respectfulness of all staff (2 statements)	20 (100%)	0 (0%)	0 (0%)
c. Quality of facility (4 statements) [a]	38 (95%)	0 (0%)	2 (5%)
d. Class structure (4 statements) [b]	31 (77.5%)	4 (10%)	5 (12.5%)
Cognitive Training			
a. Program enjoyment (1 statement)	8 (80%)	0 (0%)	2 (20%)
b. Quality of activity leader (4 statements) [c]	35 (87.5%)	3 (7.5%)	2 (5%)
Physical Exercise Training			
a. Program enjoyment (1 statement)	9 (90%)	(0%)	1 (10%)
b. Quality of activity leaders (5 statements) [c]	50 (100%)	0 (0%)	0 (0%)
Other			
a. Achievement of goals/expectations (2 statements)	18 (90%)	2 (10%)	0 (0%)
b. Recommend/endorse overall program (2 statements)	17 (85%)	1 (5%)	2 (10%)
c. Intent to continue physical activity/program (3 statements)	28 (93%)	0 (0%)	2 (7%)

Participants rated their satisfaction on a scale from 1-5 (1-2=low satisfaction, 3 = neutral, 4-5=high satisfaction). Statements were compiled into four main categories. [a] Includes facility location, space, and equipment; [b] Includes class duration, frequency, organization and timing; [c] Includes approachability, professionalism, knowledge, and leadership of activity leader(s).

Table 4. Phase 1 participant ratings of program difficulty (T3 questionnaire, n [%] total responses, n=10).

Activity Type and Difficulty Rating Scale	**CET**
Exercise program difficulty	
a. Too hard	0 (0%)
b. Somewhat hard	1 (10%)
c. Optimal	8 (80%)
d. Somewhat Easy	1 (10%)
e. Too Easy	0 (0%)
Brain activity difficulty	
a. Too hard	0 (0%)
b. Somewhat hard	2 (20%)
c. Optimal	5 (50%)
d. Somewhat Easy	2 (20%)
e. Too Easy	1 (10%)

5.1.3 Exploratory Outcomes and Analysis

All participants who completed the study completed assessments pre- and post-program. Data was missing for one participant for the Stroop task (colour naming) pre-program due to equipment malfunction. Scores for all outcome measures pre- and post-intervention are shown in Table 5. Note that statistical comparisons between pre- and post-intervention were not conducted due to small sample sizes. Therefore, indication of 'better' scores should not be taken as a statistically significant improvement.

Cognitive Function

The participants decreased their group average time on all Stroop conditions, indicating improved performance, and the majority of participants (5 to 8 out of 9) decreased their time on each task. The largest decrease in time (indicating better score post-program) was observed for the colour-word condition, which also had the largest number of participants (9 out of 9) that showed better scores post-program (compared to pre-program) out of all of the Stroop conditions (Table 5 and Figure 2). On average, participants completed the Trails A test 10.4 seconds faster post-program and 8 participants showed faster times post-program compared to pre-program. On average, participants performed more poorly on the Trails B test post-program, as they increased their time to complete by 17.7 seconds. Only four participants showed better scores post-program than pre-program in their time to complete the task (Table 5 and Figure 2).

Table 5. Phase 1 outcome assessment pre- and post-intervention (group average, n=10).

Outcome	Pre-Intervention	Post-Intervention
Stroop Task*		
Colour naming, s	33.7	31.3
Word reading, s	24.1	23.3
Named colour-word, s	59.7	52.9
Trail Making Task		
Trails A, s	47.9	37.5
Trails B, s	96.5	114.2
Timed Up-and-Go, s	8.9	6.3
Four Square Step test, s	10.3	8.2
Five Time Sit-to-Stand, s	10.2	8.4
Static Grip Strength, lbs	65.8	67.1
6-Minute Walk, # of laps	4.9	4.9
Vitality Plus scale	3.3	3.7
Bandura Self-Efficacy for Exercise scale, %	57	57

*Note: Stroop task data was missing for one participant pre-intervention due to equipment malfunction. Therefore, average scores for the Stroop task were for nine participants.

Physical Function

On average, participants had lower times post-program on the Timed Up-and-Go (2.6 seconds faster), the Four Square Step test (2.1 seconds faster), and the Five Time Sit-to-Stand (1.8 seconds faster) than pre-program. Nearly all participants (9 of 10) had better scores post-program than pre-program. Average static grip strength improved by 1.3 lbs, indicating a better average score post-program than pre-program. Five of ten participants had better scores post-program than pre-program in their static grip strength. On average, performance did not change on the 6-Minute Walk test, though seven participants showed better scores (i.e. higher average number of completed laps) post-program than pre-program (Table 5).

Overall Well-Being

Out of a maximum average score of 5, the average score for the Vitality Plus scale was 3.3 at baseline and 3.7 post-program. Seven participants demonstrated better scores post-program (i.e. increased average score) than pre-program, while two participants showed no change and one participant decreased their average score (indicating worse score post-program compared to pre-program) (Table 5).

Exercise-Related Self-Efficacy

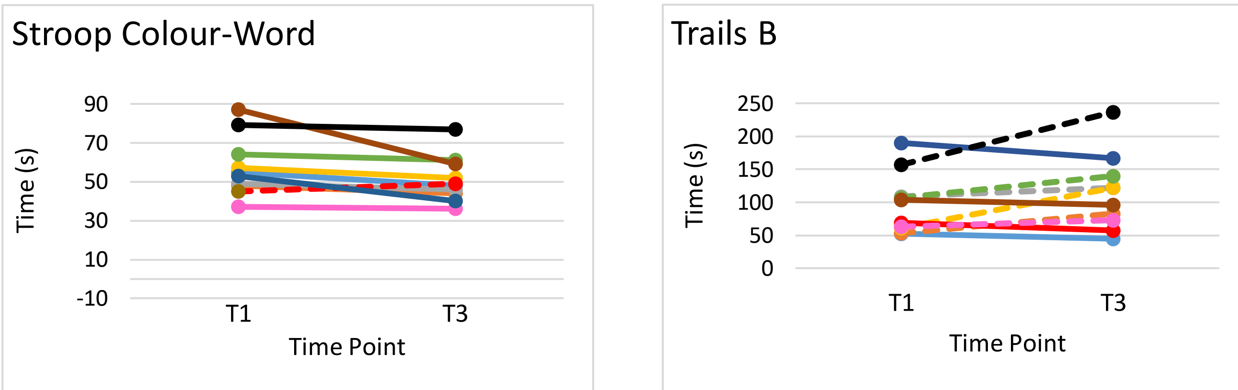
The group average for the Bandura scale score was 57% (out of 100%) at baseline and did not change post-program. Five participants demonstrated better scores post-program than pre-program in exercise-related self-efficacy, while one participant showed no change and four participants showed worse scores post-program (i.e. decreased average scores) (Table 5).

Factors Associated with Better Post-Program Cognitive Scores

Individual trajectories of change are displayed for the Stroop colour-word condition and for the Trails B condition in Figure 2, along with the characteristics of each participant. In addition, change in each cognitive outcome is graphed against and age, number of chronic conditions, baseline global cognition, and baseline physical activity in Figure 3; correlations between each pair of measures are also shown.

No correlations were near statistically significant in this sample ($p > 0.05$). However, some correlation coefficients were moderate in size, but very uncertain due to the small sample and variability. The correlation coefficients suggested people with older age, more chronic conditions, and better baseline global cognition had worse post-program scores for the Stroop color-word condition. In contrast, older adults tended to show better post-program scores than pre-program on the Trails B task.

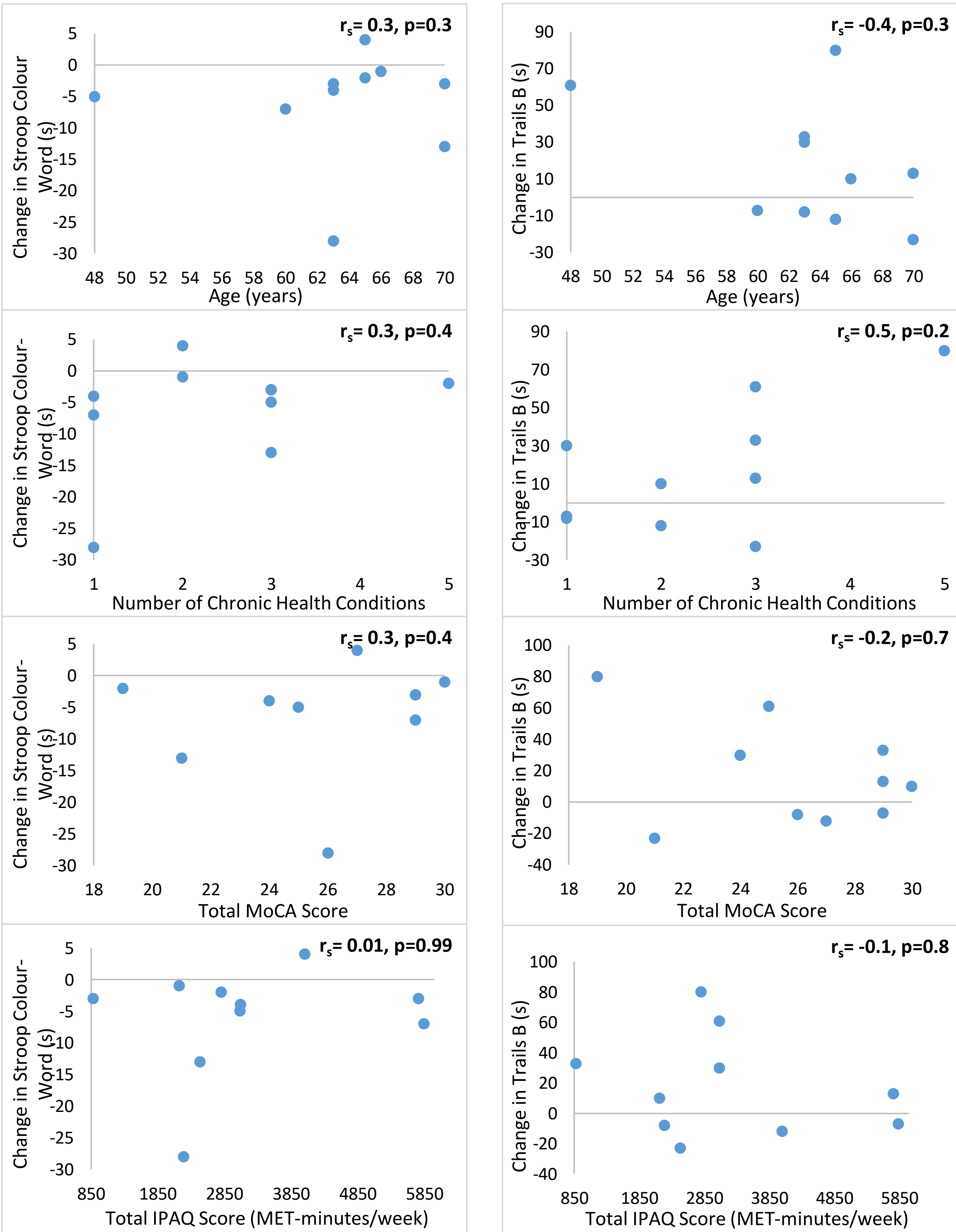
Figure 2. Pre-post trajectories and characteristics, by line colour, of participants that showed better post-program cognitive scores (solid) and those that showed worse post-program scores (dashed) than pre-program for Stroop colour-word and Trails B [a].



Characteristic	Black	Green	Yellow	Orange	Grey	Pink	Red	Light Blue	Brown	Dark Blue
Change in Stroop colour-word, s	-2.0	-3.0	-5.0	-4.0	-3.0	-1.0	+4.0	-7.0	-28.0	-13.0
Change in Trails B, s	+80.0	+33.0	+61.0	+30.0	+13.0	+10.0	-12.0	-7.0	-8.0	-23.0
Age, years	65	63	48	63	70	66	65	60	63	70
Chronic health conditions, number	5	3	3	1	3	2	2	1	1	3
MoCA	19	29	25	24	29	30	27	29	26	21
IPAQ, MET-minutes/wk [b]	2802.0	880.0	3082.5	3087.0	5758.0	2167.0	4050.0	5838.0	2238.0	2482.0

Colours are ordered from worse to better post-program scores on average; [a] Negative values represent better scores post-program; [b] Participants denoted by a light blue line, grey line, and red line over-reported their total minutes of physical activity per week.

Figure 3. Association between Stroop colour-word (seconds) and Trails B (seconds) with age, number of chronic health conditions, baseline cognitive function (MoCA) and baseline physical activity (IPAQ) [a].



[a] Negative values (decrease in pre-post completion time) represent better scores post-program.

5.2 Phase 2

5.2.1 Participants

In phase 2, 41 individuals were screened over 10 weeks, with one person excluded due to a lack of a response to follow up. Out of the remaining 40 individuals that were assessed for eligibility, six were ineligible and two declined to participate (Figure 4). A total of 32 participants (16 per group) were recruited for phase 2 of the study, and were given the option of participating Monday/Wednesday or Tuesday/Thursday. Program days (and associated participants) were randomized to CET or ExO.

The CET group had an average age of 69.0 years (range 54 to 83), 5 were men, the majority (11 of 16) identified as Caucasian, and most (10 of 16) had more than a high school education (ranging from 10 to 22 years of education). Participants in the ExO group had an average age of 66.4 years (range 54 to 74), 4 were men, most (15 of 16) identified as Caucasian, and 11 of 16 had more than a high school education (ranging from 12 to 25 years of education). The most common chronic condition reported was arthritis (75% CET and 69% ExO). No participants reported a diagnosis associated with cognitive impairment; however, 10 CET participants and 8 ExO participants scored 25.0 or less – a positive screen for cognitive impairment (Nasreddine et al., 2005). The IPAQ revealed moderate physical activity levels for both groups, with a median total physical activity score of 1463.8 MET-minutes/week and 1518.0 MET-minutes/week for the CET group and ExO group, respectively. Participant characteristics are reported in detail in Table 6.

Five staff (3 CET, 2 ExO) delivered the exercise training in phase 2. However, data was only collected from four instructors (2 for both groups), as one of the phase 2 CET instructors already participated in and completed the study during phase 1. Both CET instructors were female and identified as Caucasian. The average age of the CET instructors was 41.5 (range 41 to 42), both were highly educated with an average of 18.0 years of education (range 17 to 19). Both CET instructors were certified personal trainers and had an average of 6.5 years of prescribing exercise in practice at the YMCA (range 4 to 9). One ExO instructor was male and one ExO instructor was female, and both identified as Caucasian. The average age of the ExO instructors was 32.5 years (range 22 to 41), the average years of education was 14.0 (range 12 to 17). Both ExO instructors were certified personal trainers; one had 9 years of experience (all at the YMCA) and one had 8 months of experience (all at the YMCA).

Figure 4. Phase 2 recruitment, allocation, and assessment CONSORT flow chart.

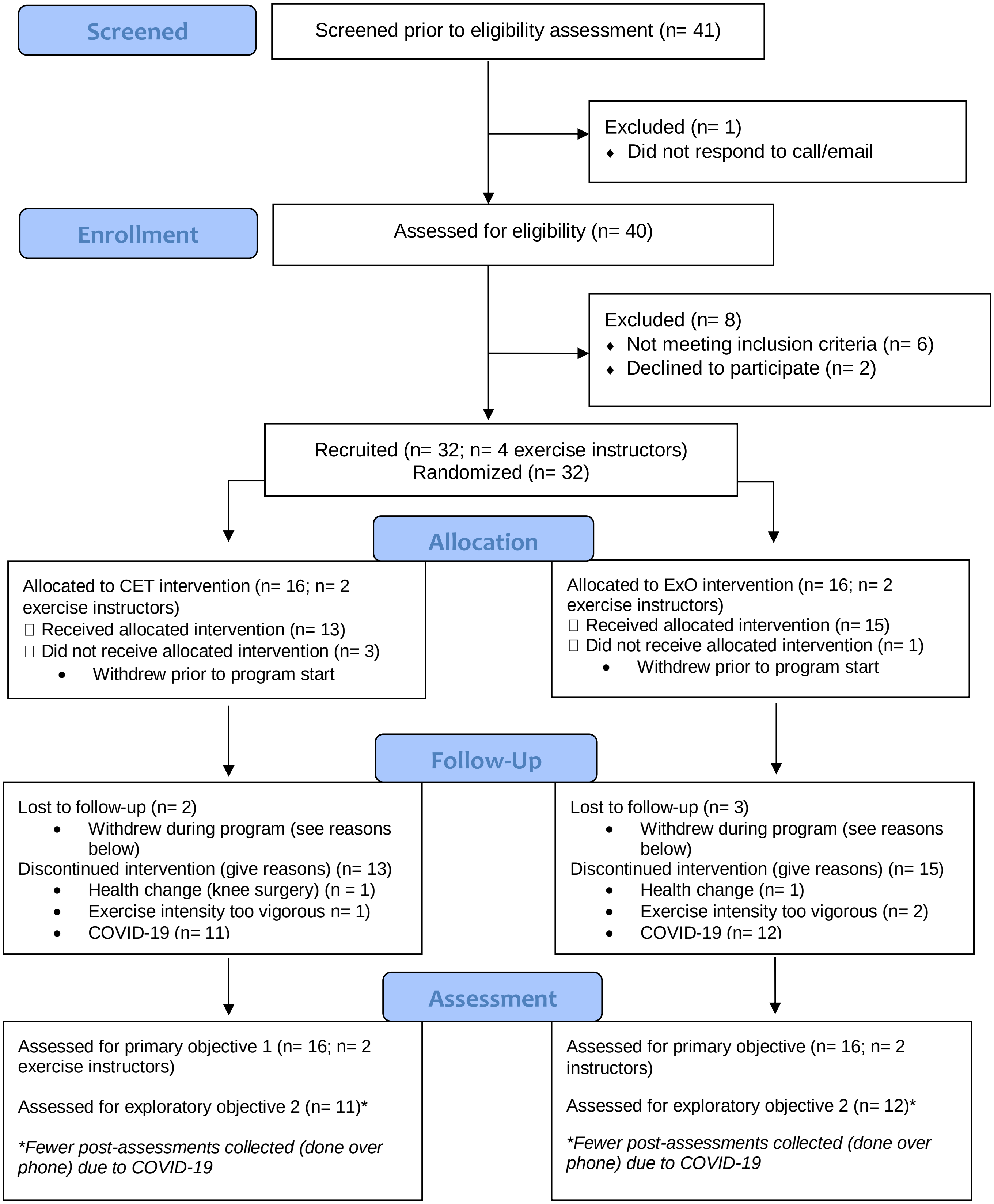


Table 6. Phase 2 participant characteristics (mean (SD], n [%], or median [min-max], n=16 CET; 16 ExO).

