Determinants of Physical Activity Engagement and Physical Activity Intervention Adherence in Individuals with Mild Cognitive Impairment: A Mixed Methods Study

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Declaration

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Summary

Background. The overarching aim of this thesis was to to identify the determinants of PA engagement and PA intervention adherence in individuals with MCI to expand on this under – researched topic and better inform PA promotion and intervention design in this cognitively at - risk population. Some study aims, namely a study of the perspectives of health care professionals, were not achieved due to the negative impact of the Covid – 19 pandemic and related restrictions.

Method. This was a convergent parallel mixed methods study in a sample of participants of the NeuroExercise study, an RCT investigating the effects of a 12-month PA programme on cognitive function in individuals with MCI. Two main studies were conducted, study 1 investigated the determinants PA engagement and study 2 investigating the determinants of PA programme adherence. Each study comprised a qualitative and quantitative sub – study, and an analysis of integrated findings. Quantitative data were statistically analysed to identify correlates. Qualitative data was collected and analysed inductively using thematic analysis to explore barriers and facilitators. Strands of findings were integrated using the COM – B framework of behaviour.

Results. Levels of PA engagement and PA programme adherence are low. There was poor agreement between self-report and objectively measured PA engagement. Subjective accounts of memory impairment are associated with engagement and adherence, but not objective measures of cognitive function. Barriers were physical (physical capability/injury), cognitive (memory issues), practical (weather, lack of time) issues, low motivation for PA, and a lack of knowledge of the cognitive benefits of PA and PA guidelines. Class sessions resulted in better adherence than home based sessions, likely due to the practical and group support they provided.

Conclusions. Individuals with MCI experience cognitive and physical limitations to PA that can be targeted to improve engagement in PA and adherence to PA programmes in this clinical group. This can be achieved through individualised PA assessment and prescription using self – report cognitive and physical health data in conjunction with objective measurement to achieve a holistic perspective of capability for PA.

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List of Abbreviations

AD	Alzheimer’s Disease
ADL	Activities of Daily Living
BCT	Behaviour Change Technique
BCW	Behaviour Change Wheel
BDNF	Brain derived neurotropic factor
CES – D	Centre for Epidemiologic Studies Depression Scale
DemQoL	Quality of Life for Dementia Questionnaire
EMCI	Early-stage MCI
GP	General Practitioner
GPAQ	Global Physical activity Questionnaire
GSES	General Self – Efficacy Scale
IADL	Instrumental Activities of Daily Living
JBI	Joanna Briggs Institute
LAPAQ	LASA Physical Activity Questionnaire
LMCI	Late-stage MCI
LMIC	Low to Middle Income Country
MCI	Mild Cognitive Impairment
METS	Metabolic Equivalents
MMSR	Mixed Methods Systematic Review
MoCA	Montreal Cognitive Assessment
MVPA	Moderate to vigorous physical activity
NCD	Non – Communicable Disease
Neo – FFI	Neo Five Factor Inventory
NERF	National Exercise Referral Framework
NERS	National Exercise Referral Scheme
NPAP	National Physical Activity Plan
OPAPAEQ	Older Persons Attitudes for Physical Activity and Exercise Questionnaire
PA	Physical Activity
PASE	Physical Activity Scale for the Elderly

PIL	Patient Information Leaflet
PSQI	Pittsburgh Sleep Quality Index
SCI	Subjective Cognitive Impairment
SMMSE	Standardised Mini Mental State Examination
SRH	Self – Rated Health
TA	Thematic Analysis
TDF	Theoretical Domains Framework
TUG	Timed Up and Go test
WMS – IV	Weschler Memory Scale version IV

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Chapter 1: Introduction

1.1 Background

1.2 Dementia as a Global Health Concern

Dementia is a significant global health concern. An estimated 50 million people are living with dementia worldwide, and this figure is projected to more than treble by 2050 (Patterson, 2018). While the age specific incidence of dementia has been decreasing in high income countries such as the USA, UK, and France in recent years, possibly related to better heart health and higher levels of education, the numbers of people living with dementia is rising in low and middle income countries (LMIC`s) due to population ageing and an increases in risk factors such as low education, diabetes, physical inactivity and hypertension in these settings (Livingston et al., 2020). It is estimated that the incidence rate of dementia is 17.18 per 1000 person-years among community dwelling adults over 60 (Fiest et al., 2016). Delaying the onset of dementia by one year could result in an estimated 9.5 million fewer cases by 2050 (Emery, 2011), and reducing risk factor exposure by 10 – 25% could prevent an estimated 1.1 – 3 million cases worldwide (Barnes & Yaffe, 2011). Thus, strategies to delay or prevent dementia are currently an important focus of population health initiatives to reduce the global burden of the disease.

1.2.1 Current Treatment

To date, pharmacological interventions for the treatment of dementia have been largely unsuccessful, and there are currently no curative treatments (Petersen et al., 2018). The primary strategies to deal with dementia therefore have been to provide symptomatic relief and behavioural intervention (Jongsiriyanyong & Limpawattana, 2018). Early intervention aimed at reducing risk factors for dementia may help delay the onset of dementia (Emery, 2011). However, an intervention to delay or interrupt the neurodegenerative process is likely to be most successful in the pre – dementia phase (Emery, 2011). In other words, intervening at time of dementia diagnosis may be too late as conversion to dementia has already occurred (Emery, 2011; Gauthier et al., 2006). In fact, post-mortem studies have shown that the pathological brain changes associated with dementia can far precede the emergence of symptoms, sometimes by up to ten years (Jack et al., 2002; Snowdon et al., 1997; Storandt et al., 2006). Therefore, a growing body of research is focusing on interventions targeting individuals at risk of cognitive impairment or at the early stages of decline before a diagnosis of dementia is reached, and as mild cognitive impairment (MCI) is an 'at risk" or prodromal stage of dementia, it may be a promising treatment target to delay or prevent the transition of cognitive impairment to the dementia stage.