Characteristic	CET	ExO
Age, years	69.0 (9.1)	66.4 (5.4)
Gender, male	5 (31%)	4 (25%)
Chronic health conditions, number	1.9 (1)	2.3 (1.4)
Education, years	14.7 (3.8)	17.0 (4.4)
Annual income, ≤ $60,000	7 (44%)	6 (38%)
MoCA	24.8 (3.2)	25.9 (2.7)
IPAQ, MET-minutes/wk [a]	1463.8 (90-2605.5)	1518.0 (518-2265)
Cognitive activity scale [b]	1.9 (0.3)	2.0 (0.4)
Social activity scale [c]	1.6 (0.3)	1.7 (0.4)

[a] Excluded 4 CET and 5 ExO participants due to over-reporting of total minutes of physical activity per week; [b] Max score of 4; [c] Max score of 3.

5.2.2 Feasibility Outcomes

Recruitment

Due to the low recruitment rates in phase 1, a 10-week recruitment window was planned. Thirty-two participants were recruited over this 10-week recruitment period (3.2 participants/week). In response to challenges in phase 1, the researcher continued to assist one YMCA staff with recruitment and participants were provided the choice of program days (the timeslots were fixed to mid-afternoon hours). In addition to paper copies of posters and flyers as used in phase 1 (resulted in 2 recruits), several recruitment strategies were added. Of the 32 recruited participants, 63% had inquired about study and program details in response to an online advertisement (5 participants heard about the study through the YMCA e-newsletter or the YMCA Facebook page) or heard about the study and/or program via word-of-mouth (15 participants). Eight recruited participants (25%) were referred to Move for Health by a clinician and were then contacted by a study recruiter, and one could not remember how they were informed about the study. Additionally, the researcher promoted the study through a Meet the Researcher event at the University of Waterloo. This strategy yielded five inquiries and one recruited participant. The *a priori* success criteria (prior to phase 1) was to recruit 24 or more participants in one month (6 participants per week), which was not met.

The main drivers of ineligibility were a lack of availability and/or an unwillingness to participate during the pre-determined program days and times (n = 4) and having a condition that impeded their ability to participate (n = 2). One eligible individual declined to participate due to a lack of interest in participating in research and one declined because of other competing priorities (providing care to a family member).

Key Issues for Feasibility

The *a priori* criterion for success (6 participants/week) was not achieved, even though the recruitment rate increased by more than 50% compared to phase 1. If recruiting 6 participants/week is necessary for success, additional program times (the main reason people were ineligible) or additional recruitment staff would be needed.

Retention

Nine of 32 participants (five of 16 CET and four of 16 ExO participants) withdrew from the study, leaving a completion rate of 72% (69% for CET and 75% for ExO) which does not meet the 75% success criterion. There was no significant difference between the completion rates of the two arms ($p = 0.96$). Post-hoc analyses showed quite high retention (83%; 85% in CET and 80% in ExO) among program starters (i.e. excluding 4 participants who withdrew prior to the start of the program). Reasons for dropping out prior to the start of the intervention varied: 2 CET participants (a spousal dyad) cited undisclosed changes in health unrelated to the study, 1 CET participant opted to participate in a different research study, and 1 ExO participant sustained a serious leg injury just prior to the start of the program. The most common reasons for withdrawal during the program were that the physical exercise was too challenging and/or vigorous given the participant's conditions (n= 1 CET, 2 ExO) and changes in health unrelated to the study (n= 1 CET [a planned surgery was rescheduled to an earlier date], 1 ExO). Subgroup analyses of completers versus withdrawals revealed that withdrawals were older (69.0 versus 66.0 years, $p<0.001$) than those that completed the intervention, but were otherwise similar (see Table 7 for more detail).

Key Issues for Feasibility

Though retention rate in phase 1 was high (91%), the retention rate in phase 2 of 72% did not meet the success criterion (75%). Four of 9 participants withdrew prior to the start of the study and did so for various reasons: undisclosed health changes unrelated to the study (n= 2), opting to participate in a different research study (n= 1), and sustaining an injury as a result of a fall (n= 1). Given these reasons, it is difficult to see how these withdrawals can be mitigated in a future study. A larger study will be needed to examine any patterns of common reasons explaining drop-outs prior to the start of the study, and to identify potential strategies to address this issue. On the other hand, the most common reason to withdraw during the program in phase 2 was that participants found the exercise to be too challenging (n= 3). Broad inclusion criteria that allows a diversity of abilities and medical conditions may make retention more challenging. Thus, further individualizing the exercise component (as done somewhat here) may minimize this issue in future trials.

Table 7. Phase 2 participant characteristics, by completion status (median [min-max] or n [%]), n=23 completers; 9 withdrawals).

Characteristic	Completers	Withdrawals
Group allocation, CET	11 (48%)	5 (56%)
Age, years	**66.0 (54-83)**	**69.0 (11)***
Gender, male	6 (26%)	3 (33%)
Chronic health conditions, number	2.0 (1-5)	2.0 (1-5)
Education, years	15.0 (11-25)	16.0 (10-24)
Annual income, ≤ $60,000	16 (70%)	7 (78%)
MoCA	25.0 (20-30)	25.0 (19-29)
IPAQ, MET-minutes/wk [a]	1518.0 (90-2265)	1560.0 (518-2605.5)
Cognitive activity scale [b]	1.9 (1.5-3)	1.9 (1.7-2.1)
Social activity scale [c]	1.6 (1-2.5)	1.8 (0.9-2.2)

[a] Excluded 6 completers (2 CET; 4 ExO) and 3 withdrawals (2 CET; 1 ExO) due to over-reporting of total minutes of physical activity per week; [b] Max score of 4; [c] Max score of 3; * Statistically significant ($p < 0.05$).

Adherence

Participants that withdrew prior to the start of the program (attendance rate of zero) were excluded from all adherence calculations and analyses. Due to facility closure due to COVID-19, the ExO group was provided 12 of 24 sessions and the CET group was provided 11 of 24 sessions (minus one because of a holiday Monday). The overall adherence (attendance) rate for phase 2 was 73%, with the same attendance in both groups and thus was not significantly different ($p = 0.7$). This meets the *a priori* criterion of 70% adherence to all program components (i.e. cognitive and exercise training for CET and exercise training only for ExO). Three CET participants missed half of a program session due to scheduling conflicts: two missed the cognitive training and one missed the exercise training. So, when breaking down adherence by activity type for the CET group post-hoc, adherence was 74% for the exercise component and 73% for the cognitive component. Subgroup analyses revealed that those who were non-adherent (attendance of ≥ 80%) were older (69.0 versus 66.0 years, p=4.0e-06), had lower baseline physical activity (IPAQ score 1280.0 versus 1584.0, p=7.5e-09), had lower baseline MoCA scores (25.0 versus 27.0, p=8.0e-07), and reported more chronic conditions (3.0 versus 1.0, p=5.9e-07). Otherwise the participants of each group were similar (see Table 8 for other characteristics).

Table 8. Phase 2 participant characteristics, by adherence status (median [min-max] or n [%]), n=17 adherent; 11 non-adherent).

Characteristic	Adherent	Non-adherent
Group allocation, CET	7 (41%)	6 (55%)
Age, years	**66.0 (54-81)**	**69.0 (54-83)***
Gender, male	4 (24%)	4 (36%)
Chronic health conditions, number	**1.0 (1-5)**	**3.0 (1-5)***
Education, years	16.0 (11-25)	15.0 (10-25)
Annual income, ≤ $60,000	11 (65%)	9 (82%)
MoCA	**27.0 (20-30)**	**25.0 (21-30)***
IPAQ, MET-minutes/wk [a]	**1584.0 (708-2265)**	**1280.0 (90-2605.5)***
Cognitive activity scale [b]	1.9 (1.5-3)	1.9 (1.6-2.1)
Social activity scale [c]	1.5 (1-2.5)	1.8 (0.9-2.2)

[a] Excluded 5 adherent (1 CET; 4 ExO) and 3 non-adherent (2 CET; 1 ExO) due to over-reporting of total minutes of physical activity per week; [b] Max score of 4; [c] Max score of 3; * Statistically significant ($p < 0.05$).

As in phase 1, participant adherence to the physical exercise component was captured for both study groups via daily exercise diaries. We were not able to retrieve the exercise diary for one ExO participant. Eight participants (n=5 CET, 3 ExO) did not provide diary entries for 1-2 of their attended classes, while the remaining 14 participants logged their exercises for every class that they attended. Similar to phase 1 participants, participants usually recorded only the duration of aerobic exercise, and not markers of intensity (speed, incline, or resistance). Only 9 participants (n=3 CET, 6 ExO) reported completing the recommended target of 15 – 20 minutes of aerobic training each class, and the rest achieved an average of 10 minutes. With the exception of three participants (1 CET, 2 ExO), the rest recorded the reps, sets, and weight of their resistance exercises consistently throughout the program (i.e. 70% or more of their attended classes). All participants reported accomplishing the target number of sets (1-2) and reps (10-12) for each exercise. The number of exercise diary entries per class appeared to increase over time.

Key Issues for Feasibility

Based on the pre-determined criterion, the overall adherence of 73% met feasibility criteria (70%) and adherence did not differ between intervention groups. However, as observed in phase 1, participants did not record markers of intensity of aerobic exercise. Future studies should consider adapting the exercise diaries or adding an objective measure of exercise intensity (i.e. heart rate monitors) so that exercise intensity can be captured throughout the program.

Randomization & Blinding

Interventions were randomized by program days after the pre-assessments were completed. Of those that were asked about their group allocation post-program, 100% of CET participants (11 of 11) and 58% of ExO participants (7 of 12) reported that they did not know which intervention they received. However, all 5 ExO participants who thought they knew their intervention group correctly reported their program allocation.

Key Issues for Feasibility

Due to participant preferences for program days and times, a 1:1 randomization was not possible in the current study. Therefore this study was quasi-experimental, as the interventions were randomized by program days. This approach was considered more feasible and should be considered for a larger scale study, recognizing the need for a pragmatic approach (though, with a large enough sample, cluster randomization may also be possible).

The same strategies to facilitate blinding implemented in phase 1 were applied here. However, 5 participants correctly reported their program allocation, all in the ExO group. All 5 participants were also recruited via word-of-mouth by a phase 1 participant, which likely contributed to their ability to identify their study group. Therefore, while word-of-mouth is an effective recruitment strategy, it may be a potential barrier to successful participant blinding. Additionally, three participants (1 CET, 2 ExO) reported being YMCA members. While it is unclear if this impacted blinding in the current study, it is possible that these participants attended the facility on their non-program days during the timeslot of the other intervention. This raises the challenge of conducting the CET and ExO interventions at the same facility. One potential way to overcome this challenge is to expand the study to multiple site locations and cluster randomize the interventions by site location.

Acceptance

Due to facility closure due to COVID-19, participants only completed one satisfaction questionnaire (at T2, 6 weeks into the program). In addition, two withdrawn participants (n= 1 CET, 1 ExO) were provided online copies of the satisfaction questionnaire since they withdrew during week 5 of the program and were considered to have similar experience to program completers. The overall program satisfaction was 4.5 out of 5 (4.5 for CET and 4.4 for ExO), meeting the *a priori* criterion of 80% (4 out of 5). The satisfaction ratings were not significantly different between groups (U=90, p=0.5). The phase 2 participants were highly satisfied with the quality of the program staff overall. Moreover, 69% of all participants rated the exercise training difficulty as optimal, and 75% of the CET participants rated the cognitive training difficulty as optimal. However, enjoyment of the cognitive training varied across CET participants, resulting in lower percentages of high satisfaction responses. In addition, class structure received lower satisfaction ratings from CET and ExO participants. A subset of participants (3 CET, 2 ExO) provided detail in the open-ended questions, saying that more time was required for the exercise training. Additional detail in satisfaction responses is provided in Tables 9 and 10.

The overall program satisfaction rate for the instructors was 4.0 out of 5 (3.9 for CET instructors and 4.1 for ExO instructors), thus just meeting the *a priori* criterion (40 of 5, 80%). These satisfaction ratings were not significantly different from each other (U=1, p=0.7). The statements with the highest ratings from the CET and ExO instructors included, but were not limited to, perceived participant enjoyment of all program activities (cognitive and exercise training) and overall personal enjoyment leading the exercise. For all instructors, statements with the lowest ratings were related to class duration and equipment availability for participants. In the open-ended questions 1 CET and 1 ExO instructor recommended adding more time to the exercise component. Out of all of the instructors, 3 (n= 2 CET, 1 ExO) rated the difficulty level of delivering the exercise as somewhat hard and only one instructor (ExO) rated it as optimal.

Key Issues for Feasibility

Similar to phase 1, the average participant satisfaction rating met the high pre-determined criterion for acceptance which indicates that it may be feasible to achieve high acceptability of the CET program in a community-setting. However, only 60 to 75% of participants found exercise and cognitive training to be the right level of difficulty. To further enhance acceptability, further individualization of the exercise and cognitive training to both abilities and readiness or desire for challenge should be considered.

Table 9. Phase 2 participant program satisfaction, by group (# [%] total responses, n=12 CET; 13 ExO).

	CET			ExO		
Program Satisfaction Categories	**High Satisfaction**	**Neutral/No Opinion**	**Low Satisfaction**	**High Satisfaction**	**Neutral/No Opinion**	**Low Satisfaction**
Overall Program						
a. Program enjoyment (1 statement)	12 (100%)	0 (0%)	0 (0%)	13 (100%)	0 (0%)	0 (0%)
b. Respectfulness of all staff (2 statements)	23 (96%)	1 (4%)	0 (0%)	26 (100%)	0 (0%)	0 (0%)
c. Quality of facility (4 statements) [a]	47 (98%)	1 (2%)	0 (0%)	50 (96%)	2 (4%)	0 (0%)
d. Class structure (4 CET statements, 3 ExO statements) [b]	38 (79%)	4 (8%)	6 (13%)	26 (66.6%)	5 (13%)	8 (20.5%)
Cognitive Training						
a. Program enjoyment (1 statement)	9 (75%)	1 (8%)	2 (17%)	-	-	-
b. Quality of activity leader (4 statements) [c]	46 (96%)	0 (0%)	2 (4%)	-	-	-
Physical Exercise Training						
a. Program enjoyment (1 statement)	9 (75%)	0 (0%)	3 (25%)	13 (100%)	0 (0%)	0 (0%)
b. Quality of activity leaders (5 statements) [c]	57 (95%)	1 (2%)	2 (3%)	58 (89%)	5 (8%)	2 (3%)
Other						
a. Achievement of goals/expectations (2 statements)	20 (83%)	3 (13%)	1 (4%)	20 (77%)	3 (11.5%)	3 (11.5%)
b. Recommend/endorse overall program (2 CET statements, 1 ExO statement)	20 (83%)	2 (8.3%)	2 (8.3%)	13 (100%)	0 (0%)	0 (0%)
c. Intent to continue physical activity/program (3 statements)	28 (78%)	4 (11%)	4 (11%)	32 (82%)	5 (13%)	2 (5%)

Participants rated their satisfaction on a scale from 1-5 (1-2=low satisfaction, 3 = neutral, 4-5=high satisfaction). Statements were compiled into four main categories. Unless specified, number of statements are equal for CET and ExO questionnaires. [a] Includes facility location, space, and equipment; [b] Includes class duration, frequency, organization and timing; [c] Includes approachability, professionalism, knowledge, and leadership of activity leader(s).

Table 10. Phase 2 participant ratings of program difficulty, by group (# [%] total responses n=12 CET; 13 ExO).

Activity Type and Difficulty Rating Scale	CET	ExO
Cognitive Training Difficulty		
a. Too hard	0 (0%)	-
b. Somewhat hard	1 (8%)	-
c. Optimal	9 (75%)	-
d. Somewhat easy	2 (17%)	-
e. Too easy	0 (0%)	-
Physical Exercise Training Difficulty		
a. Too hard	0 (0%)	1 (8%)
b. Somewhat hard	1 (8%)	2 (15%)
c. Optimal	9 (75%)	8 (62%)
d. Somewhat easy	2 (17%)	2 (15%)
e. Too easy	0 (0%)	0 (0%)

5.2.3 Exploratory Outcomes

All CET and ExO participants who remained in the study up until week six (when facility closure occurred due to COVID-19) completed pre-program and post-program phone assessments. No cognitive or physical function assessments were conducted.

Overall Well-Being

Among CET participants, the average score on the Vitality Plus scale was 3.4 (of 5) at baseline and 3.6 (of 5) at week six (Table 11). Seven CET participants showed better average scores at week six than pre-program while one showed no change and three showed worse average scores (i.e. decreased averages) at week six.

The ExO participants' average Vitality Plus score of 3.5 (out of 5) did not change at week six (Table 11). Seven participants showed better average scores at week six compared to pre-program, while one showed no change and four displayed worse average scores at week six.