1.2.2 Mild Cognitive Impairment (MCI)

Mild cognitive impairment is a term used to describe a level of decline in cognitive function which is an intermediate stage between normal ageing and dementia, often considered to be a prodromal stage of neurodegeneration which may progress to dementia (Apostolo et al., 2016; Petersen et al., 2009). It is defined as a level of cognitive decline beyond that of normal ageing and greater than expected for an individual's age and level of education (Petersen et al., 2009). The clinical criteria for MCI are subjective or objective decline in one or more cognitive domain independent of neurological, psychiatric, systemic disorders, metabolic dysfunction or as the result of medications, but with essentially normal functioning and preserved activities of daily living (ADL`s) (Jongsiriyanyong & Limpawattana, 2018; Petersen et al., 2009). Although individuals with MCI can remain stable or revert to normal functioning, a significant proportion of individuals with MCI progress to dementia within 5 years (Gauthier et al., 2006). Thus, MCI is considered to be a high - risk state of cognitive change (Apostolo et al., 2016).

MCI is often further sub – categorised as amnestic (aMCI, memory) and non – amnestic (naMCI, domains other than memory) (Petersen et al., 2009). Population based studies have shown that aMCI is more common than naMCI (Glynn et al., 2020; Petersen et al., 2010).

However, a recent study based on longitudinal data with a 6 year follow up period reported naMCI to be more common than aMCI in community dwelling adults (Overton et al., 2019). Adults with aMCI are more likely to progress to dementia relative to naMCI (Glynn et al., 2020; Yaffe et al., 2006) and cross sectional MRI evidence has demonstrated the presence of structural brain changes in both individuals with aMCI and naMCI, albeit with significantly greater structural changes observed for aMCI (e.g., reduced volume of the hippocampus and amygdala) , relative to cognitively healthy controls (Csukly et al., 2016).

1.2.3 Prevalence of MCI

Prevalence and incidence rates in MCI can vary by age, severity of MCI (Overton et al., 2019; Petersen et al., 2010), the criteria used to diagnose MCI and according to community versus clinical setting (Farias et al., 2009). There are substantial differences in reported rates of the prevalence of MCI (Apostolo et al., 2016) which can be attributed in part to varying definitions MCI across studies (Jongsiriyanyong & Limpawattana, 2018). For example, one systematic review estimated the prevalence of MCI in all ages to range from 5 % - 36. 7%. However, this varied between studies according to how MCI was defined and measured, with studies using the Clinical Dementia Rating Scale showing prevalence rates of between 1.8% - 14.9 % and those the MMSE reporting rates of between 2.1% - 20. 7% (Sachdev et al., 2015). Other systematic review evidence suggests the prevalence of MCI in adults aged 60 years and older to be between 5.5 % - 25.2% (Apostolo et al., 2016; Hu et al., 2017; Jongsiriyanyong & Limpawattana, 2018) and 22% in adults over 70 (Apostolo et al., 2016; Plassman et al., 2008). Further age specific reports cite prevalence rates of 6.7% for ages 60–64, 8.4% for 65–69, 10.1% for 70–74, 14.8% for 75–79, and 25.2% for 80–84 (Petersen et al., 2018).

1.2.4 Conversion Rates of MCI to dementia

Progression to dementia from normal cognitive functioning in older adults is typically 1% - 2% per year (Petersen et al., 1999; Vega & Newhouse, 2014) and it is thought that this occurs at a higher rate in individuals with MCI, though current estimates are variable. For example, one meta-analysis reported that annually 45% of individuals with MCI remain stable, 15% revert to normal functioning, 34% convert to dementia and 28% convert to AD (Hu et al., 2017). Comparable rates were reported in a cohort study in individuals with MCI which found that over a 6 year follow up period 59% remained stable, 31% converted to dementia, but a much lower reversion rate of 3% was reported (Velayudhan et al., 2018). In addition, one non -systematic review cited an annual conversion rate of 15 - 41% (Apostolo et al., 2016), while a subsequent narrative review cited a conversion rate of 5% - 17% annually (Jongsiriyanyong & Limpawattana, 2018). This is in accordance with the reported incidence of dementia of 14.9% for adults over 65 years with MCI over a 2 year follow up period (Petersen et al., 2018). However, prospective studies have cited lower rates of conversion, with one study finding that 8% of individuals with MCI converted to dementia over 3 years (Tervo et al., 2004), and data from the Italian longitudinal study on ageing (ILSA) reporting a conversion rate of 3.8% (Solfrizzi et al., 2004). Conversion rates from MCI to dementia have also been found to differ according to setting. A previous prospective longitudinal study found that 13% of a clinic sample compared with 3% of a community sample of individuals with MCI converted to dementia during a 1 year follow up (Farias et al., 2009), with baseline cognitive function driving the difference according to the authors. Hu (Hu et al., 2017) concluded from their meta – analysis of prevalence and conversion rates from MCI to dementia, that stable disease rate and reversion rates are higher in community settings, and that dementia and AD rates are higher in clinical settings.