Exercise-Related Self-Efficacy

For CET participants, the average Bandura exercise-related self-efficacy score was 56% at baseline and 53% (out of 100%) at week six (Table 11), where higher scores are better. However, six CET participants reported better exercise-related self-efficacy scores (i.e. increased average) at six weeks compared to pre-program, while five showed worse scores.

Participants in the ExO group showed no change in exercise-related self-efficacy from baseline to week six (63% at both time points) (Table 11). Seven participants showed better average exercise-related self-efficacy scores at week six compared to pre-program, while one showed no change and four demonstrated worse average scores at week six.

Table 11. Outcome assessment pre-intervention and at week six (group average, n= 11 CET; 12 ExO).

	CET		ExO	
Outcome	**Pre-Intervention**	**Week Six**	**Pre-Intervention**	**Week Six**
Vitality Plus scale	3.4	3.6	3.5	3.5
Bandura Self-Efficacy for Exercise scale, %	56	53	63	63

5.3 Overall Feasibility Outcomes (Phases 1 and 2)

Over the two study phases, 80 people were screened for study and program eligibility. Of those, 71 were assessed for eligibility and 43 participants were recruited. The average recruitment rate across phases was 2.5 participants per week, falling well short of the criteria for success (6 participants/week). Retention was 78% (80% for CET and 75% for ExO [phase 2 only]), thus meeting the *a priori* criterion for success (≥ 75%). The average adherence rate across study phases was 75% (76% for CET and 73% for ExO [phase 2 only]), also meeting the prior criterion for success (≥ 70%). Participant satisfaction ratings averaged 4.5 out of 5 overall, and were similar for CET and ExO (4.5 and 4.4, respectively), therefore surpassing the criterion for success (≥ 4 of 5). Average instructor satisfaction ratings was 4.2 out of 5 (4.3 for CET and 4.1 for ExO [phase 2 only]), also surpassing the criterion for success.

5.4 Themes from Qualitative Data: Phases 1 and 2

Ten of 11 phase 1 participants and 22 of 32 phase 2 participants (10 CET, 12 ExO) participated in the post-program interviews; one phase 2 CET participant opted out of the post-program interview and one phase 2 CET participant opted not to be audio recorded during the post-program interview (but agreed to have written notes taken of their responses). Therefore, a total of 32 participant interviews and 7 instructor interviews were conducted, all of which were included in the analysis. The average duration of the interviews was 14.8 ± 4.7 minutes and 15.2 ± 5.9 minutes for phase 1 and phase 2 participants and instructors, respectively. The thematic analysis revealed three major themes: 1) progression and successes motivate participant adherence, 2) participants' diverse abilities and preferences influence study feasibility; and 3) pragmatic approach leads to variability in intervention and experience.

Theme #1: Progression and successes motivate participant adherence

There are many sources that contributed to participants' motivation to adhere to the intervention. In particular, participants reported that observed and perceived progression and successes throughout the program were important motivators. Noticeable improvements in participants' physical and mental health were reported in and out of program, which in turn increased motivation to continue participation.

Sub-theme 1.1: Improvement in cognitive training performance inspired participants

Participants and instructors (including the researcher) observed improvements in participants' cognitive performance over the course of the program. Participants from both study phases were able to see improvements in statistics at the end of the cognitive training each day, which made them happy and encouraged them to continue and become more engaged in the training. This was acknowledged by both instructors and participants:

> *"Yeah [the cognitive training reports] shows that uh practice can improve your cognitive ability […] so that was encouraging." – CET Participant WP26*

> *"Definitely you could see like they were getting faster and like getting more into it." – CET Instructor FI03*

However, the visual displays of session results also highlight if participants performed worse than previous sessions. This resulted in some participants feeling discouraged, as observed by the researcher:

> *Some [phase 1 participants] were disappointed by having slow response results/not getting high accuracy – C.E. (researcher observational notes)*

Thus, receiving feedback about their progressions and successes in the cognitive training was a motivator; however, it is clear that negative feedback may have opposing effects on program satisfaction and motivation to adhere.

While personal improvements were a primary driver of motivation, friendly competition and comparisons between participants also contributed. Specifically, some participants would discuss and compare their cognitive training session results immediately after and/or during the exercise component. This was observed by instructors as well as the researcher observing the sessions:

Two participants discussed and compared their cognitive training session scores afterwards (in friendly way) – C.E. (researcher observational notes)

"I really enjoyed seeing how excited and engaged participants were with the cognitive aspect of the program." – CET Instructor FI01

In addition, it was evident that motivation driven by improvements also led to a greater desire to maintain engagement in cognitive activities outside of the program. This was noted by one phase 1 participant:

"That encouraged me-when I came here for the cognitive training […] it's just not enough to read the newspaper and you need to do more. [The cognitive training] made me do more." – CET Participant FP06

Therefore, it is evident that the daily visual displays of the participants' performance on the cognitive training was a motivator to continue the program, as well as a motivator to engage in cognitive activities outside of the program.

Subtheme 1.2: Exercise-related improvements were perceived and objectively observed during the program

In addition to improvements observed for the cognitive training, exercise-related improvements have also shown to motivate participants. Personal progressions and successes related to physical function and ADLs were reported by all participants. Along with testimonies of improvements in objective medical tests (i.e. lower blood sugar and increased lung capacity) and perceived improvements in strength, sleep, stamina, and overall energy, some participants reported other feelings of improved health:

"I feel like it was working on the chronic pain, I think it was helping." – CET Participant WP38

"My blood pressure started to go down." – ExO Participant WP24

"I was able to stand up from a chair easier." – CET Participant WP17

Thus, it is evident that many participants reported personally meaningful successes related to physical function and daily living. However, improvements associated with physical exercise were not limited to physical health. Many reported improvements in social engagement, mood, and other areas of psychological and mental health, as noted by the following participants:

> *"I think I'm sort of prone to depression um and I can look at the negative side. But I find that when I exercise, that helps me a lot." – CET Participant FP03*

> *"I am more social and have a more positive outlook since I started the program." – ExO Participant WP14*

Further, two participants from phase 2 expressed their joy in discovering and/or rediscovering physical activities that they can do independently, indicating perceived improvements in exercise related self-efficacy. One participant reported:

> *"I was always so scared [to go biking] and [the program] proved to me that yes you can." – ExO Participant WP43*

One instructor confirmed that the participants' self-confidence in their ability to do an exercise is always a main consideration when prescribing, saying:

> *"We're giving them ideally exercises that they have the confidence to do themselves." – CET Instructor WI04*

Similar to the cognitive training, the motivation driven by exercise-associated improvements increased in-program adherence and it inspired participants to maintain physical activity post-program. For instance, two participants reported:

> *"Mainly I liked committing to an exercise program and perhaps I'll do it in the future." – ExO Participant WP14*

> *"I am more motivated now to continue mainly what I've been doing here […] because um whatever I gained, I don't want to lose." – CET Participant FP02*

In addition to participant and instructor interviews, researcher observations also recognized a positive relationship between motivation and progressions in abilities. Specifically, the researcher reported the following observation regarding the exercise component:

> *Over time participants appear to be striving to improve and are more engaged with the [exercise] task. – C.E. (researcher observational notes)*

Participants' motivation during the study were driven by successes associated with the CET program. Noticeable improvements in participants' physical and mental health were observed both in and out of program, enhancing program satisfaction, adherence, and motivation to engage in healthy behaviours outside of the program.

Theme #2: Participants' diverse abilities and preferences influence study feasibility

In addition to program-associated improvements, participants' unique abilities and program-related preferences influence study feasibility. Due to the broad and inclusive study eligibility criteria, the sample was medically and socially diverse. While this resulted in a group of participants that was more reflective of the community, it also introduced a range of preferences and abilities which influenced program feasibility outcomes such as satisfaction, retention, and adherence. Furthermore, the diversity of participants also led to challenges with accommodating each participant's needs and wants, as stated by one instructor:

> *"It's always challenging to get people of different levels of ability and then also comfort." – CET Instructor FI02*

Sub-theme 2.1: Diverse abilities led to diverse levels of satisfaction

Participants had very different physical and cognitive abilities at study entry, and accordingly responded differently to the program components. It was evident that some participants perceived the exercise as challenging, while others thought otherwise:

> *"I thought [the exercises] would be easier." – CET Participant WP18*

> *"For me, I found [the exercises] sometimes a little easy." – CET Participant FP01*

One participant acknowledged that they were slower at completing their exercises in comparison to others in the program due to their health conditions:

> *"I was different than the rest of them [...] the other people they could jump from one thing to another, it took me a long time to do one exercise, so I would say I was very behind compared to the other, uh, people." – CET Participant WP15*

Similarly, the range of the participants' cognitive abilities gave them different experience with the cognitive training, which ultimately translated to their overall program satisfaction. The interview data revealed contradicting views on the difficulty level of the cognitive activity. Some reported that it was too easy, while others described it as optimal and helpful:

> *"Other people may have thought [the cognitive training] was simple but, it was fine for me." – CET Participant WP15*

> *"It's not, to me, not cognitively challenging." – CET Participant WP38*

These conflicting comments reflect the variability in the participants' abilities related to the cognitive and exercise components of the program. As a result of the range of abilities across participants, there were mixed opinions of both components which may have influenced their overall program satisfaction.

<u>Sub-theme 2.2: Personal preferences along with program flexibility affect adherence and satisfaction</u>

In addition to the spectrum of physical capabilities, the heterogeneous sample reported a wide variety of preferences pertaining to the physical, cognitive, and social aspects of the program. For instance, the researcher reported that some participants appeared to prefer aerobic exercise over resistance training, saying:

> *Some prefer cardio over resistance training and spend more time (than what is recommended by the instructors) on cardio – C.E. (researcher observational notes)*

The participants' exercise diary entries confirmed that some participants spent more time doing aerobic training, resulting in fewer resistance exercises logged and, presumably, completed (see "Adherence" sections). Preferences for some types of exercises over others may have also impacted participant adherence to the prescribed program. However, it should be noted that the qualitative data did not reveal any explicit information related to why aerobic exercises were preferred.

Several people also reported that they liked the cognitive activity and that it was interesting and fun like a video game:

> *"I like the cognitive training. That was a very nice […] Um makes you think more, makes you use your brain more." – CET Participant FP06*

> *"The cognitive part of it was just like a, fun, video game-y type activity […] it seemed to complement doing [the exercises]." – CET Participant WP30*

However, some were indifferent to it and described the cognitive training as long and repetitive. One participant reported in the recommendations section of the satisfaction questionnaire:

> *"I did find [the cognitive training] very repetitive […] A little more variety and a little shorter." – CET Participant FP05*

Again, these reports demonstrate the variety of preferences associated with the cognitive training activity. Given that some of these comments were revealed in the satisfaction questionnaire (in addition to the interviews), it emphasizes the impact that these varying preferences likely had on the participants' experiences and thus their overall satisfaction ratings.

Although there was no purposeful social intervention, there was an inherent social component within the group-based exercise setting. Enjoyment seemed to be influenced by the variability in participants' social preferences. For instance, the observational notes highlighted that many participants enjoyed exercising with others, while some preferred to exercise independently. This was confirmed by a few participants in the interviews, with one phase 1 participant reporting:

> *"I don't like talking when I'm doing my exercises." – CET Participant FP04*

Another ExO participant said the following when asked about their thoughts on the social connections or social aspects of the program:

"It was about me […] it was taking whatever opportunity I could get to help myself." – ExO Participant WP25

While social engagement may have motivated some, socializing during the exercise may also have some negative impacts. For example, the researcher observed that socializing sometimes resulted in reduced adherence to the exercise prescription, as stated in the observational notes:

Sometimes conversations (with other participants) would go for too long […]. Resulted in participants doing the same exercise for too long, lose count of reps, or do less than what is prescribed." – C.E. (researcher observational notes)

In contrast, observational notes also stated that participants created social connections, in part, by discussing their exercises and helping each other remember how to execute proper form. It was also expressed by instructors and participants that socializing during the program created a sense of belonging and accountability that ultimately resulted in greater program adherence and retention:

"Everyone really connected well…It's also really beneficial in building that kind of community so I think that's part of the reason that they are coming back." – CET Instructor FI03

"Everybody had issues, everybody was there for a reason. Nobody really criticized anybody […] and like everybody was in the same boat." – ExO Participant WP24

"Um I love the group um accumulation and the instructor […] I enjoyed the group setting. There's accountability." – CET Participant FP08

Therefore, this sample was diverse and thus had varying preferences and abilities related to the CET program (design and difficulty), which influenced program retention, adherence, and satisfaction. Consistent with the retention and adherence data, the qualitative data revealed an association between varied physical abilities and program retention and exercise adherence. Furthermore, while it is possible that a preference to socialize during exercise hindered adherence to the prescription, creating social connections may have facilitated overall program retention and adherence.

Theme #3: Pragmatic approach leads to variability in intervention and experience

In addition to diverse physical, cognitive, and social preferences and abilities, feasibility of the study was likely influenced by the research methods themselves. The design of the current study was pragmatic. That is, it was meant to replicate a program as it could occur in a real-world setting. This approach inevitably introduced challenges and factors beyond the researchers' control. The qualitative data revealed that, as a result of taking a pragmatic approach, there were challenges associated with the consistency of program delivery (specifically the exercise component). In addition, conducting the study in an established community centre impacted how participants perceived the experience, and thus influenced recruitment, adherence, and participant blinding.

Sub-theme 3.1: The pragmatic approach diminished consistency of program delivery

The pragmatic approach of this study inherently introduced variability in the intervention. For example, the restricted amount of time for the exercise program contributed to more inconsistencies with program delivery. For example, the instructors and participants often reported that the program duration was too short, and participants developed individual work-arounds to complete the exercise prescriptions. One participant reported:

> *"I came early so that I could get the extra time in because I wasn't getting through all of the stuff I wanted to get through." – ExO Participant WP25*

Other participants reported a variety of methods to get their exercise routines accomplished, including arriving early, staying late, or completing some exercises at home.

The addition of cognitive training to the exercise program further exacerbated the issue of too little exercise time. The CET instructors were particularly aware of this problem, with one saying:

> *"I found the challenge was transitioning between um our classroom option down to working out and then making sure everybody was back in time to get to their cognitive piece." – CET Instructor WI07*

The researcher also observed that it was typical for the exercise to run five minutes late. Consequently, CET participants who were randomly assigned to complete the cognitive training after exercise were often late. In an attempt to avoid this, instructors of the CET group decided to end the exercise component five minutes earlier than the active controls; thereby adding variability in program delivery and adherence between the CET and ExO groups.

Also, a new element of the program was introduced unknowingly to researchers. That is, participants explored the YMCA facility in 6 sessions over the last 6 weeks of the program (phase 1 only). Participants explored the facility as a group and participated in 30 minutes of different exercise programs that the YMCA offers (e.g. yoga, aquatic exercises, and circuit training). The remaining time of the class was spent on their own individual resistance and aerobic programs as normal. Most participants reported that these YMCA "fieldtrips" increased program variety and, therefore, increased their enjoyment and satisfaction with the program. However, it reduced the consistency of the exercise intervention. In addition, phase 2 participants completed the intervention at 6 weeks so were never introduced to the YMCA facility exploration. A few expressed their desire to do something like this as part of the program:

> *"I would've loved to have had a chance to do other things at the Y."* *– CET Participant WP38*

However, the YMCA fieldtrips were optional. While the majority usually participated, there were 1 – 3 participants each class that opted out and completed their prescribed exercises instead. Consequently, the duration and content of some of the exercise sessions was inconsistent among phase 1 participants, adding further variability to the intervention.

Taking a pragmatic approach also limited control over certain program elements, including the location of the exercise and the instructors and volunteers involved in the study. For instance, due to scheduling conflicts with other regular YMCA programs, the location of the exercise component differed between phases 1 and 2. In phase 1, the exercise component took place in a more secluded space that is typically used for the Move for Health program and other similar programs. However, in phase 2 the exercise component was located in the main conditioning room that is open for use to all YMCA members during operating hours. According to the observational reports, the types of equipment available did not differ substantially between the two locations. However, the researcher noted that the exercise location in phase 2 was visibly larger than the one used in phase 1, and phase 2 participants also acknowledged the large exercise space:

> *"I didn't feel it was too crowded."* *– ExO Participant WP20*

"And I liked that there were two or three different areas that you could go to um when you were off the cardio. So again that you're not on top of each other." – ExO Participant WP31

"The space and equipment was fantastic." – CET Participant WP33

However, several instructors reported that the larger space affected their ability to connect with each participant and monitor the group to ensure they were adhering to their programs safely and efficiently. For instance, two phase 2 instructors commented:

"Because it is a bigger space it was harder to keep track of where people were […] especially when people are learning new exercises." – ExO Instructor WI06

"One negative of the space is how spread out we were um so the challenge of initially um helping to develop a program." – ExO Instructor WI05

In addition, coordinators of the research study had no control over the instructors and volunteers involved with running the exercise portion of the program. However, the decision to conduct the study in a well-established facility with a qualified and experienced staff dedicated to running these exercise programs enhanced program consistency. Many participants reported that the high quality of the instructors contributed greatly to their overall program satisfaction, with two participants saying:

"[The instructors were] friendly, approachable, um knowledgeable, interested in your health." – ExO Participant WP14

"I was treated like a person." – CET Participant FP05

However, there were notable discrepancies in the quality of the volunteers between the CET and ExO groups in phase 2. According to the observational notes, the volunteers in the CET group had over 1 year of experience volunteering at the YMCA; whereas the volunteers assigned to the ExO group were new to volunteering at the facility. Opposing comments regarding the helpfulness of the volunteers were noted by participants as well as instructors. For instance, one phase 2 CET participant commented:

"The volunteer is personable, helpful, and sets a good example for physical fitness." – CET Participant WP38

In contrast one ExO instructor expressed their dissatisfaction with the unreliable attendance of their volunteers, citing:

> *"[…] we really didn't have any volunteers so […] it's a difficult thing to ensure that we have those two volunteers, especially for a [participant] group that size."* – *ExO Instructor WI06*

This further adds to the inconsistencies in how the program was delivered and perceived and thus likely impacted participant and instructor program satisfaction.

Sub-theme 3.2: Some participants perceived the study as a YMCA program, influencing their experience

Using a pragmatic program also meant that some participants perceived their experience as taking part in an implemented YMCA program, while others only viewed it as participating in a research study. Therefore, the pragmatic approach led to participants having different interpretations of their own experiences, which impacted recruitment, adherence, and participant blinding.

Viewing the experience through different lenses influenced the participants' decision to participate, and thus impacted recruitment. For instance, several participants from both phases acknowledged and appreciated that the program was cost-free, despite being notified early on that there were no fees because it was a research study. For example, two participants reported:

> *"The fact that it was free was really I think probably opened a lot of doors for people."* – *CET Participant WP38*

> *"I came here because it was free."* – *ExO Participant WP25*

This is further complemented by the fact that all Move for Health programs were free at the time, because of sponsorship from the Local Health Integration Network – so some participants saw this as one of many Move for Health classes. Therefore, some participants perceived the experience as taking part in a free YMCA program which contributed to their decision to join and complete the program and, thus, increased recruitment. On the other hand, a few individuals cited that participating in an exercise research study was one of their main reasons for agreeing to do the program (either for personal interest or to help someone else). Two participants were quoted saying:

"Well I'm interested in participating in academic studies and I've done it a number of times." – *CET Participant WP34*

"I knew I was doing my part to help somebody with their project." – *ExO Participant WP42*

In contrast, it was clear that many participants remained cognisant of the fact that they were participating in a research study due to, in part, how they were recruited. For example, it was reported in the researcher's observational notes that several active control participants from phase 2 were inquisitive about whether or not they were going to do any "cognitive stuff" in the program. When questioned about their group allocation, these same participants correctly identified their group, with some reporting:

"[A friend] had done a study where they did cognitive exercises, and I thought we'd be doing that too but we didn't in this one so." – *ExO Participant WP35*

"I sort of thought well we must be the uh the control group because I just didn't feel like we were doing those extra things that I thought we might be doing." – *ExO Participant WP31*

As evidenced by other recorded testimonies, all of the participants that knew their group allocation were recruited via word-of-mouth from a phase 1 participant. Therefore, while word-of-mouth was an effective recruitment strategy, it also influenced how participants perceived the experience and hindered participant blinding. Moreover, participants continued to perceive the experience as participating in a research study because they were more conscious of the researcher who was observing the program sessions. In fact, the presence of the researcher was viewed by some as an additional incentive to adhere more to the exercise and to the study overall. One instructor and participant commented:

"Having a trainer over there and the researcher is present - that keeps me mindful about things like even unconsciously." – *ExO Participant WP32*

"I will say that our attendance was not bad […] compared to the attendance we would get with classes where there's no researcher waiting for them." – *CET Instructor WI04*

Therefore, the pragmatic design of the current study introduced challenges and factors beyond the control the researchers that ultimately influenced feasibility outcomes. Specifically, challenges associated with structural elements of the program impacted consistency of exercise program delivery. Furthermore, conducting the study in a well-established community centre influenced participants' perceptions of the intervention as a research study or as a program.

6. Discussion

This feasibility study suggests that a larger scale trial of CET may be feasible in a community setting, provided adjustments are made to study protocols. Despite a wide range of participant abilities and preferences (which made it difficult to meet all participants' needs), completion rate, adherence rate, and satisfaction ratings met or surpassed *a priori* criteria for success when collapsed across study phases. Only phase 2 retention and phase 1 and 2 recruitment rates were short of success. People who were older, with lower physical activity and baseline global cognitive function, and more comorbidities were less likely to complete the trial. However, these people are also at higher risk of dementia, making them an important target group. Additional supports or individualization may be needed to enhance retention in this group. Although the addition of new recruitment strategies in phase 2 increased recruitment rates, the results still fell well short of recruitment targets. A lack of availability or desire to participate in the program on certain days or times was the primary reason for ineligibility, indicating that greater variety of program times may be necessary in a future trial.

The results of this study suggest that a larger scale quasi-experimental trial of CET against ExO may be feasible and acceptable with some adjustments. Overall retention rate across phases surpassed the *a priori* criterion of 75%. However, phase 2 retention fell short of this target (72%) primarily because of non-starters across groups, who made up nearly half of the withdrawn participants in phase 2. This poses as a potential issue for trial feasibility, as it would be an unproductive use of resources to assess a large number of people who did not start the trial. Previous studies have reported that older adults tended to be less physically active and more sedentary during the winter months compared to other seasons (Arnardottir et al., 2017; Cepeda et al., 2018). Therefore, it is possible that the lower retention rate observed in phase 2, which was conducted during the winter, was due to seasonality. If this is the case, it is likely that annual retention rates would be sufficient, as overall retention across both phases of the study met the success criterion. Alternatively, if the low retention was due to inherent issues with the two-arm study, additional retention strategies would need to be implemented. These could include more frequent check-ins with participants by exercise providers and researchers (i.e. to ensure exercise intensity is appropriate and to address any other general concerns), and further individualization of exercise programs to ensure appropriate exercise intensity.

More optimistically, retention was high among program starters for both CET and ExO. As a result, the CET program (not trial) appears likely to be feasible and acceptable, indicating potential for implementation into community programming. Furthermore, adherence rates, as indicated by attendance, were similar between CET and ExO groups and were also similar to published systematic reviews and individual studies of group exercise in older adults (McPhate et al., 2013; Picorelli et al., 2014; Callisaya et al., 2017; Falck et al., 2017), computerized cognitive training in healthy and cognitively impaired older adults (Gigler et al., 2013; Djabelkhir et al., 2017), and of CET programs in healthy older adults (Nishiguchi et al., 2015; Desjardins-Crépeau et al., 2016).

Our study found similar adherence rates (as measured by attendance) and retention rates for the CET and ExO groups, which contradicts two prior studies that found lower adherence for cognitive training (Turunen et al., 2019) and CET (Lam et al. 2015) compared to exercise interventions. Researchers have hypothesized that combined interventions may be more demanding, resulting in worse adherence (Lam et al. 2015; Turunen et al., 2019). Even though the CET group intervention was 90 minutes compared to 60 minutes for the ExO group, this did not appear to adversely affect adherence or retention in the current study. However, prior studies had some or all of the cognitive training completed at home, which may have led to lower adherence compared to the current study (Lam et al. 2015; Turnunen et al., 2019). Additionally, both prior studies were longer in length compared to the current study (12 months to 2 years). It has been previously suggested that interventions that are supervised by a certified instructor, take place in a group setting, and are shorter in length have greater adherence rates (McPhate et al., 2013; Picorelli et al., 2014). This is in line with the qualitative data of the current study, which revealed that encouraging instructors and social engagement were motivators to participate for participants, as in previous studies (Amieva et al., 2010; Farrance et al., 2014). It is also possible that the shorter program length in the current study was perceived as more manageable and, thus, less fatiguing or overwhelming. Therefore, these findings highlight the need for group-based, supervised CET programs to be available and accessible to people in community facilities.

Adherence to the exercise training (in contrast with attendance) was more difficult to capture accurately in this study, due to inconsistent reporting. Exercise diaries were the primary indicator of adherence to exercise prescriptions; however, exercise intensity was not captured in the YMCA exercise program diary entries. A future study should alter the diaries to specifically probe for intensity, or should have participants wear heart rate monitors as an objective measure of intensity (Box 1).

Furthermore, the current study demonstrated that greater retention and adherence was associated with fewer chronic conditions, higher baseline MoCA scores, and higher baseline physical activity. Due to the small sample size in both phases, these findings should be interpreted with caution. However, these results are in agreement with previous studies that investigated adherence to exercise programs (Jancey et al., 2007; Findorff et al., 2009; Stineman et al., 2011; Shatil, 2013) and to CET programs (Lam et al., 2015; Turunen et al., 2019) in healthy and cognitively impaired older adults. Altogether, this suggests that participants with more chronic health conditions, poorer global cognition, and lower physical activity may require further program modifications to accommodate their needs. Additional strategies, such as providing more social and motivational support, may also be necessary to enhance adherence among individuals with these characteristics. Alternatively, participants with these characteristics may also be more vulnerable to getting sick (especially during the winter season), more likely to feel fatigued following exercise and require more rest in between sessions, and/or more hesitant to travel in poorer weather. Therefore, strategies to help accommodate for these potential barriers to adherence and retention may need to be considered. This could include offering the option of home-based cognitive and exercise training and providing a third optional day of program (i.e. for those who miss sessions). Furthermore, it should be noted that the effect size estimates and sample size calculations for future trials may have to consider reduced attendance among these more at-risk groups.

Younger age was also associated with better program retention and adherence in the current study. The literature, however, has reported inconsistent findings regarding age and program adherence, with some exercise studies reporting better adherence with younger age (Sjösten et al., 2007; Dolansky et al., 2010), others reporting better exercise and cognitive training adherence with advanced age (Stineman et al., 2011; Double & Birney, 2016), and one CET study reporting null results (Lam et al., 2015). While the relationship between adherence and age is not entirely clear, it is possible that older adults may be less likely to adhere due to increased vulnerability to health issues. Alternatively, those that are older may be less able or willing to travel to a facility during inclement weather or they may have other competing priorities (i.e. babysitting grandchildren).

Though success criteria were met for most feasibility outcomes, recruitment was slower than the target, which could be a challenge to future trials of CET program feasibility and efficacy. However, the target recruitment was large based on the needs for this small feasibility study. In a larger feasibility RCT, there are several adaptations that could support recruitment rates. First, future trials could expand to more location sites to increase the sampling pool and thus, facilitate achieving recruitment targets. Second, increasing the recruitment period duration (i.e. to 10 weeks) and including the researcher in the recruitment process likely contributed to the slight increase in recruitment rate from phase 1 to phase 2. Additional recruitment staff would likely support recruitment rates in a future trial (Box 1). Most impactful, it was evident that potential participants expected to have choice of program days/times in this pragmatic setting. Changing the program time from early morning to mid-afternoon, in part, increased recruitment in this study. Making the CET program available at a variety of times of the day would likely have the most impact on recruitment rates (Box 1). One possible way to implement this would be to pair cognitive training with all Move for Health program offerings, and cluster randomize by facility location.

Participants were highly satisfied with the CET program (as well as ExO), in line with prior studies of computerized cognitive training among cognitively healthy older adults (Schmiedek et al., 2010; Kueider et al., 2012; Hill et al., 2015). For example, Figueiredo et al. (2017) investigated satisfaction of a computer-based cognitive training program among thirty community-dwelling healthy older adults. Following a group training session to become familiar with the software, participants were given thirty days to complete nine games (ninety exercises per game) that trained executive function, attention, visuospatial reasoning, and memory. Results showed that 100% of participants reported that they enjoyed using the cognitive training program, citing that the exercises were stimulating and the instructions were easy to understand (Figueiredo et al., 2017). The fact that the cognitive training was perceived as "stimulating" is consistent with the responses that some participants provided during the interviews of the present study. In addition, CET participants in this study reported that they were inspired to engage in other cognitive activities outside of the program. Feelings of enjoyment during an activity is a form of intrinsic motivation (Deci, 1975), and has been associated with greater long-term adherence of healthy behaviours (Teixeira et al., 2012). Therefore, enjoyment of the cognitive training likely contributed to the high overall CET program satisfaction ratings, and could have facilitated motivation to adhere to the program and to continue engagement long after the program ended.

Though participants had high satisfaction with the program overall, the diversity in individual cognitive abilities created some challenges to meeting preferences and needs. Acceptance data and interview data both revealed that CET participants had varied perceptions regarding the difficulty of the cognitive training, from being optimal to being too easy. In part, this may be explained by the cognitive training being insufficiently challenging for participants with very good baseline global cognitive function. This is not well supported in our study. A post hoc analysis indicated that 60% of the people who indicated that the cognitive training was somewhat or too easy had high baseline cognition (MoCA scores of 26 – 29); however, 40% of participants that described the training as somewhat or too easy had cognition below screening cut-offs for cognitive impairment (MoCA scores of 21 – 23). This indicates a discordance between cognitive abilities and perceived difficulty. A prior study of computerized cognitive training found that individual preferences for level of challenge influenced feasibility and acceptability of the training program under study – that is, some participants appreciated challenge while others did not (Hill et al., 2015). Furthermore, previous studies have found that those who are more open to new or challenging experiences and those with a more positive attitude towards cognitively demanding tasks showed greater cognitive training adherence (Gignac et al., 2004; Jaeggi et al., 2014). As a result, individualization to abilities may not entirely address issues related to perceived difficulty, which may be driven by personality rather than ability.

In addition to introducing diverse participant abilities, the pragmatic approach also introduced inconsistencies in exercise delivery. Participants often found the exercise duration too short, and so introduced individual work-arounds to complete unfinished aerobic and/or resistance exercises (e.g. arrive early, stay late, or do exercises at home). Furthermore, adding the cognitive training after exercise compounded the problem as CET instructors typically ended the exercise earlier than the ExO group to ensure participants arrived to the cognitive training on time. Therefore, conducting the cognitive training before exercise would likely lead to a more consistent exercise program duration (Box 1). On the other hand, some suggest greater efficacy of CET when exercise precedes cognitive training (Legault et al., 2011; Langdon & Corbett, 2012), though the literature is inconsistent (Oswald et al., 2006). More information is needed to confirm the effects of activity order on CET program feasibility and efficacy.

The pragmatic approach also allowed the introduction of changes or adaptations to the program mid-study, as was observed in this trial. For example, the location of the exercise program changed between phase 1 and phase 2, which appeared to alter the level of instructor supervision and participant social engagement. In addition, the YMCA introduced facility exploration, which was not communicated to the researchers. This not only introduced a novel program element, but also resulted in inconsistencies in the program across participants because facility explorations were optional. While participants reported increased program enjoyment and satisfaction because of the variety added by the YMCA explorations, the lack of consistency of the exercise intervention would be a potential confounding factor affecting efficacy outcomes.

Lastly, due to using a pragmatic approach, the research coordinators had no control over the instructors and volunteers that were delivering the exercise program. Most of the instructors had several years of experience and all were certified exercise providers, which enhanced consistency of delivery within and between groups. High satisfaction with the quality of instructors was also reported both in the acceptance data and interview data, which likely impacted overall program satisfaction and program adherence, as shown in a previous mixed-methods systematic review (Farrance et al., 2016). However, there were notable discrepancies of the instructor- and participant-reported quality of the volunteers between the CET group and ExO group; specifically, the volunteers assigned to the ExO group were less experienced. Not only did this contribute to between-group inconsistencies regarding the exercise intervention, but it also likely impacted overall satisfaction. While it may be possible to restrict the experience and expertise of program instructors and volunteers, this would decrease the extent to which the intervention reflects the real-world delivery, as desirable in a pragmatic trial.

In this study, we leveraged an existing program (Move for Health) and combined it with cognitive training. An alternative, but still pragmatic approach, would be to implement and evaluate the CET intervention as a standalone program in community centres – that is, separate from an existing exercise program. This would allow for more control over program variables and delivery, including the target population and the intervention dosage, while still providing the program in a pragmatic setting. In such a study, participant eligibility and interventions could be designed based on best-evidence, while still being readily translatable to the 'real-world'. For example, participation could be restricted to those at highest risk of dementia due to being inactive (Riebe et al., 2018) or by virtue of having subjective or objective cognitive impairment. Sedentary older adults and those with subjective cognitive complaints have shown to benefit from community-based exercise (Yan et al., 2009) and cognitive training (Kwok et al., 2013), and individuals with these characteristics have shown to be at greater risk for developing dementia (Mitchell et al., 2014; Yan et al., 2020). It should be noted, however, that there is no conclusive evidence that those at risk for dementia are more likely to benefit from CET than healthier individuals.

Providing CET as a standalone intervention may also have the advantage of aligning program characteristics to best-evidence from the literature. While there is no consensus regarding optimal dosage of exercise or cognitive training (alone or combined), the CET frequency of the current study was on the lower end of the range (2 – 5 times per week) that has been previously studied (Li et al., 2011; Zhu et al., 2016; Lauenroth et al., 2016). A more frequent program may be more beneficial. In particular, aerobic exercise is recommended to be performed at least 3 days of the week for cognitive and overall health purposes (Nagamatsu et al., 2012; Lampit et al., 2014; Lauenroth et al., 2016; Riebe et al., 2018). Thus, a CET program that is at least 3 times per week may have greater global benefits. In addition, a purposefully designed CET may have physical exercise that requires complex movement sequences and/or coordination, which may result in greater cognitive benefits due to the engagement of higher order cognitive brain regions (Coubard et al., 2011; Predovan et al., 2012). However, the potential disadvantages of offering CET as an independent intervention includes scheduling conflicts and restrictions due to other running programs, and recruitment barriers with more restrictive eligibility criteria.

Furthermore, community programming and clinical trials have become more challenging in the wake of the COVID-19 pandemic. Here, phase 2 of the study was required to halt at the mid-point (6 weeks). This meant that participants only received half of their anticipated interventions. Consequently, results are unlikely to reflect the impact of a 12-week program. Furthermore, we were unable to describe changes in cognitive and physical function within or between groups as these measures could not be collected. Finally, it is possible that the adherence and completion rates were overestimated for phase 2, as the study was cut short.