There are further inconsistencies in reported rates of conversion between sub- types of MCI. Some studies have reported comparable rates of conversion to dementia between amnestic and non-amnestic MCI sub – types (Duara et al., 2011; Han et al., 2012; Rountree et al., 2007). In contrast, many clinic-based studies have demonstrated a higher risk of conversion to dementia in aMCI sub – groups compared with naMCI (Ferman et al., 2013; Jungwirth et al., 2012; Langa &

Levine, 2014; Maioli et al., 2007). For example, one retrospective study of MCI among Irish adults showed that 32% converted to dementia within 2 years, with individuals with aMCI twice as likely to convert than those with naMCI (Glynn et al., 2020). A more conservative annual conversion rate of 10 % - 15% in those with aMCI compared to 1 – 2% in cognitively healthy adults was reported in one systematic review (Vega & Newhouse, 2014). Not all individuals with MCI progress to dementia, and some estimates of the rate of reversion from MCI to normal cognition have been placed at 25% - 30% (Vega & Newhouse, 2014). However, the authors state that those who reverted to normal cognitive functioning were still at an increased risk of dementia in later life. Thus, MCI is a heterogenous high-risk phase, but the likelihood of reversion to normal cognitive functioning among community dwelling individuals with MCI identifies an ideal target population for intervention to positively impact cognitive health in those at risk of dementia (Apostolo et al., 2016).

1.3 Preventing or Delaying MCI

1.3.1 Pharmacological Interventions

There is no recognised pharmacological treatment for MCI and most of the current evidence agrees that there is no good evidence to support the efficacy of pharmacological treatment for disease modifying purposes in MCI (Apostolo et al., 2016; Livingston et al., 2020; Petersen et al., 2018; Sanford, 2017; Strohle et al., 2015; Vega & Newhouse, 2014). A number of RCT studies in individuals with MCI have found a small positive effect of galantamine (Koontz & Baskys, 2005) and donepezil on cognitive function (Doody et al., 2010). However, systematic reviews, including one Cochrane review (Russ & Morling, 2012), have concluded that there is a lack of evidence to support the efficacy of cholinesterase inhibitors to improve cognitive function or to delay or prevent conversion from MCI to dementia (Anderson, 2019; Langa & Levine, 2014; Petersen et al., 2018).

Other pharmacological therapies that have been investigated in relation to MCI include vitamin B (B12, B6 and folic acid), vitamin E, and omega 3 fatty acids. One RCT reported that vitamin B supplementations slowed cognitive decline in individuals with MCI (de Jager et al., 2012), but this was in contrast to an earlier RCT finding which reported no effect (van Uffelen et al., 2008). Systematic review evidence has concluded that the efficacy of vitamin B supplementation for improving cognitive function and slowing cognitive decline to be unclear at present due to a lack of evidence of its effect on executive function, attention, and general cognitive function (Apostolo et al., 2016; Li et al., 2014; Vega & Newhouse, 2014). Similarly, the evidence does not support the use of vitamin E as an effective treatment for slowing progression from MCI to dementia (Petersen et al., 2018), though omega 3 fatty acids may be useful in improving mood symptoms in individuals with MCI (Vega & Newhouse, 2014). The use of statins has shown some positive effect on cognitive decline in observational studies, but a recent review concluded that further RCT data is needed to conclude an overall effect (Yang & Williamson, 2019). However, the use of anti-hypertensive medications may reduce the risk of incident MCI (Peters et al., 2019; Solfrizzi et al., 2013), and dementia in older adults (Etgen et al., 2010). In addition, some anti-depressant medications, such as sertraline, have shown some efficacy in promoting attention, episodic memory, and executive function on neuropsychological tests in individuals with MCI (Apostolo et al., 2016).

1.3.2 Non – Pharmacological Interventions

1.3.2.1 Targeting Modifiable Risk Factors. Given the absence of effective pharmacological methods of prevention and inconsistent evidence for drugs to delay progression or reversing MCI, interventions which aim to prevent or delay cognitive decline through addressing known risk factors may achieve greater results in reducing the incidence of dementia (Livingston et al., 2020). Interventions which positively impact vascular health, obesity, and hypertension in adults 40 -60 years old have potential to be valuable in maintaining cognitive health and reducing later life dementia risk (Prince et al., 2016; Prince et al., 2014). It has been estimated that risk modifying interventions such as those addressing smoking or enhancing physical activity could be applied to individuals without dementia (e.g., those 45 – 65 years old) to prevent or delay dementia cases worldwide by up to one third . Currently, 12 modifiable risk factors for dementia have been identified which have been estimated to contribute up to 40% of the population attributable fraction to dementia risk (Livingston et al., 2020). These are lower levels of education, smoking, hearing impairment, hypertension, obesity, diabetes, depression, physical inactivity, low social contact, excessive alcohol consumption, traumatic brain injury, and air pollution. Public health approaches and interventions that target these modifiable risk factors could be helpful for individuals with MCI and reduce progression to dementia. There is some evidence to suggest that interventions such as improved social interaction (Bennett et al., 2006; Hughes et al., 2013) and a Mediterranean diet (Sanford, 2017; Singh et al., 2014) may reduce the risk of MCI and AD, and progression of MCI to dementia. However, the most common forms of non – pharmacological intervention for MCI that have been reviewed systematically and non – systematically in the current literature are cognitive and physical activity interventions, which have shown promise for promoting cognitive function in healthy older adults (Bherer, 2015; Lautenschlager et al., 2014; Livingston et al., 2020) and individuals with MCI (Apostolo et al., 2016; Petersen et al., 2018; Sanford, 2017; Vega & Newhouse, 2014).