COVID-19 has also highlighted a need to consider remote programming. Future trials should evaluate virtual and/or home-based versions of CET. Participants who cannot or choose not to travel to community centres (i.e. due to inclement weather, physical or mobility limitations, and/or limited transportation options) may also benefit from this alternative method of program delivery. However, home- and virtual-based CET would require participants to have access to cognitive training and exercise-related equipment (i.e. a computer or touch tablet, resistance bands and free weights) and have sufficient familiarity with such equipment to be able to conduct the intervention independently and safely (especially exercise). In addition, technological difficulties, like unstable Wi-Fi connections, may introduce unnecessary frustration among participants and instructors. These complications, in addition to lower instructor and peer engagement, could explain why previous studies have shown worse program adherence for home-based exercise and CET interventions compared to centre-based (Picorelli et al., 2014; Lam et al. 2015; Turnunen et al., 2019). It has also been proposed that facility-based CET may be less reliant on self-motivation as the routine is defined by the researchers (Lam et al., 2015). On the other hand, lower adherence to home-based training for some participants may be due to a lack of the necessary technological skills and lack of ownership of or easy access to the necessary equipment (Turnunen et al., 2019). In addition, Picorelli et al. (2014) postulated that home-based program adherence rates may be vulnerable to self-reporting biases and, thus, under or over-estimation. Virtual-based exercise sessions and online tracking of completed cognitive training sessions could help minimize the issues to self-reported adherence to home-based programs (Picorelli et al., 2014; Turnunen et al., 2019).

Virtual group sessions could also help overcome a number of barriers associated with home-based participation. First, the sessions could be done in a group setting, providing social engagement and peer support. Second, qualified instructors could supervise remotely. Both of these factors are shown to enhance participant motivation to adhere in the current study and in previous research (Amieva et al., 2010; McPhate et al., 2013; Farrance et al., 2014; Picorelli et al., 2014). In addition, supervision by qualified instructors could help overcome some of the intensity restrictions normally encountered with home-based exercise, especially among persons with chronic conditions. Therefore, home-based CET or remote program delivery may provide as an attractive option to participants with mobility limitations, and as a realistic method for researchers evaluating the intervention during a pandemic.

Exploratory analysis of outcomes had mixed effects. Most CET participants in phase 1 had better scores post-program than pre-program for the Stroop task. These results suggest potential positive changes in inhibition and selective attention following CET, in line with other exercise studies (Liu-Ambrose et al., 2010; Nagamatsu et al., 2012; Best et al., 2015), cognitive training studies (Kelly et al., 2014; Reijnders et al., 2013; Coyle et al., 2015) and CET studies (Desjardins-Crépeau et al., 2016). Any positive changes in the Stroop task should be interpreted with the utmost caution. Behavioural measures of cognition, including the Stroop, have shown to be vulnerable to practice effects (Lemay et al., 2004; Buck et al., 2008), even with test-retest intervals lasting from 12 – 16 weeks (Salinsky et al., 2001) to several years (Calamia et al., 2012). Further, there is no consensus on the clinically meaningful change for the Stroop task, though researchers have called for a need for consensus on this issue (Davis et al., 2011).

In addition, our participants had poorer scores post-program on the Trails B task, indicative of decline in task-switching performance. Since it has been shown that cognitive improvements are somewhat confined to the trained cognitive functions (Lauenroth et al., 2016), it is possible that participants relied more on inhibition and selective attention, rather than task-switching (the primary cognitive skill targeted by the Trails B task), to successfully complete the cognitive training activity. Impact of CET, and CET versus ExO, in a community setting on cognitive outcomes needs further research.

The association between improvements in the cognitive outcomes and participant characteristics were explored in this study. Results should be considered with the utmost caution as correlations were far from significant. The Spearman rank coefficients, however, suggested a trend for greater cognitive improvements among individuals with fewer chronic health conditions in CET participants for both cognitive outcomes. It is possible that participants that reported fewer chronic health conditions in the current study were in a better position to adhere to the program (as observed) and were, thus, able to achieve greater improvements on the Stroop colour-word task and the Trails B task. However, the relationship between number of chronic conditions and change in cognitive performance was likely driven by a few outliers. Moreover, considering that frail older adults and those with multiple chronic conditions are at greater risk for MCI and dementia (Robertson et al., 2013; Santini et al., 2015; Livingston et al., 2017), people with multiple comorbidities should not be excluded. Instead, additional strategies may be needed to maximize program engagement and benefits for individuals with more chronic health conditions, either by individualizing the intervention to their abilities (as done somewhat) or providing additional encouragement/supports for attendance.

Box 1. Summary of recommendations for future feasibility and efficacy trials and program implementation.

Recommendations for Future Trials and Program Implementation

Study Design
 	
• Recruitment:
    o Increase recruitment duration (e.g. to 10 weeks) and have a research-specific recruitment staff of 3 or more people
    o Expand study site locations to increase sampling pool
    o Offer study participation at all scheduled times of the Move for Health exercise program
    o Cluster randomize by timeslot or by study site
 	
• Exercise training component
    o Adapt exercise diary or add heart rate monitors to track exercise intensity/adherence
 	
• Cognitive training component
    o Schedule cognitive training before exercise to minimize impact of inconsistency in exercise program class duration

This study has several notable strengths, but it also has some limitations. Our pragmatic and inclusive approach meant that our study examined a CET program in a way that it could be implemented in the real-world, among participants that enter community lifestyle programs. We also included daily observations, which allowed us to go beyond summary measures of feasibility and give insight into adherence to a detailed study protocol. Unfortunately, our study could not be completed as originally planned, both due to low recruitment rates and due to an early ending as a result of COVID-19. In addition, though the sample was more representative than most clinical trials with respect to medical conditions, education, and socioeconomic status, our participants were mostly females so it is not clear whether the results would also represent males. Lastly, the factors influencing program adherence and cognitive gains addressed in the current study are not exhaustive. Prior computer use (Turunen et al., 2019), personality type (Gignac et al., 2004), metacognitive beliefs (Jaeggi et al., 2014), and baseline psychological health (Picorelli et al., 2014) may also influence CET feasibility and training-related cognitive changes.

Prior to this study, there was no published research evaluating the feasibility of implementing this kind of intervention in a community-based setting. The results of the current study suggest that CET may be feasible and well accepted by older adults of the community. However, a future trial would be limited by slow recruitment, unless additional strategies could be implemented to enhance recruitment. For example, increasing the variety of program times may be necessary to increase recruitment to achieve the target rates. Participants that were older, reported more chronic conditions, had poorer baseline global cognition, and lower baseline physical activity were less likely to retain and adhere. This suggests a need for additional strategies to enhance retention and adherence among these individuals. Conducting the study and program through alternative methods, such as home- or virtual-based sessions or as a standalone program, should also be considered to enhance program delivery consistency and effectiveness. The information from this study provides important lessons and recommendations that can better inform future larger trials of CET and program implementation (Box 1). Therefore, this study is an essential first step towards further program evaluation and wide-spread implementation, and thus has the potential to benefit the cognitive health of older adults across Canada.

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Appendices

Appendix A

YMCA Smart Start Application

YMCAs of Cambridge & Kitchener-Waterloo
YMCA Wellness Programs

Office Only
Reviewed by:
Physician Approval Required:
☐ Yes ☐ No
☐ Member
☐ Program Card
SMART START Session
Date: ______/_____/_____
Instructor:

Smart Start Application

Date *(yyyy/mm/dd)* ____________/______/______

SMART START is a free one hour customized introduction to individual and group wellness programs at the YMCA. **SMART START** is for anyone with a chronic condition and/or low fitness level. Please complete this **SMART START** application and return to A.R. Kaufman Family YMCA or Chaplin Family YMCA in order to book your **SMART START** session. We look forward to giving you customized instruction and direction to help you get started with exercise.

PARTICIPANT INFORMATION - *please complete the following*				
Last Name	First Name		Birth Date *(yyyy/mm/dd)*	Age / ☐ M ☐ F
Address	City	Postal Code	Home Phone	
Cell Phone	Email		Emergency Contact Full Name	
Emergency Contact Home Phone	Emergency Contact Cell Phone		Relationship to Participant (ie. friend)	

How did you learn about our programs/facility? ______________________________

Is there a specific wellness program you would like to participate in? If yes, please list name of program:

____

MEDICAL HISTORY *(Please check all that apply to you)*

☐ Cardiac *(heart)* event: Date ______/_____/_____
Description ______________________
☐ Angina
☐ Other heart condition
Description ______________________
☐ Diabetes: ☐ Type 1 ☐ Type 2 ☐ At Risk
☐ Insulin dependent
☐ Diabetes complications ______________________
____
☐ Stroke or TIA Date ______/______/______
☐ Residual effects
Description ______________________
☐ High blood pressure
☐ Neurological Condition
Description ______________________
☐ Arthritis (Osteoarthritis/ Rheumatoid)

☐ Joint replacement*(s)*: Date ______/_____/_____
Description ______________________
☐ Osteoporosis
☐ Painful joint /bone/muscle
Description ______________________
☐ You have had a fracture in the last two years
Description ______________________
☐ COPD/ Asthma
☐ Depression/Anxiety
☐ Injury/Accident Date ______/______/______
Description ______________________
☐ Cancer: Date ______/_____/_____
Currently receiving treatment ☐ Yes ☐ No
☐ You have had a surgical procedure in the last two years
Description ______________________
☐ Other; please list ______________________

SMART START DETAILED SCREENING Q & A

**Please complete during phone/in person screening of application*

1) If YMCA member already, how are you using your membership?

2) I notice from your application that you have listed your goals as.....can you tell me a little more about what you want to achieve?

3) I noticed that you have checked that you recently completed a rehab program. Do you have an exercise plan from your therapist? If yes, could you please bring to your smart start session.

4) Do you feel your health conditions (say specific ones they listed on the application) you have are controlled?

5) Is your doctor aware that you are interested in participating in a fitness class/facility?
If yes, record answer here.
If no, mention the CSEP Get Active Questionnaire. We will give them a copy of the CSEP questionnaire at their smart start session. They can fill this out on their own and discuss with their doctor. This is for their information only, we do not need this back.

6) Can you tell me a little about what types of physical activity that you have done in the past that you enjoyed?

7) If individual not planning on joining the YMCA and requires home exercise program: What types of equipment and/or space do you have access to?

Appendix B

Description of Balance, Posture, Coordination, and Agility Exercises

Example 1. Heel-to-toe walking

Examples of Balance Exercises:

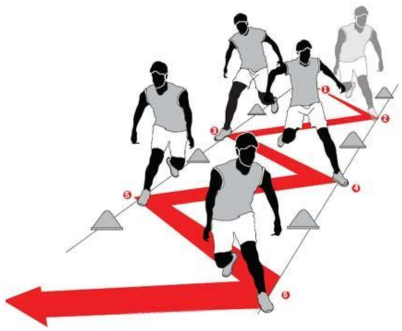
- Narrow stance, tandem stance, single leg stance hold, kickstand/tree pose (eyes open and closed)
- Heel-to-toe walking
- Standing on a bosu ball
- Seated march on an exercise ball

Example 2. Wall angels

Examples of Posture Exercises:

- Standing overhead press against a wall (a.k.a. standing wall angels)
- Floor wall angels
- Chink tuck exercise
- Dowel-assisted exercises (i.e. squats, bird-dog)

Example 3. Zig-zag hops



Examples of Coordination/Agility Exercises:

- Pole walking around indoor track/gym
- Agility ladder patterns (i.e. in-in-out-out, side-stepping)
- Zig-zag hops (i.e. speed skater-like steps/hops from one numbered rubber pad to another)

Appendix C

YMCA Physician Screening Letter

YMCAs of Cambridge &
Kitchener-Waterloo

January 2019

Wellness Programs Physician Letter

Dear Health Care provider,

Your patient ______________________________, ____________________ (D.O.B)
is interested in participating in a YMCA Wellness Program.

We offer supervised individual and group exercise programs for those with numerous conditions including but not limited to; osteoporosis, arthritis, diabetes, controlled cardiac conditions, COPD, neurological conditions and/or impaired physical mobility. These programs are designed and supervised by Registered Kinesiologists and YMCA fitness trainers.

Sessions generally include: safe and effective, light to moderate intensity exercise that includes a warm-up, cardio, resistance training and cooldown. Healthy living education is also provided in a number of wellness programs.

Please check one and provide details if required:

☐ I am not aware of any contraindications for participation in this program.

☐ The applicant can participate in the program, but I urge caution because:

____

____

☐ The applicant can participate in the program but should not engage in the following activities:

____

____

This patient has my approval to begin an exercise program with the recommendations or restrictions stated above.

Health Care Provider Name *(please print)* ______________________________

Health Care Provider Signature ____________________ Date ________/________/________
(yyyy/mm/dd)

FORM SUBMISSION

Patient returns completed letter to the YMCA **OR**

Direct referral via email or mail to the YMCA and include patient contact information below:

Physician/clinic stamp

Patient Name *(please print)* ______________________________

Phone Number ____________________ or Email ____________________

Note: *This program participation approval is valid for a maximum of six months and becomes invalid if your medical condition changes.*

A.R. Kaufman/Stork Family YMCA
Attn: Katelyn Corke R. Kin
333 Carwood Avenue, Kitchener, ON N2G 3C5
T: 519-743-5201 x 230 | **F:** 519-743-5204
E: katelyn.corke@ckw.ymca.ca

Chaplin Family YMCA
Attn: Jeremy Tiller CSEP-CEP
250 Hespeler Road, Cambridge, ON N1R 3H3
T: 519-623-9622 x 2214 | **F:** 519-621-6580
E: jeremy.tiller@ckw.ymca.ca

Appendix D

Participant Demographics Questionnaire

City of Residence: ________________________

DOB & Age (month and year only):________________________

Gender: ☐ Male ☐ Female

Ethnicity: _____________________________

Years of Education (starting at gr.1):_____________

1st (Primary) Language: ____________________

Current Marital Status: ☐ Married ☐ with Partner ☐ Single ☐ Widowed

Handedness: ____________ (left, right, or ambidextrous)

Height (to the nearest cm):_________________cm

Weight (to the nearest 0.1 kg):________________kg

BMI (to the nearest 0.1 kg/m2): __________________ kg/m2

BP (to the nearest 1mmHg): _____________ / _____________mmHg Resting HR:

Waist Circumference (to the nearest cm): __________________ cm

Mobility Aid: ☐ Yes ☐ No If yes explain:____________________

In the past 2 months, have you fallen (ended up on the ground or floor)?

☐ Yes ☐ No

If yes;

a) Have you fallen more than once? ☐ Yes ☐ No

b) Were you injured as a result of the fall(s) ☐ Yes ☐ No

c) Did you have trouble getting up? ☐ Yes ☐ No

Physical Activity History:

Did you participate in moderate to strenuous physical activity 3x/week (or more);

As a teenager ☐ Yes ☐ No

In Midlife ☐ Yes ☐ No

Currently ☐ Yes ☐ No

Comorbidities and Medications

Could you please report any health problems you have experienced?

Heart Attack or Heart Operation ☐ Yes ☐ No ________________________________

Disease of the Arteries ☐ Yes ☐ No ________________________________

High Cholesterol ☐ Yes ☐ No ________________________________

Diabetes (diet or insulin) ☐ Yes ☐ No ________________________________

Heart Murmur ☐ Yes ☐ No ________________________________

Congenital Heart Disease ☐ Yes ☐No________________________________

High Blood Pressure ☐ Yes ☐No________________________________

Chronic Back Pain ☐ Yes ☐ No ________________________________

Knee Injury ☐ Yes ☐ No ________________________________

Hip Injury ☐ Yes ☐ No ________________________________

☐ Other: ____

Cognitive Health

Do you feel like your memory or thinking is becoming worse?

☐ Yes ☐ No

If yes;

a) Does this worry you? ☐ Yes ☐ No

b) Do you feel like your memory or thinking is worse than that of other people the same age as you? ☐ Yes ☐ No

Do you have a clinical diagnosis of mild cognitive impairment or dementia?

 Yes No

These questions (related to cognitive health) were adapted from two sources: (1) Jessen, Frank, Rebecca E. Amariglio, Martin Van Boxtel, Monique Breteler, Mathieu Ceccaldi, Gaël Chételat, Bruno Dubois et al. "A conceptual framework for research on subjective cognitive decline in preclinical Alzheimer's disease." Alzheimer's & Dementia 10, no. 6 (2014): 844-852. (2) Jessen F, Wiese B, Bachmann C, Eifflaender-Gorfer S, Haller F, et al. (2010) Prediction of Dementia by Subjective Memory Impairment: Effects of Severity and Temporal Association With Cognitive Impairment. Arch Gen Psychiatry 67 (4): 414–422.

CURRENT medications and associated health conditions:

Medication/Supplement	Condition	Frequency & Dosage	Start

CURRENT health conditions that may impact your ability to be physically active:

____

____

____

Employment History

What is your current employment status? (Choose one)

 Paid employment Voluntary/unpaid work Unemployed Retired

IF RETIRED

At what age did you retire? ________________

Why did you retire? ____

When you were/are working, what type of work did/do you do?

For the majority of your employment history, about how many hours/week did you work?

□ Employed full-time (≥ 30 hours/wk)

□ Employed some of the time (20 ≤ hours/wk < 30)

□ Employed part-time (< 20 hours/wk)

Socioeconomic Status

Do you have enough money to meet your needs?

□ Not at all

□ A little

□ Moderately

□Mostly

□ Completely

Do you receive any of the following benefits or allowances? (Check all that apply)

□ Private pension plan

□ Canada/Quebec pension plan

□ Guaranteed income supplement

□ Old age security pension

□ Allowance program

□ Allowance for survivor program

What is you approximate total household income (from all sources) before taxes last year? (Choose one)

□ Under $20, 000

□ $20, 000 or more, but less than $40, 000

□ $40, 000 or more, but less than $60, 000

□ $60, 000 or more, but less than $80, 000

□ $80, 000 or more, but less than $100, 000

□ $100, 000 or more

Appendix E

Instructors Demographics Questionnaire

DOB & Age (month and year only):________________________

Sex: ☐ Male ☐ Female ☐ Prefer to self-identify (option to specify): ____________ ☐ Prefer not to disclose

Ethnicity: _____________________________

Credentials

Years of Education (starting at gr.1):_____________

Degree (e.g. BSc, MSc, PhD): ____________________

Specify major: ______________________________________

Years of Practice (as an exercise provider)

At the YMCA:

____

At other facilities (please specify, if applicable):

____

As a self-employed exercise provider (if applicable):

____

Please check all certifications you currently have:

☐ Certified Exercise Physiologist, please specify accrediting body: ______________________

☐ Registered Kinesiologist

☐ Personal Training, please specify accrediting body: ______________________

☐ Other, please specify certification and accrediting body:

____

Employment Status

What is your current employment status as an exercise provider? (Choose one)

☐ Full time paid employment

☐ Part-time paid employment

□ Voluntary/unpaid work

□ Other, please specify: ____

Socioeconomic Status

Do you have enough money to meet your needs?