1.3.2.2. Cognitive Interventions. Cognitive interventions targeting cognitive decline typically utilise strategies to improve general or specific areas of cognitive function (Livingston et al., 2020). Findings regarding their effectiveness have been mixed. One meta – analysis reported contrasting findings of their effectiveness, with some studies demonstrating moderate positive improvements in verbal fluency, general cognition and activities of daily living, overall cognition and metacognitive outcomes and a decreased incidence of memory decline, but others showing no improvement from specific cognitive interventions on generalised cognition (Livingston et al., 2020). The authors concluded that overall, these findings were inconclusive and of limited clinical value due to a low standard of studies, risk of bias and heterogeneity of results. However, contrasting findings from systematic and non – systematic reviews have reported that cognitive interventions improved global cognitive functioning and memory in individuals with MCI, with small improvements to executive function (Gallaway et al., 2017) and delayed memory (Apostolo et al., 2016; Ge et al., 2018; Vega & Newhouse, 2014; Whitty et al., 2020), whereas another systematic review concluded a positive effect of cognitive training in healthy older adults but insufficient evidence to conclude a benefit in individuals with MCI (Butler et al., 2018). A recent meta-analysis of cognitive interventions in individuals with MCI showed significant overall effects for interventions targeting memory, which was superior to the modest effect determined for multidomain interventions (Sherman et al., 2017). Reports from two 12 week cognitive intervention studies in individuals with MCI have reported beneficial effects on memory (Lee et al., 2018), verbal memory and executive function, with superior improvement demonstrated in a virtual reality cognitive training condition compared with standard cognitive training on global cognitive function, verbal memory and instrumental activities of daily living (IADLs) (Liao et al., 2020). One further RCT showed significant cognitive improvements, with a time/ intervention interaction effect, for a 6-month cognitive intervention (Peng et al., 2019). However, meta-analytic evidence suggests time is not a moderating factor (Sherman et al., 2017). Further, evidence suggests that cognitive training may be limited in its utility as there are few transfer effects (i.e., positive effects only occur in the specific targeted domain) (Jongsiriyanyong & Limpawattana, 2018; Livingston et al., 2020; Willis et al., 2006)), though broad transfer may sometimes occur (Sherman et al., 2017) and multicomponent cognitive training may enhance this effect (Basak et al., 2020). For example, computerised dual task training was found to improve measures of physical functioning in non – impaired older adults in one systematic review (Bherer, 2015) and ancillary improvements in anxiety, depression and ADLs were reported in another systematic review (Ge et al., 2018).

Few interventions have examined the effect of cognitive training on non-cognitively impaired older adults and those that have lacked randomisation (Jongsiriyanyong &

Limpawattana, 2018; Willis et al., 2006). However, one large RCT of cognitively normal older adults with a 10 year follow up period (the ACTIVE study) found significant and durable cognitive and functional improvements following ten sessions of cognitive training targeting memory, reasoning, and processing speed with 8 subsequent booster sessions (Rebok et al., 2014). In that study, a moderate positive effect was found for all three targeted cognitive domains, and the effect was sustained over the follow up period for reasoning and processing speed. The intervention groups had significantly greater self – reported IADL functioning relative to baseline compared to controls. In addition, booster training enhanced this effect. Those findings followed on from the reported improvements in reasoning, but not memory or processing speed following the ACTIVE intervention at the 5 year follow up (Willis et al., 2006).

1.3.2.3 Physical Activity. Physical activity (PA) has received attention as a possible viable modifiable lifestyle risk target (Apostolo et al., 2016) and potentially useful therapeutic strategy for the prevention of dementia (Ahlskog et al., 2011). Interventions including both combined cognitive and physical activity or physical activity are considered beneficial in improving cognitive measures (Petersen et al., 2018). The most recent Lancet Commission on dementia document states that sustained PA in mid and late life is associated with improved cognitive outcomes and reduced risk of dementia in older adults (Livingston et al., 2020).

However, evidence of this is inconsistent between types of research studies. For example, observational studies largely support a protective effect of PA, but the evidence coming from the majority of RCT`s is less clear. For example, cross sectional studies have reported that greater self – reported leisure time physical activity was related to reduced risk of MCI, dementia, and AD in later life (Barnes & Yaffe, 2011; Gallaway et al., 2017; Geda et al., 2010; Tolppanen et al., 2015). A number of longitudinal studies have also supported this assertion (Chu et al., 2015; Laurin et al., 2001; Lytle et al., 2004; Tortosa-Martinez et al., 2015; Weuve et al., 2004). Additionally, systematic reviews and meta- analyses of prospective (Ahlskog et al., 2011), and longitudinal studies (Apostolo et al., 2016) have supported a positive association between mid and late life PA and reduced risk of MCI, dementia, and AD.

However, findings from experimental studies has been less consistent. For example, a number of systematic reviews of RCTs have reported no overall evidence of a significant effect of PA on cognitive function in non - impaired populations (Kelly et al., 2014) or in adults with dementia (Forbes et al., 2008), and found no consistent evidence to support the role of PA in preventing or delaying MCI or dementia (de Souto Barreto et al., 2018; Kane et al., 2017). In contrast, a number of other systematic reviews of RCTs have shown modest improvements in cognitive performance in adults with dementia (McDonnell et al., 2011), and an overall positive effect of PA on global cognitive function in healthy older adults (Carvalho et al., 2014) and individuals with MCI and AD (Strohle et al., 2015). Further meta-analyses and systematic reviews of PA interventions have found aerobic PA improves global cognitive function, memory attention and processing speed in individuals with MCI (Cai & Abrahamson, 2016; Zheng et al., 2016). One systematic review which reported on both experimental and observational studies (cross - sectional and cohort studies) stated that observational studies support a protective effect of PA on risk of MCI , dementia, and AD whereas experimental studies suggest PA may induce improvements in the cognitive domains of attention, memory, language, executive function, and global cognitive function in cognitively healthy older adults (Lu et al., 2016). The authors conclude however, that more rigorous RCT data is needed to support this assertion in experimental settings. Similarly, two previous meta – analyses concluded that overall, the evidence from epidemiological, cross-sectional, and neuroimaging research in cognitively healthy adults is supportive of a relationship between greater levels of PA and reduced risk of cognitive decline, but evidence from randomised controlled trials (RCTs) is less conclusive and requires further investigation (Apostolo et al., 2016; Kelly et al., 2014). Moreover, one recent systematic review of RCTs concluded that although PA interventions improved global cognitive function in individuals with MCI, the benefits of PA in all stages of AD remains unclear (Cammisuli et al., 2018).

The inconsistent findings within RCT studies, and between RCT and observational evidence may partly be explained by methodological differences, such as differences in study and intervention design (e.g. duration/ mode of PA), outcome measures (Barha et al., 2017; Cui et al., 2018; Forbes et al., 2008; Kelly et al., 2014; Song et al., 2018), follow up periods (Kane et al., 2017) and varying definitions of PA across studies. However, some research has suggested that inconsistencies in intervention adherence, adherence data collection and reporting of adherence may contribute to varying RCT outcomes (Di Lorito et al., 2020; Kane et al., 2017; Kelly et al., 2014). For example, observational studies have commonly used self – reported PA data which may be subject to recall bias in cognitively impaired populations (Di Lorito et al., 2020). A possible under or over – estimation of PA by cognitively impaired adults may result in unreliable PA data and contribute to the variation in findings between observational and experimental studies. As greater adherence to PA interventions has been shown to result in better cognitive outcomes in individuals with MCI (van Uffelen et al., 2008), understanding the determinants of adherence in individuals with MCI may be important for understanding the variation in reported outcomes with the current literature.

1.3.2.4 Possible Pathways Related to Cognitive Improvement. The current literature has offered a number of mechanistic explanations for the physiological pathways through which PA positively impacts cognitive function. PA may promote neuroplasticity (Ahlskog et al., 2011; Bherer, 2015; Chirles et al., 2017), reduce proinflammatory cytokines and improve peripheral BDNF concentration (Devenney et al., 2019; Nascimento et al., 2015; Sleiman et al., 2016). PA has also been reported to reduce hippocampal atrophy (Ahlskog et al., 2011; Jaroudi et al., 2017; ten Brinke et al., 2015), attenuate age associated reduction in grey matter volume (Ahlskog et al., 2011; Jaroudi et al., 2017), improve vascular and cardiorespiratory health (Schultz et al., 2017), and mitigate cerebrovascular risk such as reducing the impact of small vessel disease on risk of dementia (Ahlskog et al., 2011). Further, regular PA may mediate the positive impact of cognitive reserve on cognitive functioning (Chirles et al., 2017; Clare et al., 2017) and may also have positive effect on cognitive function through exercise induced changes in the circadian pattern of cortisol excretion (Tortosa-Martinez et al., 2015).

1.3.2.5 Frequency, Duration, Intensity and Type of Physical Activity. There is limited available evidence regarding the efficacy of specific types of PA and the characteristics of PA programmes, such as duration, frequency, and intensity, that are most likely to positively impact risk of dementia (Livingston et al., 2020) or MCI (Cai & Abrahamson, 2016) in older adults. However, two meta – analyses of RCT data in healthy older adults (Ahlskog et al., 2011) and adults with AD (Groot et al., 2016) reported overall positive effects on cognitive function for interventions that included aerobic PA compared to non – aerobic interventions. In MCI populations, aerobic PA has been found to significantly increase hippocampal volume in older women following a 6-month aerobic PA programme (ten Brinke et al., 2015). Daily aerobic or mind – body exercise has also been related to reduced risk of dementia in a longitudinal study with a 6year follow up, though stretching and toning was not (Lee et al., 2015). Some meta – analytic and systematic review evidence has shown resistance training to be positively related to measures of global cognitive function, executive function (Li et al., 2018) and reasoning in healthy older adults (Kelly et al., 2014). However, multimodal PA interventions (aerobic and resistance training) may be superior in terms of cognitive benefits to resistance or aerobic training in healthy older adults, though data is currently limited (Saez de Asteasu et al., 2017).

Evidence regarding the ideal duration of PA sessions for cognitive benefits is limited. However, there is some evidence to suggest that durations of 30 minutes or more predicted a reduced risk of cognitive decline in healthy older adults (Chu et al., 2015). In contrast, one systematic review of PA intervention studies found that only intervention duration in hours (52 hours), and not session duration or frequency, was significantly related to improved cognitive performance (Gomes-Osman et al., 2018) in adults with and without cognitive impairment. Similarly, there is scant evidence regarding the ideal frequency and intensity for impacting cognitive function. A meta-analysis of PA interventions in adults with AD found no significant difference in cognitive function between high frequency and low frequency of PA sessions amongst intervention groups suggesting no relationship between session frequency and cognitive outcomes (Groot et al., 2016). However, resistance training three times per week was significantly associated with greater global cognitive gains compared with twice weekly resistance training in one recent systematic review in healthy older adults (Li et al., 2018). Differences in cognitive domains positively impacted by differing PA intensities further complicates our current understanding. For example, moderate intensity aerobic PA may positively impact global cognitive function, working memory and attention, and verbal memory and attention, whereas low intensity aerobic PA may promote improved visual spatial perception and attention (Koscak Tivadar, 2017).