□ Not at all

□ A little

□ Moderately

□Mostly

□ Completely

What is you approximate total household income (from all sources) before taxes last year? (Choose one)

□ Under $20, 000

□ $20, 000 or more, but less than $40, 000

□ $40, 000 or more, but less than $60, 000

□ $60, 000 or more, but less than $80, 000

□ $80, 000 or more, but less than $100, 000

□ $100, 000 or more

Appendix F

Cognitive Activity Scale

Please rate how frequently you engage in the following cognitive activities on a scale of 0 (= never or not in the past year) to 4 (=daily).

		Never/not in the past year	Less than once per month	1 - 4 times per month	5 or more times per month	Daily
		0	1	2	3	4
1	Playing chess, bridge, or knowledge games (trivia/math)					
2	Playing board/card games of skill or chance					
3	Solving crossword puzzles, acrostics (poems/word searches)					
4	Watching TV					
5	Listening to the radio/music					
6	Gardening					
7	Reading newspaper					
8	Reading books/stories					
9	Writing letters					
10	Talking on the phone/visiting people					
11	Doing original art or craft work/knitting					
12	Doing art or craft kits/patterns					
13	Making complex home repairs (i.e. renovations/plumbing/electrical)					
14	Making simple home repairs (i.e. painting)					
15	Preparing meals from new recipes					
16	Cooking familiar recipes					
17	Leading discussions					
18	Taking a course (educational or skill based)					
19	Managing of investments					
20	Doing routine financial work (i.e. paying bills)					
21	Walking/driving in unfamiliar places					
22	Walking/driving in familiar places					
23	Going to social clubs					
24	Attending church/religious activities					
25	Shopping					
Other:						
Other:						

Appendix G

Social Activity Scale

Please rate how often you interact with or contact the following groups of people on a scale of 0 (= never) to 3 (= daily). Interactions/contacts include face-to-face conversations, phone calls, Skype/Facetime, letters/text messages, and electronic emails).

	Never	**Few times every year OR every month**	**Weekly**	**Daily**
	0	**1**	**2**	**3**
Spouse/partner				
Other family members				
Neighbours				
Close friends				
People from religious services				
People from club/volunteer/activity meetings or events				
Colleagues				
Strangers/people you don't know well				
Other				

This scale was adapted from two different sources:(1) Zuelsdorff, M. L., Koscik, R. L., Okonkwo, O. C., Peppard, P. E., Hermann, B. P., Sager, M. A., ... & Engelman, C. D. (2018). Reliability of a novel social activity questionnaire: Perceived social support and verbal interaction in the Wisconsin Registry for Alzheimer's Prevention. Journal of aging and health, 30(2), 305-320. https://doi.org/10.1177/0898264316674812. (2) Lee, T., Lipnicki, D. M., Crawford, J. D., Henry, J. D., Trollor, J. N., Ames, D., ... & OATS Research Team. (2013). Leisure activity, health, and medical correlates of neurocognitive performance among monozygotic twins: The Older Australian Twins Study. Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 69(4), 514-522. https://doi.org/10.1093/geronb/gbt031.

Appendix H

CET Participant Satisfaction Questionnaire

1. Please rate your level of level of agreement with the following statements, with 1 being that you strongly disagree and 5 being that you strongly agree.

		Strongly disagree	**Disagree**	**No opinion**	**Agree**	**Strongly agree**
		1	**2**	**3**	**4**	**5**
1	Overall, I enjoyed participating in the Move for Health program.					
2	When I think about the goals I set before starting this program, I feel they have been met.					
3	I felt I was treated with respect while participating in this program.					
4	I felt listened to while participating in this program.					
5	I thought the physical activity part of the program was unenjoyable and/or boring.					
6	I felt the physical activity program leaders were knowledgeable.					
7	I felt the physical activity program leaders did a good job leading the exercise program.					
8	I do not plan on continuing to be physically active after the program.					
9	I felt the physical activity program leaders were professional.					
10	Information was made available to me on other activities and programs available at the YMCA and in the community.					
11	I felt the physical activity program leaders were unapproachable.					
12	I felt comfortable in the location that the program took place.					

13	I felt the location in which the program took place was accessible.					
14	I found the brain activity part of Move for Health unenjoyable and/or boring.					
15	I felt the brain activity program leader was unapproachable.					
16	I was satisfied with the time of the class.					
17	I found the duration of the class suboptimal (too long or too short)					
18	I felt the leader of the brain activity part of the program was knowledgeable.					
19	I felt the leader of the brain activity part of the program did a good job leading the activities.					
20	I was satisfied with the number of classes per week.					
21	I was satisfied with the equipment availability.					
22	I found that the exercise space (i.e. the arrangement of equipment) was messy.					
23	I felt the brain activity program leader was professional.					
24	I was unsatisfied with the organization of the combined brain activity and exercise training (i.e. the timing/scheduling of the two trainings).					
25	This program failed to meet and/or exceed my expectations of it.					
26	I am going to make a point of finding other activities in the community to participate in.					
27	I would recommend adding brain activity to the exercise program.					
28	I would recommend this program to other people.					
29	I would not want to participate in this program again.					

2. How would you rate the difficulty of the **exercise** program?

	Too Hard	Somewhat Hard	Optimal	Somewhat Easy	Too Easy
Program Difficulty					

3. How would you rate the difficulty of the **brain** activity?

	Too Hard	Somewhat Hard	Optimal	Somewhat Easy	Too Easy
Program Difficulty					

4. How much would you be willing to spend to participate in this program?
   - ☐ Less than $50
   - ☐ More than $50, but less than $100
   - ☐ More than $100, but less than $150
   - ☐ More than $150, but less than $200
   - ☐ More than $200

5. If I could change anything about Move for Health (brain and/or physical activity), it would be…

6. Additional comments or recommendations.

Appendix I

ExO Participant Satisfaction Questionnaire

1. Please rate your level of level of agreement with the following statements, with 1 being that you strongly disagree and 5 being that you strongly agree.

		Strongly disagree	Disagree	No opinion	Agree	Strongly agree
		1	2	3	4	5
1	Overall, I enjoyed participating in the Move for Health program.					
2	When I think about the goals I set before starting this program, I feel they have been met.					
3	I felt I was treated with respect while participating in this program.					
4	I felt listened to while participating in this program.					
5	I thought the physical activity was unenjoyable and/or boring.					
6	I felt the physical activity program leaders were knowledgeable.					
7	I felt the physical activity program leaders did a good job leading the exercise program.					
8	I do not plan on continuing to be physically active.					
9	I felt the physical activity program leaders were professional.					
10	Information was made available to me on other activities and programs available at the YMCA and in the community.					
11	I felt comfortable in the location that the program took place.					
12	I felt the physical activity program leaders were unapproachable.					
13	I felt the location in which the program took place was accessible.					
14	I was satisfied with the time of the class.					

15	I found the duration of the class suboptimal (too long or too short)					
16	I was satisfied with the number of classes per week.					
17	I was satisfied with the equipment availability.					
18	I found that the exercise space (i.e. the arrangement of equipment) was messy.					
19	This program failed to meet and/or exceed my expectations of it.					
20	I am going to make a point of finding other activities in the community to participate in.					
21	I would recommend this program to other people.					
22	I would not want to participate in this program again.					

2. How would you rate the difficulty of the exercise program?

	Too Hard	Somewhat Hard	Optimal	Somewhat Easy	Too Easy
Program Difficulty					

3. How much would you be willing to spend to participate in this program?
   - ☐ Less than $50
   - ☐ More than $50, but less than $100
   - ☐ More than $100, but less than $150
   - ☐ More than $150, but less than $200
   - ☐ More than $200

4. If I could change anything about Move for Health, it would be…

5. Additional comments or recommendations.

Appendix J

CET Instructor Satisfaction Questionnaire

1. Please rate your level of level of agreement with the following statements, with 1 being that you strongly disagree and 5 being that you strongly agree.

		Strongly disagree	Disagree	No opinion	Agree	Strongly agree
		1	**2**	**3**	**4**	**5**
1	Overall, I enjoyed leading the Move for Health program.					
2	I felt I was treated with respect while leading this program (by participants and colleagues).					
3	I believe the majority of participants did not enjoy the exercise part of the program.					
4	I felt listened to while leading this program.					
5	I felt the brain activity program leader was approachable.					
6	I was unsatisfied with the organization of the combined brain activity and exercise training (i.e. the timing/scheduling of the two trainings).					
7	I felt the leader of the brain activity part of the program was knowledgeable.					
8	I felt the leader of the brain activity part of the program did a good job leading the activity.					
9	I found the length of the class to be suboptimal (too long or too short).					
10	I believe that the majority of the participants found the brain activity part of Move for Health unenjoyable and/or boring.					
11	I was satisfied with the equipment availability (for the participants).					
12	I felt the brain activity program leader was professional.					

13	This program failed to meet and/or exceed my expectations of it.					
14	I was satisfied with the equipment arrangement.					
15	I would recommend adding the brain activity to the exercise program.					
16	I would lead this program again in the future.					

2. How would you rate the difficulty of teaching/managing the program?

	Too Hard	Somewhat Hard	Optimal	Somewhat Easy	Too Easy
Program Difficulty					

3. How much do you think a participant would be willing to spend to participate in this program?
   - ☐ Less than $50
   - ☐ More than $50, but less than $100
   - ☐ More than $100, but less than $150
   - ☐ More than $150, but less than $200
   - ☐ More than $200

4. If I could change anything about Move for Health (brain and/or physical activity), it would be…

5. Additional comments or recommendations.

Appendix K

ExO Instructor Satisfaction Questionnaire

1. Please rate your level of level of agreement with the following statements, with 1 being that you strongly disagree and 5 being that you strongly agree.

		Strongly disagree 1	Disagree 2	No opinion 3	Agree 4	Strongly agree 5
1	Overall, I enjoyed leading the Move for Health program.					
2	I felt I was treated with respect while leading this program (by participants and colleagues).					
3	I believe the majority of participants did not enjoy the exercise training.					
4	I felt listened to while leading this program.					
5	I found the length of the class to be suboptimal (too long or too short).					
6	I was satisfied with the equipment availability (for the participants).					
7	This program failed to meet and/or exceed my expectations of it.					
8	I was satisfied with the equipment arrangement.					
9	I would lead this program again in the future.					

2. How would you rate the difficulty of teaching/managing the program?

	Too Hard	Somewhat Hard	Optimal	Somewhat Easy	Too Easy
Program Difficulty					

3. How much do you think a participant would be willing to spend to participate in this program?
   - ☐ Less than $50
   - ☐ More than $50, but less than $100
   - ☐ More than $100, but less than $150
   - ☐ More than $150, but less than $200
   - ☐ More than $200

4. If I could change anything about Move for Health, it would be…

5. Additional comments or recommendations.

Appendix L

Interview Script: Guiding Questions and Prompts

Introduction:

The purpose of this interview is to provide the researchers of this study further insight regarding your experience with the exercise program and research study. You are reminded that all information you provide will be de-identified via a numeric participant ID. You may provide as much or as little information that you wish to the researchers, you may skip any questions, and you may take breaks or cease participation in the interview for whatever reason at any time.

For those who initially agreed to be audio-taped and allowed quotes to be used:

You may also remember that at the beginning of the study, you gave the researchers permission to 1) audio record your interview and 2) to use anonymous quotations in publications/presentations. Do you still agree to allow us to audio record the interview? Do you still agree to allow us to use quotations?

For those who initially agreed to be audio-taped only:

You may also remember that at the beginning of the study, you gave the researchers permission to 1) audio record your interview. Do you still agree to allow us to audio record the interview?

For those who initially agreed to the use of quotations only:

You may also remember that at the beginning of the study, you gave the researchers permission to use anonymous quotations in publications/presentations. Do you still agree to allow us to use quotations?

[IF YES] Great! Let's begin

Questions:

1. Why did you decide to participate in the Move for Health Program?
    a. How did you hear about the study or program?
    b. Prompt – Goals (if any were set before the program), incentives to join?
    c. Prompt – Feelings before, during and/or after the sessions

2. What were some of the benefits or positive aspects of your experience in the Move for Health program?
    a. Prompt – YMCA facility (location, scheduling of classes, class size, format)
    b. Prompt – Cognitive training
    c. Prompt – Exercise program

   d. Prompt – Exercise staff/other members of the facility
   e. Prompt – Educational sessions
   f. Prompt – Interaction with other participants

3. What are some of the challenges or negative aspects of your experience in the Move for Health Program?
   a. Prompt – YMCA facility (location, scheduling of classes, class size, format)
      i. Format → group vs staggered start (INSTRUCTORS only)
      ii. Format →cost/YMCA membership/access to facility
      iii. Format → frequency, session length
   b. Prompt – Cognitive training
   c. Prompt – Exercise program
   d. Prompt – Exercise staff/other members of the facility
   e. Prompt – Educational sessions
   f. Prompt – Interacting with other participants

4. Other than the program, have you engaged in other physical activities (structured or unstructured) since January? What about cognitive or social activities? Were they typical activities or were they new to your routine?

5. Are there any changes you would recommend that would enhance one's experience of the Move for Health Program?

6. Do you have any final thoughts about the Move for Health Program that you would like to share with me?

7. There were 2 different groups in this study – the regular move for health group and a group that took part in a different version of the program. Do you have any idea which program you were randomly assigned to?

Thank you for participating in the interview and for your time.

Appendix M

Catherine Lee's Undergraduate Thesis Project

UNIVERSITY OF WATERLOO | FACULTY OF APPLIED HEALTH SCIENCES **Department of Kinesiology**

Experiences Participating in a Combined Cognitive and Exercise Training Community Program: A Qualitative Interview Study

Kin 432 Honours Research Project

Supervisor: Dr. Laura Middleton

Student: Catherine Lee

Abstract (323 words):

Introduction: Dementia affects more than 5% of older adults aged 60 years and older worldwide and remains as a significant cause of disability and dependency globally among older persons. Although no cure for dementia currently exists, evidence suggests that physical activity and cognitive training may be two modifiable factors that can decrease the risk of dementia. Despite this evidence, there are currently no combined cognitive and exercise training (CET) programs offered in Canadian communities.

Objective: To explore the experiences of adults, older adults, and instructors that have engaged in a CET community program, including exploration of the facilitators, barriers and perceived benefits of participating or leading a community CET program.

Methods: Eligible participants for this study were (1) adults and older adults who were diagnosed or at high risk for chronic diseases common with aging and completed a pilot 12 week, 60-min, twice-weekly CET program and; (2) instructors who led this pilot CET program. At the conclusion of the program, participants completed a face-to-face, semi-structured interview that probed about their experiences. Interviews were transcribed and analyzed using thematic analysis.

Results: Ten adult/older adult and three instructor interviews were conducted. The main themes that emerged were as follows: 1) The variety in the CET program structure was a unique facilitator; 2) Motivation driven by progression and successes in the CET program; 3) High overall satisfaction with CET Program due to addressing needs and desires; 4) Instructors are key to the success of the CET program; 5) Challenges with accommodating diverse abilities and preferences in the CET program and; 6) Differences in socialization preferences can impact CET program perception.

Conclusion: Despite challenges with addressing diverse preferences and needs, a pilot CET community program was positively reviewed by both participants and instructors. Further investigation into areas such as motivation sources and program personalization considerations will assist in informing the future development, implementation, and evaluation of CET community programs with larger sample sizes and in different settings.

Introduction

Dementia has been estimated to affect 5 to 8.5% of the world's population of older adults aged 60 years and older[1]. In 2010, this translated to an estimated 35.6 million persons living with dementia with the prevalence expected to double every two decades to 65.7 million in 2030 and 115.4 in 2050[1]. In Canada specifically, more than 419 000 older adults aged 65 years and older were living with a diagnosed dementia between 2015-2016[2]. As an umbrella term for a range of conditions, dementia is characterized by a progressive decline in cognitive abilities[2]. According to the fifth edition of the American Psychiatric Association's Diagnostic and Statistical Manual (DSM-5), a diagnosis of dementia involves impairment in one or more cognitive domains[3]. Persons with dementia present with difficulty or inability to complete specific activities of daily living (ADLs) and/or instrumental activities of daily living (IADLs) and the severity of deficits dependant on the cognitive domains affected and extent of cognitive decline[2,4]. As such, dementia can have significant effects on one's quality of life. For instance, Canadian caregivers spent approximately 26 hours a week supporting a person with dementia[2]. Substantial economic considerations are also associated with the management of dementia; In 2011, the projected total health care costs and out-of-pocket caregiver costs in Canada totaled $8.3 billion[2]. Globally, similar trends in prevalence has been reported in numerous countries[4] and dementia remains as one of the major cases of disability and dependency among older persons[5]. Despite the significant associated implications of dementia, there is no pharmaceutical treatment or cure currently available[5]. This lack of a viable cure highlights the need for alternate preventive or management approaches. In particular, there has been interest in the management of modifiable risk factors associated with cognitive decline and dementia[6].