1. 4 Study Rationale

There are barriers to utilising PA as an intervention to prevent or delay dementia in community dwelling individuals with MCI. According to current global PA guidelines, adults aged 18 and older should engage in at least 30 minutes of moderate intensity PA a day five days per week, or 150 minutes per week. The most recent guidelines have increased the minimum amount of recommended PA to 150 – 300 minutes of moderate or 75 -150 minutes of vigorous intensity PA per week (Bull et al., 2020). However, as this study was conducted prior to the release of these updated guidelines, this thesis will focus on recommended PA as per the previous guidelines of 150 minutes of moderate PA or 75 minutes of vigorous PA per week. In response to the growing body of literature supporting PA interventions as a promising therapy for preventing or slowing cognitive decline in MCI and dementia (Groot et al., 2016; Nuzum et al., 2020; Petersen et al., 2018) some health policy and research agencies have begun to make PA recommendations targeting adults at risk of cognitive decline. In their updated Practice Guidelines for MCI, the American Academy of Neurology advise clinicians to recommend twice weekly exercise to their MCI patients for the management of cognitive decline (American Academy of

Neurology, 2017). Similarly, some countries, such as Australia, have published MCI specific PA guidelines (Chong et al., 2020).

However, there are challenges to utilising PA to target cognitive decline in MCI. Cognitively impaired adults have been found to be less physically active than healthy older adults. For example, adults with subjective cognitive impairment (Miyawaki et al., 2017), MCI (Gagliardi et al., 2016) and dementia (van Alphen et al., 2016; Watts et al., 2013) have been found to be less physical active compared with non – impaired adults. The reasons for reduced PA engagement in individuals with MCI are not well understood and require further study to inform efficient PA promotion within this group. Rates of PA intervention adherence among individuals with MCI are also variable and there is a lack of understanding of the determining factors related to PA adherence in MCI. Indeed, the lack of consistent data regarding rates of adherence to PA interventions for adults with cognitive impairment may be partly responsible for the inconsistent findings regarding cognitive outcomes in the experimental literature (Kane et al., 2017; Kelly et al., 2014).

In addition, MCI is often associated with poor physical health (Frisoni et al., 2000). Recent evidence shows that memory status positively predicts physical health, whereas the opposite relationship was found to be weaker (Nelson et al., 2020). This suggests that cognitive impairment could negatively impact physical health and thus in theory, the ability to be physically active. Cognitive deficits in MCI might also constitute a key barrier to PA engagement and PA intervention adherence as it is unclear whether low levels of PA in cognitively impaired adults is a consequence of cognitive decline or if the reverse is true (Livingston et al., 2020).

Other health related factors that are common in individuals with MCI may also negatively impact on ability for PA, and their relationship to PA as an outcome remains to be clarified. For example, though one of the criteria for diagnosis of MCI is intact ability to complete activities of daily living (ADL`s), recent research suggests that ADL`s (Puente et al., 2014) and IADL`s (instrumental activities of daily living) (Reppermund et al., 2013) are negatively impacted in MCI, with high cognitive demand activities becoming impaired prior to an MCI diagnosis and progression of cognitive decline leading to greater levels of error in IADLs which can impair individual's ability to complete tasks independently (Schmitter-Edgecombe & Parsey, 2014).

Mobility is also often impaired in individuals with MCI compared to cognitively healthy older adults, with greater loss of mobility in adults with naMCI (Gonzales et al., 2016; Pedersen et al., 2014). Similarly, physical frailty is significantly associated with poor cognitive function in adults (Cammisuli et al., 2018). Medication use may also confound the relationship between MCI and PA. Individuals with MCI take an average of 3 medications, with 40 % of individuals with MCI regularly consuming 4 medications for chronic illness such as cardiovascular drugs, antidepressants, sedatives, and thyroid drugs (Livingston et al., 2020; Tsolaki et al., 2016). Moreover, multi medication use has been negatively linked to gait speed (Umegaki et al., 2019) verbal fluency and quality of life in individuals with MCI and mild dementia (Bonfiglio et al., 2019). Psychosocial factors, such as depression, have also been cited as contributing to dementia and AD risk (Jaroudi et al., 2017) and to MCI (Apostolo et al., 2016), and has also been shown to be a predictor of PA engagement in adults with and without cognitive impairment (Watts et al., 2018), further demonstrating the possible complex nature of interacting relationships between cognitive impairment and its associated co - morbidities and PA engagement or PA intervention adherence.

1. 4.1 Limitations to the Current Literature

MCI is heterogenous (Overton et al., 2019; Petersen et al., 2010) and varies by sub – type, age, and setting (Farias et al., 2009; Glynn et al., 2020; Petersen et al., 2018). This heterogeneity may be partly responsible for inconsistencies across study findings regarding incidence and prevalence of MCI. It also may limit the efficacy of PA interventions as not enough is understood about the causes of this heterogeneity in MCI to effectively decide who or when to use targeted PA intervention for cognitive health, or what type of PA intervention will be acceptable or feasible for individuals with MCI.

Greater PA programme adherence is associated with better cognitive outcomes in individuals with MCI (van Uffelen et al., 2008). However, the determinants of PA in this group are currently unclear. Many factors associated with MCI may also impact PA, but little data exists which explains how these factors might impact PA in individuals with MCI, either directly or indirectly. For example, co – morbidities and reduced physical function are associated with MCI and also with reduced PA engagement. Additionally, psychosocial factors such as depression have been independently associated with cognitive impairment and low levels of PA .Thus, they may impede the ability of individuals with MCI to engage in and adhere to PA interventions for cognitive health. In addition, the degree of cognitive impairment experienced by individuals with MCI and the domains affected may also theoretically pose a barrier to engagement and intervention adherence, yet this is currently an under- researched area. Therefore, there is a gap in the literature regarding how cognitive, physical, and psychosocial factors associated with MCI impact on PA engagement and programme adherence in this cohort. This lack of understanding of the contribution and interactions between these factors when operationalised as variables has resulted in a sparse evidence base on which to promote PA engagement for cognitive health in this at-risk cohort of individuals and additional data is required that is specific to individuals with MCI.

In addition, inconsistent adherence to PA interventions has been cited as a possible reason for inconclusive evidence regarding the cognitive benefits of PA in experimental studies (Kane et al., 2017; Kelly et al., 2014). Indeed, PA intervention adherence rates in individuals with MCI are variable across the literature and the possible reasons for this variability are not well understood (Di Lorito et al., 2020). Further research is needed to expand on what is currently known, and to identify possible correlates and barriers to PA intervention adherence in this cohort of at-risk adults. Similarly, although individuals with MCI and dementia are known to be less physically active than non – impaired adults (Miyawaki et al., 2017; van Alphen et al., 2016; Vidoni et al., 2016; Watts et al., 2013), little research exists to explain the reduced rates of PA engagement in this cohort. Further studies are required to determine the facilitators and barriers to PA engagement in individuals with MCI to further an in depth understanding of this phenomenon.

Another limitation with respect to the current literature is the paucity of evidence regarding the ideal frequency, duration and type of PA that is most beneficial for cognitive health in individuals with MCI. Further, there is a paucity of studies that have investigated these factors in relation to their relationship with PA engagement or PA programme adherence. Aerobic PA may produce superior cognitive benefits to resistance training, and multimodal PA may be the most beneficial, but these findings are not conclusive. Interventions of at least 30 minutes in duration may be needed to detect a beneficial effect, but this finding is lacking replication. Thus, there is a lack of understanding from the literature of the characteristics of PA programmes most likely to maximise cognitive outcomes. Further to this, there is scant available evidence regarding the acceptability of intervention characteristics or preferences of individuals with MCI that might improve engagement or intervention adherence. Understanding the cognitive and physical limitations of individuals with MCI may lead to a greater understanding of the type of PA intervention that best meets their needs, in addition to identifying the preferred mode of PA intervention dissemination among people with MCI that is likely to enhance PA engagement and PA intervention adherence, and thus enhance the desired cognitive outcomes.

Finally, there is a lack of data regarding rates of PA engagement and PA programme adherence, and factors associated with these outcomes in an Irish context, meaning that the current literature may not be generalisable to Irish adults. Thus, clarity regarding PA engagement and programme adherence on a national, as well as international level, is required to further this field.

1. 4.2 Thesis Aim and Objectives

The overarching aim of this study was to identify the determinants of PA engagement (Study 1) and PA intervention adherence (Study 2) in individuals with MCI to better inform PA intervention design and PA promotion in this cognitively at - risk population. This aim was achieved through a number of objectives and sub – objectives, presented in Table 1. In summary, individual quantitative investigations of PA engagement (objective 1, sub – objective 1.1. 1.1.1 and 1.1.2) and PA programme adherence (objective 2, sub – objective 2.1), as well as qualitative exploration of the barriers and facilitators to PA engagement (objective 1, sub – objective 1.2) and PA programme adherence (objective 2, sub – objective 2.2) in this cohort were conducted. Study 1, sub - objective 1.1 was further sub – divided to include analysis of participants level of PA engagement (sub – objective 1.1.1) and level of agreement between subjective and objective methods of PA data collection (sub – objective 1.1.2). Finally, quantitative and qualitative findings pertaining to PA engagement were integrated (objective 1, sub – objective 1.3), as were quantitative and qualitative findings regarding PA programme adherence (objective 2, sub – objective 2.3) to address the main mixed methods aim of this thesis of expanding on what is currently known, and to provide recommendations to support PA engagement and PA programme adherence in individuals with MCI and inform intervention design.

Table 1.

Thesis Objectives and Sub – Objectives

Study	Objectives and sub - objectives	Description
Study 1: PA engagement	Objective 1	A mixed methods analysis of the determinants of PA engagement in Irish adults with MCI
Sub – study 1.1	Sub – objective 1.1.	Quantitatively assess the relative contribution of cognitive, demographic, physical, and psychological variables on PA engagement
	Sub – objective 1.1.1	Describe PA engagement relative to global physical activity guidelines
	Sub – objective 1.1.2	Analyse level of agreement between self- reported and objectively measured PA data
Sub – study 1.2	Sub – objective 1.2	Explore barriers and facilitators to PA engagement
Sub – study 1.3	Sub – objective 1.3	Integrate qualitative and quantitative findings to expand depth of understanding and generate insight, and form evidence-based recommendations to promote PA engagement
Study 2: PA programme adherence	Objective 2 (Study 2)	A mixed methods analysis of the determinants of PA programme adherence in Irish adults with MCI
Sub – study 2.1	Sub – objective 2.1	Quantitatively assess the relative contribution of cognitive, demographic, physical, psychological and

		programme related variables on PA programme adherence and report adherence rates
Sub – study 2.2	Sub – objective 2.2	Explore the barriers and facilitators to PA programme adherence
Sub – study 2.3	Sub – objective 2.3	Integrate qualitative and quantitative findings to expand depth of understanding and generate insight, and form evidence-based recommendations to support programme adherence

1.4.3 Thesis Contributions

The findings of this body of research have the potential to benefit multiple stakeholders. From a research perspective, the findings of this thesis will aid in intervention design targeting PA in individuals with MCI by identifying barriers and facilitators, and thus identify directions for future research invested in the use of PA as an intervention to delay or prevent dementia. Health policy makers and health care professionals will have a strengthened evidence base of determinants of PA engagement and PA programme adherence to draw on to tailor PA promotion and health policy advice for individuals with MCI. Finally, promotion of PA engagement and PA programme adherence is thought to benefit individuals with MCI themselves through its associated cognitive benefits and its potential to support brain health.