As a form of non-pharmaceutical treatment, increased participation in physical activity can potentially have a protective effect on cognition in individuals without or at risk of cognitive impairment[7–10]. Recent evidence suggests that the cognitive benefits associated with physical activity arises from the presence of multiple interconnected mechanisms. For instance, exercise can enhance overall cardiovascular fitness[10], which has been reported to be an accurate predictor of cognitive decline[11]. Physical exercise can also improve overall muscular strength and endurance and these changes also been associated with benefits in memory performance and executive functioning[12]. Although the literature remains mixed regarding the significance of cognitive benefits achieved through physical activity, promising results from recent meta-analyses have generally supported the association between increased physical activity and improved cognitive function[13,14]. Exercise can be subject to a number of moderators such as type, intensity and frequency, these factors alone may not accurately determine whether significant changes in cognition is achieved[15]. It is also suggested that multicomponent training, consisting of both aerobic and resistance training, may yield greater outcomes on cognitive functioning than single component training in healthy older adults[16].

Cognitive training is another modifiable lifestyle factor that is currently being studied for its potential effects on cognition. A Cochrane systematic review published in 2011 reported significant improvement in immediate and delayed verbal recalls in healthy older adults that underwent memory training interventions compared to a control condition[17]. In another systematic review of RCTs and longitudinal studies, cognitive training in healthy older individuals showed protective effects on neuropsychological performance, with some effects on specific dementia-relevant domains reported[18]. Aside from structured cognitive training programs, active participation in cognitively-stimulating leisure activities may also play a similar role in reducing risk of developing dementia[19]. As with the evidence surrounding the benefits of exercise on cognition, the reliability of the effectiveness of cognitive training interventions is limited by the lack of consensus on the type, frequency and length that will yield maximal cognitive benefits. As such, further research into the effects of cognitive training interventions is necessary to determine its capability as a preventative intervention for cognitive decline.

Due to the variability in the impact of separate interventions, it is suggested that multimodal approaches to prevent cognitive decline should be utilized[20–23]. For instance, preliminary evidence suggests that combined exercise and cognitive training can have clinically meaningful benefits for cognition, despite the relative paucity of literature regarding this combination of interventions compared to single interventions. A meta-analysis of 10 RCTs of combined cognitive and physical exercise training in older adults with mild cognitive impairment or dementia reported a small-to-medium positive effect on global cognition with a moderate-to-large positive effect for ADLs and mood[24]. In another ongoing trial titled the "Synergic Trial", preliminary results have showed improvement in ADAS-Cog 13 scores ($p = 0.046$) for the participants with MCI that were receiving both physical and cognitive training[25]. In another review of RCTs involving samples of community-dwelling and healthy individuals, combined physical and cognitive training programs appeared to be more successful than single physical or cognitive exercise interventions, although the results were dependent on the training characteristics[26].

In Canada, exercise programs for older adults are commonly available in the community. However, combined cognitive and exercise training (CET) are not readily present in the community. Separate cognitive training programs are also not presently available for community-dwelling individuals, aside from participation in clinical trials and the use of generally untested computer programs or smart phone applications. As such, the feasibility, acceptability of and changes occurring with a CET community program have not been studied and are unknown. In a single arm quasi-experimental study, adults and older adults in the community were asked to participate in a 12-week, 60-min, twice weekly 'enhanced' exercise program intended to improve cognitive function at a community center. Evaluation includes both quantitative and qualitative assessments, the latter of which is the focus of this proposal. Specifically, the main aim of this study will be to explore the experiences of adults, older adults, and instructors that have engaged in a CET community program. Specific objectives include determining: (1) The facilitators and barriers of participating in or leading a CET community program and (2) The perceived benefits of participating in or leading a CET community program.

Methods

Study Design

This descriptive qualitative study was conducted as part of a larger pilot study titled "Combined Cognitive and Exercise Training for Older Adults: Feasibility & Effectiveness". Although the overall study is a pragmatic, randomized, parallel-group pilot study, the phase of the pilot program included in this study ran as a single arm quasi-experimental study due to low recruitment rates. In the future, the program will be run with both groups, an interventional (CET) group and control group (exercise training only) concurrently. At the end of the 12-week program, adult and older adult participants as well as the program instructors were asked to engage in a post-program interview about their views and perspectives of the CET community program.

Participants

In this pilot study, adults and older adults living in the community were recruited to take part in the Move for Health program. Eligible participants for the Move for Health program were adults (50 years of age or older) and older adults (65 years of age or older) who were: (1) Diagnosed or at high risk for chronic diseases common with aging; and (2) Able to walk 10m with/without the use of a mobility aid. Chronic conditions included osteoarthritis, osteoporosis, pre/post joint replacement, fibromyalgia, high blood pressure/cholesterol, stable heart conditions, COPD, diabetes, and obesity. Exclusion criteria included being unavailable during the study program days/times, completing the Move for Health program within the past year, sustained a concussion in the last six months, currently undergoing cancer treatment and presenting with severe/untreated cognitive, visual and/or auditory impairments.

Intervention

In the pilot program, the CET program intervention was delivered by the addition of a cognitive training component to a currently offered community exercise program called the Move for Health Program. More details about these separate two components are provided below. Midway through the CET program, the instructors also conducted short "fieldtrips" for the participants to experience different programs offered at the YMCA, such as swimming classes and yoga sessions.

The Move for Health Program

The Move for Health Program is a 12-week, twice weekly 60-minute program that consists of aerobic exercise and strength training[27]. The program is delivered by instructors employed at the A.R Kaufman Family YMCA location in Kitchener, Ontario. This program is primarily group-based but participants are provided individualized and progressive exercise prescriptions that include aerobic training, whole body resistance training, and balance training. In addition to the exercise training, a short educational component is also provided by instructor on topics regarding healthy living strategies. The main objective of this program is to provide individuals living with a chronic condition the opportunity to receive support in exercise participation[27]. As such, this program is geared towards those with chronic conditions such as osteoarthritis, osteoporosis, pre/post joint replacement, fibromyalgia, high blood pressure/cholesterol, stable heart conditions, chronic obstructive pulmonary disorder (COPD), diabetes, and obesity[27]. It is also ideal for individuals who are transitioning from a rehabilitation program to exercising in a community setting[27].

Cognitive Training

The cognitive training component of the CET community program was a 30-minute session of dual-task training that is delivered on an Android Tablet. In this cognitive training task, participants were required to share attention between two visuomotor tasks that are performed unilaterally and bilaterally and execute the appropriate response based on the presented stimuli. Participants were asked to prioritize their response and perform tasks quickly while maintaining accuracy. As such, the training required participants to utilize higher-order cognitive abilities such as divided attention and executive functioning. In a similar manner to the exercise component, the difficulty of the training was individualized and progressive based on the participant's current performance.

Interview Procedures

Face-to-face, semi-structured interviews were utilized, and interview lengths varied from 10 to 30 minutes, depending on the natural course of discussion. Prior to the start of the interviews, all participants were well-informed by the interviewer that the purpose of these interviews was to receive insight into their personal experience with the CET community program. All participants were also informed of their rights, such as providing only as much information as they wished to the interviewer and having the option to not answer any questions, take breaks or cease the interview at any point without consequences. The conducted interviews were semi-structured and followed an interview guide (see appendix). All interviews were conducted, audio-recorded, and transcribed verbatim with the participants' consent.

Data analysis

Thematic analysis was utilized in order to identify, analyze and report patterns of themes within the text[28–30]. Once all interviews were transcribed, all transcripts were reviewed independently by two researchers (CL and CE) for accuracy. In addition, both researchers immersed themselves into the data to ensure that familiarity with the data, such as its content and patterns, was achieved[30]. The next phase involved the detailed line-by-line coding of each transcript. Two researchers (CL and CE) independently coded one transcript and reviewed codes together in order to establish a preliminary coding scheme or codebook. If there was any disagreement regarding the codes between the two researchers that could not be resolved, a third researcher (LM) was consulted to reach agreement on the most suitable interpretation. Once the preliminary coding scheme had been finalized, the remaining transcripts were additionally coded individually by the two researchers (CL and CE) and discussed together within a few rounds to ensure consistency in coding (e.g. after every 3 transcripts).

Codes were clustered in broader sub-themes and/or themes with definitions. Relevant quotes from participants for each sub-theme or theme were labelled using the following indications: “FP” to denote adult or older adult participant and “FI” to denote instructor of the CET community program. Themes and categories were organized into a framework in order to visually represent the perspectives of participating adults, older adults and instructors regarding a CET community program. NVivo qualitative software was used for data management[29]. In addition, themes were reviewed and revised with the wider research team to ensure that data within themes were cohesive and meaningful while maintaining clear and identifiable distinctions between individual themes. A few topics were examined in a deductive manner as well. These were barriers to participants and program adaptation issues, which were two areas that had been identified as important when considering the overall aims of the study.

Although no method to guarantee complete validity in qualitative study exists, a number of strategies regarding measures such as credibility, transferability, dependability and confirmability, were taken to ensure the most accurate, legitimate interpretation of the text[31,32]. In terms of credibility, for example, tactics such as informing the participant of their rights (e.g. their right to participate or not in the post-program interview) and iterative questioning (e.g. use of probes) assisted in encouraging honest contributions of participants[32]. In addition, frequent debriefing sessions between the two researchers (CL and CE) with the supervising professor (LM) and other research team members were held. These debriefing sessions allowed for the inclusion of fresh perspectives and critical feedback, which increased the study’s credibility. To allow readers to examine the transferability and confirmability of this qualitative study, an “audit trail”, which refers to an extensive documentation of study-related records such as raw data, data analysis products and data reconstruction products, was also maintained and reported in rich detail as needed[31,32].

Results

There were 11 adult and older adults recruited to the CET program, 1 withdrawal over the program and 10 who completed interviews. Demographic characteristics of the adult and older adult participants who completed interviews are shown in Table 1.

Table 1: Participant demographics (mean ± SD or n, %)

Characteristics	**N=10**
Sex (Female)	7, 70%
Age (years)	63.3 ± 0.5
Ethnicity	
White	6, 60%
Latin American	2, 20%
South Asian	1, 10%
Indigenous	1, 10%
Education (years)	14.8 ± 3.1
Occupation Status	
Retired	7, 70%
Chronic Health Conditions	
Osteoarthritis/osteoporosis/joint replacements	8, 80%
High blood pressure/cholesterol	5, 50%
Diabetes/Pre-diabetes	3, 30%
COPD/Sleep apnea/MAC	3, 30%

Note: These results are preliminary and further analysis is underway.

There were also three participating instructors who led the CET community program and participated in interviews. Demographic information of instructors was not collected.

Themes and Sub-themes

A visual framework of the main themes was created from the experiences of the participants and instructors with the CET program (see Figure 1).

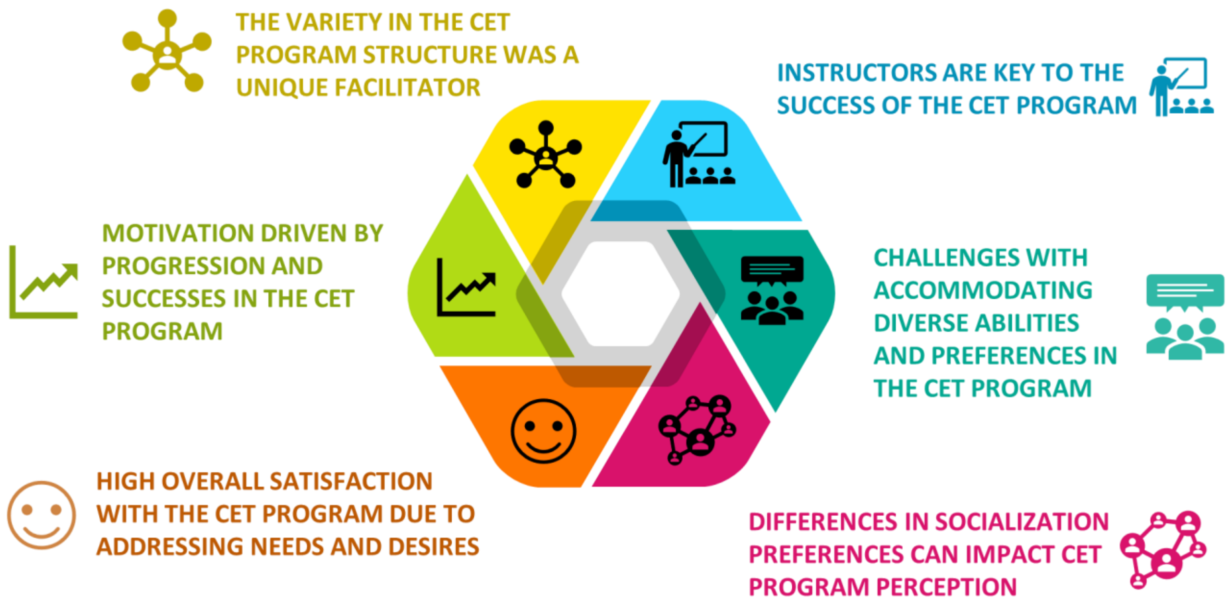


Figure 1: Framework of themes of the participants' and instructors' experiences with the CET Program

Theme #1: The variety in the CET program structure was a unique facilitator

The opportunity to receive a variety of exercise and cognitive training activities in one convenient setting was perceived to be a unique facilitator for participants. Although the CET program was conducted in a group-based environment, the cognitive and exercise training were tailored to each participant's current ability level and needs. As such, the individualization of these separate components of the CET program contributed to increasing the variety of activities offered to participants. In particular, this perception of variety played a central role in the overall success of the CET program. During the exercise training specifically, program accommodations were demonstrated through the instructors' actions in matching the difficulty of exercises to the participants' current capabilities and preferences. For instance, one participant was quoted as saying:

"They [in reference to instructors] really tried to figure out what people's individual needs were and to try to accommodate them and teach to those needs." -FP02

In regard to the cognitive training, it was perceived to be interesting as none of the participants had experienced something of this nature in the community setting before:

"It as a bit of a novelty to me. Um, to-to-to do that one or two things at once so… but I just really enjoyed that program." -FP08

In addition to this enjoyment of trying something new, participants commented positively about how the difficulty of the cognitive training was matched to their ongoing performance. As a result, this individualization of the cognitive training helped to increase the perception of variety in the overall program. A minor component of the CET program that also contributed to the participants' awareness of variety was the opportunity to explore other parts of the facility and offered programs. As stated by one participant below, the experience of trying out multiple and different types of classes was helpful in improving the variety of activities that was offered to them:

"And there's the variety that they kind of put in there for the classes was really good, too. So we did a like a yoga class. We did a bunch of other types of classes as well. Circuit training, things like that. It gives you a variety because one thing doesn't fit everyone." - FP04

Theme #2: Motivation driven by progression and successes in the CET program

A significant factor that positively influenced the participants' perception of the CET program was having a number of opportunities to measure their progression and experience personal successes. One of these chances to measure progression was through the cognitive training score reports that each participant received at the end of each session. This score report would contain details of the participant's performance, such as their accuracy and speed, and allowed individuals to view their progression by including comparison statistics with previous sessions. Receiving these score reports each session was an important aspect of encouraging the participants to be further engaged with the cognitive training, as mentioned by one participant below:

> *"Seeing the report uh uh with the improvement, it's interesting to see your improvement, which makes you happy." -FP07*

Many participants also reported that the score reports encouraged them to improve their scores in accuracy and speed. As such, individuals would try different strategies to increase their overall performance and would compare performances with each other in a friendly manner. For instance, the participant below mentioned how their dislike for the cognitive training initially disappeared due to having the opportunity to improve their score:

> *"I actually really hated those little brain things when we started [...], but I got to like it after a while because then I started to uh try to figure out how I could improve my score." – FP02*

Throughout the CET program, there were numerous reported successes for all of the participants. These successes ranged from those that were related to functional/physical health, mental and cognitive health, general enhanced well-being and meeting established goals prior to the start of the program. These successes were specific to each participant and played an important role in not only motivating the participants to remain engaged with the program, but also promoted uptake and maintenance of healthier behaviours. In terms of functional and physical health, a number of participants reported improvements in their overall strength, movement patterns and sleep quality, as seen below:

"I feel a little healthier. I feel a little stronger." – *FP05*

For other participants, there were reported benefits related to their specific conditions and comorbidities. Two of the participants reported improvements in lung capacity, which were demonstrated through improved clinical tests results and self-reported as well. In addition, the CET program helped to reduce pain for those who were experiencing pain in their joints, as stated by one of the participants:

"I've seen the difference in my pain um before I started this program and after." – *FP03*

In terms of mental and cognitive health, the CET program seemed to promote more positive thinking behaviour. For instance, two participants specifically mentioned in their interview how attending the CET program improved their mood and well-being as described below:

"I think I'm sort of prone to depression um and I can look at the negative side. But I find that when I exercise, that helps me a lot." –*FP03*

"And what I found is on days even when I slept poorly, didn't feel great, I still dragged myself here and um I felt better after it." – *FP02*

For the instructors, one of the benefits of leading the program was seeing participants meet their goals:

"When people are reaching their goals. That's always nice." - *FI02*

"There are definitely some big success stories, which is always great" - *FI03*

Since the CET program led to numerous successes for participants, it had a positive impact on creating new habits related to physical and cognitive activity. For some participants, attending the CET program allowed them to receive key instruction and guidance on how to be active and accordingly, improved motivation to maintain active behaviours:

"I am more motivated now to continue mainly what I've been doing here. I'm going to try and do it three times a week because um whatever I gained, I don't want to lose." – FP02

Another common remark by participants was how they were more motivated to use what they learned in the CET program to engage in more activities in the future, as seen below:

"I will continue doing what I learned from this program and and I'll probably sign up or uh join some of the programs =YMCA= offers all the time. I think it's something I need to do."- FP07

In terms of the cognitive training, one participant specifically mentioned how it encouraged them to engage in more cognitively stimulating activities at home, outside of the CET program:

"[The cognitive training] made me do more." – FP06

For other participants who had previously been active, the CET program also played an instrumental role in returning to an active lifestyle, as seen below:

"It helps you get back into the routine when you've stepped away for a while...It's a good kick start." – FP04

Theme #3: High overall satisfaction with CET Program due to addressing needs and desires

There was an overwhelming positive response to the CET program primarily due to the fact that that it met the majority of the group's preferences and needs. Each separate component of the program was well-received by the participants for different reasons. For instance, the exercise training was noted by participants for being customizable to their activity level while the cognitive training was described as being fun to complete, similar to a game. On the other hand, the educational lessons and opportunity to visit other facilities/programs were described as being informative and useful for implementation in current or future lifestyle routines of the participants. In addition to these positive perceptions of the separate components, this combination of activities in the CET program as a whole was positively reviewed by the participants, as seen by this example below:

> *"All the different things - the exercise, the cognitive, and then the education in the films. I like all of it. I hope it's run again." - FP05*

Many participants also indicated a wish for the program to continue for not only themselves, but for other individuals in the future. One participant interestingly noted that there was a great need in the community for a program of this type, especially for older persons:

> *"But it's offered again. I think there's a great need in the community as we are um … An older population, you know, we're getting into an older population and um… to get people to get out of their house so that they're mobile and they're independent for the remainder of their life as much as possible." -FP08*

This same finding of overall high satisfaction among the participants was also mentioned by the instructors, who received validation from the participants about their enjoyment of the CET program:

> *Overall, I think it went really well. I think they… got what they expected or maybe exceeded what they expected out of the program.... So I think it was a successful program – FI02*

Theme #4: Instructors are key to the success of the CET program

High satisfaction with the instructors was perceived by many of the participants to be a positive component of the CET program. Since the instructors were primarily responsible for the delivery of the separate program components, they played a pivotal role in the perception of the overall program for the participants. As a result, the high reported satisfaction with the instructors played a significant role in the overall success of the CET program. Firstly, instructors were described by participants as being an accessible source of support and instruction:

"They were, they were supportive, they I mean they pushed me towards trying stuff that was a little bit more difficult which is good yea." -FP01

Instructors were also noted by some participants for being invaluable in promoting safety during each program sessions and helping the participants with accommodations as needed, as seen below:

"I love the fact that there are people there all the time watching kind of to see if I'm doing it right." - FP03

In addition, the fact that the instructors were friendly and approachable assisted participants in feeling comfortable to not only partake in the program but also be willing to discuss program alterations with the instructors as quoted by one participant below:

"I was treated like a person" - FP05

Theme #5: Challenges with accommodating diverse abilities and preferences in the CET program

In the CET program, there was a number of differing health conditions and exercise capabilities present in the group of ten participants. In addition, there were differences in the comfort of activity levels, with some participants already leading active lifestyles and others who had not previously completed any type of exercise program. Since there were varying functional and exercise capacities in the group of participants for the CET program, it was difficult to accommodate for the different preferences and ability levels. For some participants, the exercises were noticeably more difficult due to their current health conditions as seen below:

"Challenging, it was for me, like some of the exercises which I was finding difficult um, because of my knee conditions." -FP07

For other participants who were already physically active, there was a preference for an advanced design of the CET program. One participant suggested having differing groupings for the exercise component, such as one for those were starting out and less physically active and one with more challenging activities for those that were more physically active. The difficulty in planning a CET program for individuals of differing comfort and ability levels was mentioned by instructors as mentioned by one below:

> *"It's always challenging to get people of different levels of ability and then also comfort, right? So, there's a confidence thing. There's people that are um…confident just sort of go off and do their own thing or think they know um… what they need to do. So the challenge on that end is just sort of pull them back in and get them to start um…from a place of strength. And then the other ones um…that this is their first time or they have a lot of pain or whatever that is." - FI02*

This challenge in designing a program of these nature to accommodate a varying range was also confirmed by participants as well:

> *"It's very hard to plan something for people with a range of abilities that there were in that class" – FP02*

This difficulty in accommodating for different needs was also reflected in the cognitive training component of the CET program. For some of the older individuals, the activities featured in the cognitive training seemed to be an appropriate level while individuals who were younger mentioned how the cognitive training at times was repetitive and not as challenging. For instance, one of the younger participants of the group were quoted as saying below:

> *"For me, I found it sometimes a little easy." -FP01*

One participant suggested that aside from having all the cognitive activities done on the tablet, having more variety in the type of cognitive activities, such as those conducted during the baseline cognitive testing (e.g. MoCA, Trails B), would be preferable to increase the difficulty of cognitive training.

Theme #6: Differences in socialization preferences can impact CET program perception

Despite being a group-based program, there was a contrast in perceptions regarding the presence of socialization opportunities in the CET program. Some participants and the instructors found that the CET program fostered a sense of community while other participants mentioned how there was a lack of opportunities to socialize with others in the program. These differences in opinions may have been affected by differing preferences regarding when to socialize during the program. In the interview, instructors mostly noted how the group exercise format of the CET program promoted a sense of union among the participants, which may have aided in providing additional motivation for consistent attendance:

> *Yeah, I feel like everyone really connected well…It's also really beneficial in building that kind of community so I think that's part of the reason that they are coming back – FI03*

Most of the participants also noted how they enjoyed the opportunity to meet new people and make friends, as mentioned by one participant below:

> *"Yes, I got to meet a few people and make a couple of new friends. That was good- FP06*

For one participant in particular who mentioned that they were not a friendly person, the chance to meet two other participants that they got along with in the program was an additional benefit in attending the CET program. In addition, the group setting of the CET program was mentioned by some participants to be helpful in encouraging accountability among one another to continue attending the sessions. In contrast to these results, some participants noted that there was a lack of socialization opportunities with other participants during the overall CET program. As mentioned previously, this may have been strongly influenced by individual mind-set and personality of participants. For instance, one participant described how they personally do not socialize when completing the exercises and was quoted as follows:

> *"Socializing, you need to have a certain section for that. Like I won't, I don't like talking when I'm doing my exercises."-FP04*

In addition, the lack of opportunity to socialize during the cognitive training sessions was mentioned as it required the participants to intensely concentrate on the activities with minimal distractions. As such, it appeared that finding ample time to socialize within the CET program was challenging for a few of the participants.

Discussion

To the best of the author's knowledge, this is the first qualitative study to explore the experiences of participating in a CET community program from the perspectives of participants and instructors. One of the main findings of this study suggests the presence of multiple facilitators that influenced the participants' overall positive perception of the CET program. Although there were similar factors between participants that influenced their engagement with the CET program, the interdependent relationship of these factors is emphasized in this study and may be better understood using the Self-Determination Theory (SDT). SDT is a macro theory that focuses on the different types of human motivation, development, and wellness and has been widely applied to a range of life domains due to its broad scope[33]. In regard to the application of SDT to the realm of exercise and physical activity, there is a strong positive relationship between autonomous forms of motivation, such as identified and intrinsic regulations and the promotion of physical activity[34]. Intrinsic forms of behavioural regulation refer to a person completing an activity because it is enjoyable or satisfying while identified forms refers to the completion of an activity due to the personal value it holds for the individual[34]. In this study, both forms of identified and intrinsic regulation seemed to be highly prevalent among the participants who attended the CET program. Due to the customized nature of the CET program, there was a considerable range of successes that were specific to each individual. In another trial, the presence of specialized and individual exercise programs helped to increase self-efficacy for exercise and promote behavioural changes in a sample of community dwelling older adults who were not regularly active [35]. Although the CET program in this study was primarily group-based, similar improvements in self-efficacy and motivation for healthy behaviours were found among the participants in the CET program due to the tailoring of many program aspects to each participant's needs and preferences. As an example of identified regulation, the experience of personal successes throughout the CET program appeared to motivate the participants to maintain good health by continuing to engage with the CET program and intention to adopt healthier behaviours (i.e. staying active at the conclusion of the program). It is important to note that while these perceived benefits may have acted as a facilitator for the participants' motivation, it is unclear on whether the anticipation of these benefits played a role in the initial engagement process of the participants with the CET program. Compared to other programs solely offering exercise training, the presence of the cognitive training in the CET program may have served as a form of intrinsic regulation rather than identified regulation. This is due to the fact that most participants specifically commented on the enjoyment of the cognitive activities and the satisfaction they received when given the opportunity to measure their progression via the cognitive score reports. This enjoyment and satisfaction led to increased motivation to partake in more cognitive stimulating activities as specifically mentioned by one of the participants.

Another concept of the SDT is "relatedness", which describes the personal connections with others and how these relationships can shape motivation to engage in behaviour change[34]. Certain characteristics of program instructors such as personality, experience and motivation training were reported in one study to be significant in influencing participants' adherence with exercise classes[36]. For the CET program, instructors were perceived by the participants to be highly professional and accommodating, especially in regard to their ability to successfully customize the program to the participants' needs and preferences. In addition to the possible influence of the group-based setting, these characteristics of the instructors may have played a significant role in improving the motivation of the participants to remain engaged with the CET program and desire to adopt other healthy lifestyle behaviours. In contrast to the participants, the instructor's perception of the CET program was influenced by their own personal observations of the participants' enjoyment of the CET program and successes received from the program. Specifically, this aspect may have acted as a form of extrinsic regulation for the instructors and helped to motivate them to lead the program to the best of their abilities. In a systematic review focusing on exercise, physical activity and the SDT, identified regulation seemed to be more predicative of initial or short-term adoption of exercise behaviours while intrinsic motivation was found to be more predictive of long-term exercise adherence[34]. In this study however, it is difficult to determine whether this finding is present due to the fact that there are multiple sources of motivation embedded within the CET program for the participants. Therefore, it is highly likely that participants of the CET program had interconnected motives behind adopting or maintaining specific health behaviours, which should be further explored in future research studies regarding the application of the SDT to multicomponent programs such as the CET program. In addition, exploring the mechanisms of motivation for instructors leading the CET or other community programs should be a future research area of interest as well due to the instrumental role of these individuals in the perception of such programs.

Similar to other community programs, the challenge of appealing to a wide variety of preferences and needs was apparent in the CET program. Since there was considerable variety in the age range and current health conditions of the overall sample, it was often challenging for the instructors to realistically adjust each aspect of the program to what was best suited for a specific individual. This was also evident in the challenge of accounting for socialization opportunities, which can play a strong role in reinforcing engagement with the CET program and participation in healthy lifestyle behaviours if carried out successfully. This challenge of planning for diverse needs in community programming is not a rare occurrence and has been discussed in other studies to be a key barrier in uptake of exercise behaviours[37,38]. For individuals living with chronic disease, there is an established need to broadly offer safe and accessible exercise programs to optimize overall function and decrease disease-related impairment[39]. In regard to CET programs, the self-reported benefits in our study and positive outcomes as discussed in other meta-analyses[21–23] reflects the need for this type of programming in the community space. Therefore, considerations for further customization of these programs to meet the needs of persons with multiple health conditions or chronic conditions and differing mobility levels should be explored. For the exercise component, the presence of experienced and knowledgeable instructors that are able to effectively tailor the exercise difficulty is crucial to ensuring that the needs and preferences of participants are appropriately addressed. In addition, offering different versions of the program, such as those that are either disease or disability oriented, can ensure that exercises are suitably adapted to the functional limitations of participants. In terms of the cognitive training aspect, one of the benefits of having a computer-based cognitive training delivered on tablets is that there are options available to further offer individualized training, such by improving the mechanism in which the level of task difficulty is adjusted as the participant improves upon their performance. This opportunity for further improvement provides incentive for researchers or developers to create more evidence-based cognitive training applications that can be readily administered in a community setting. As such, future implementations of CET programs should explore the effects of different customization methods on participant satisfaction and behaviours. Similar to other community exercise programs, the long-term sustainability of CET programs should also be a focus of further research to ensure the consistent delivery and accessibility of such programs in the community space.

Strengths

One of the main strengths of this study is that the perceptions and opinions of individuals involved with a CET program in the community environment were captured and described in detail to further indicate areas of future research. In particular, the perspectives of the instructors leading the CET program were captured and this is helpful in identifying next steps for future implementation of CET community programs. Another strength is the detailed process that was undertaken to ensure validity in this qualitative study through the incorporation of numerous strategies such as using iterative questioning during the interviews and holding frequent debriefing sessions.

Limitations

Despite the strengths, this study does possess some limitations. This qualitative study was conducted based on a small sample that was mostly retired, community-dwelling women at one centre in an urban setting. As such, it is highly likely that this sample does not represent a full range of experiences of community-dwelling adults and older adults, making it difficult to generalize the results of this study to the wider population such as men or those living in rural settings. This sample however is more diverse compared to other published trials focusing on dementia risk, which was one of the primary advantages of using a community center affiliated with the YMCA. Another limitation of this study is the lack of formal experience in qualitative data analysis for the two researchers who were primarily responsible for the coding of transcripts. Both of these two researchers were, however, familiarized with the process of conducting thematic analysis beforehand. As discussed previously, other research team members who are well-experienced in conducting qualitative data analysis were also involved in the process of re-examining codes, sub-themes and themes to ensure that all relevant quotes and interpretations were captured in this study.

Conclusion

In summary, this study aimed to gain an understanding of the perspectives from participants and instructors of a pilot CET program. Despite challenges in varying preferences and abilities, a pilot CET community program was positively reviewed by both participants and instructors due to its perceived variety and multiple opportunities to measure progression and/or successes. Although these results were based on a small sample of interviewees, a rich description of insights and recommendations for future iterations of the CET program was nevertheless received from key individuals involved in the pilot program. The considerations and recommendations outlined in this study, such as further exploration of motivation mechanisms and program customization methods, will provide a basis in informing the future development, implementation, and evaluation of CET community programs with larger sample sizes and in different settings. These findings will also assist in the development of accessible and impactful community programs that will address the growing prevalence of dementia in the older population.

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Appendix N

Guide for Daily Observational Notes

Describe the instructors' and participants' experiences with the exercise and cognitive training program from your perspective. Use the following questions as prompts when taking notes of your observations:

1. Do participants appear to be enjoying the exercise/cognitive training? Do instructors appear to be enjoying running the exercise program?

2. What challenges or barriers were encountered during the session (i.e. timing, transition between cognitive and exercise training, quality and availability of space/equipment, wifi issues, etc.)?

3. Did participants ask for help/ask questions to instructors? What kind of questions?

4. Did participants follow the training as prescribed (i.e. were there any social conversations occurring during the session)?

5. Did instructors roam the floor effectively (i.e. did they cover the whole area throughout the session)? Did they answer questions or intervene when appropriate (i.e. to cue proper form)?

Notes:

Appendix O

Successes and Failures Sample Report

Report of Successes and Failures

Success	**Failure**
Date: - Recruits for the day/week - Pre/post assessments (length, organization, smoothness) - Number attended in class - Other study/program facilitators or positives	Date: - Dropouts for the day/week - Pre/post assessments (length, organization, smoothness) - Number of absentees in class - Other study/program barriers or negatives

Appendix P

YMCA Pre and Post-Program Assessments

Participant Name:_______________________________________

Assessment Date:_______________________________________/_________________________________/
____(yyyy/mm/dd)

Select Program: ☐ Diabetes Fit ☐ Live Smart ☐ Neuro Fit ☐ Fitness For Function

Location: ☐ Chaplin Family YMCA ☐ A.R. Kaufman Family YMCA

RESTING MEASURES AND ANTHROPOMETRICS		
Pre exercise BP:	Pre exercise HR:	Height:
Post exercise BP:	Post exercise HR:	Weight:
Waist Circumference:	Hip Circumference:	WHR:

BALANCE TESTS	
TUG TEST: **Trial 1:** ________ **sec** **Trial 2:** ________ **sec** **Gait Aid Used? Yes NO** **Specify:** _________________	**FOUR SQUARE STEP TEST:** **Trial 1:** ________ **sec** **Trial 2:** ________ **sec** **Cane Used? Yes NO**

STRENGTH TEST	
STATIC GRIP STRENGTH TEST: **Dominant Hand:** ☐ Right ☐ Left **Stroke?** ☐ Y ☐ N **Affected Side** ☐ R ☐ L LEFT : Trial 1: _____lb Trial 2: _____lb RIGHT: Trial 1: _____lb Trial 2:_____lb NORMATIVE VALUE: ___________	**5-TIMES SIT-TO-STAND TEST:** Time (sec): _______________ % or Predicted: ____________

AEROBIC FITNESS TESTS	
6 MINUTE WALK TEST:	
Check one of the following and complete accordingly:	
☐ **Track**	**Laps:** ____________________________________
☐ **Wellness Centre**	**Distance:** ____________________________________
☐ **Other** **Specify:**__________	**Distance:** ____________________________________
Notes:	

Appendix Q

Sample Codebook

Themes	Quotes
Theme #1: Progression and successes motivate participant adherence	Sub-theme 1.1: Improvement in cognitive training performance inspired participants
	Subtheme 1.2: Exercise-related improvements were perceived and objectively observed during the program
Theme #2: Participants' diverse abilities and preferences influence study feasibility	Sub-theme 2.1: Diverse abilities led to diverse levels of satisfaction
	Sub-theme 2.2: Personal preferences along with program flexibility affect adherence and satisfaction
Theme #3: Pragmatic approach leads to variability in intervention and experience	Sub-theme 3.1: The pragmatic approach diminished consistency of program delivery
	Sub-theme 3.2: Some participants perceived the study as a YMCA program, influencing their experience

Appendix R

Sample Exercise Diary

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Date								
Pre Exercise BP								
Pre Exercise HR								
Other								
Warm Up	Type							
	Time							
Cardio	Time							
Strength 1	Reps							
	Weight							
2	Reps							
	Weight							
3	Reps							
	Weight							
4	Reps							
	Weight							
5	Reps							
	Weight							
6	Reps							
	Weight							

7	Reps							
	Weight							
8	Reps							
	Weight							
9	Reps							
	Weight							
10	Reps							
	Weight							
11	Reps							
	Weight							
Balance								
Posture								
Post Exercise BP								
Post Exercise HR								
Other								
Comments								

See your instructor for a program update

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