1.5 Thesis Overview

This thesis consists of 2 primary studies. Study 1 investigates the determinants of PA engagement in individuals with MCI, and study 2 investigates the determinants of PA programme adherence. Both study 1 and 2 contain 3 further sub – studies which are a qualitative and a quantitative component, and an integrated analysis of sub – studies for each primary study. Thus, there are 3 chapters for each primary study as part of a convergent parallel mixed methods design.

Chapter 1: An introduction to the research context and rationale for this study is presented.

Chapter 2: The mixed methods approach, and the convergent parallel research design is described and a rationale for the use of these approaches are presented. Each empirical study and the approach to integration as part of the mixed methods design are outlined.

Chapter 3: A mixed methods systematic review (MMSR) of the current literature in area of interest is presented. A description of the convergent segregated approach to the literature review and a rationale for its use is provided. The theoretical framework used in this study is introduced and its application described. Findings are discussed individually for the different strands of evidence and a synthesised review of findings is then provided.

Chapter 4: This chapter introduces the first quantitative sub – study of study 1 (sub – study 1.1), sub – objectives 1.1, and 1.1.1 regarding correlates of PA engagement in individuals with MCI. Results are presented and findings discussed.

Chapter 5: An introduction to the topic and a description of the methods used for the qualitative sub- study 1.2, , sub – objective 1.2 concerning the barriers and facilitators to PA engagement in individuals with MCI is provided, followed by results and a discussion of findings.

Chapter 6: This chapter presents an integrated analysis of the findings from the quantitative and qualitative components of Study 1 (sub – study 1.3, sub- objective 1.3). Recommendations for future research and practise are presented.

Chapter 7: This chapter details the background, methods, results, and a discussion of the results of the quantitative sub – study 2.1 of Study 2, sub – objective 2.1, regarding PA programme adherence in individuals with MCI.

Chapter 8: This chapter presents the background, methods, results, and a discussion of the barriers and facilitators associated with PA programme adherence in individuals with MCI (sub – study 2.2, sub – objective 2.2).

Chapter 9: The introduction and methods for the second integrated analysis of this thesis are presented (study 2, sub – study 2.3), and findings are discussed regarding the synthesised determinants of PA programme adherence (sub – objective 2.3). Recommendations for research and practice are presented.

Chapter 10: This chapter provides a discussion of the thesis findings, in addition to providing strengths and limitations of this study and summarising conclusions and recommendations arising from this study.

1.6 Chapter Summary

In summary, this thesis investigates the determinants of PA engagement and PA programme adherence in a sample of Irish individuals with MCI. The rationale for this study originated from the need to improve our understanding of the barriers and facilitators of PA engagement and programme adherence in this cohort. The findings of this thesis will improve the existing knowledge base in this area and better inform evidence-based PA interventions for MCI.

Chapter 2: Methodology

This chapter outlines the research approach taken in this thesis, including the over – arching study design and methodology, and an overview of the methods used and approach to integration. A rationale for mixed methods and a description of the study design and worldview are presented in section 2.1.1. Section 2.1.2 describes the role of the NeuroExercise study in this thesis, and outlines the methods used throughout. More detail on the methods used for individual sub – studies are provided in the corresponding chapters (Chapters 3 – 9).

2.1 Mixed Methods

2.1.1 Rationale

Mixed methods research is a valuable tool for investigating complex phenomena in health research (Fetters et al., 2013), involving the rigorous gathering of both quantitative and qualitative data in response to an overarching research aim, and the integration of both to generate new insights and expand understanding of a phenomenon (Creswell, 2015; Greene et al., 1989; Levitt et al., 2018). Mixed methods research maintains that neither deductive (drawing conclusions based on the assumption of a premise being true) nor inductive knowledge (drawing conclusions based on the probability that a premise is true) is superior to the other, and both can be successfully integrated to complement each other (Teddlie, 2009). To account for possible conflicting epistemologies between strands of a mixed methods study researchers often employ the use of an overarching paradigm that guides both quantitative and qualitative components of a study (Creswell, 2015). In the case of this current thesis, the overall approach was a pragmatic one. The pragmatic approach assumes that reality is co- constructed in research and the researcher is active in interpreting research findings (Creswell et al., 2003; Fulop et al., 2003; Lincoln & Guba, 1985; Teddlie, 2009). This approach is commonly paired with mixed methods research as it rejects the traditional dichotomous philosophies of the constructivism and positivism paradigms. Instead, the mixed methods approach aims to understand the research problem through multiple perspectives and is therefore situated on a continuum within the inductive -deductive research cycle (Teddlie, 2009).

The main assumption of a mixed methods design is that the combination of information regarding quantitative and qualitative data regarding a phenomenon collectively provides greater insight into a research problem than either form of data analysis alone (Creswell, 2015). For example, the current qualitative literature regarding PA engagement and PA programme adherence is scant, not specific to MCI populations, and does not allow for the generalisation of findings from a sample to a wider population. Similarly, the current quantitative data does not provide insight into the determinants of PA from the perspective of individuals with MCI. A key strength of mixed methods research is its ability to integrate two differing methodologies to fully draw on the data to make interpretations, an approach that is particularly useful in health research (O'Cathain et al., 2007). Thus, mixed methods was chosen as the methodology of this study in response to a limited understanding of the determinants of PA engagement and PA programme adherence in adults with MCI in general, and in an Irish context, to expand the depth of understanding and addressing a lack of current mixed methods studies that have investigated this topic.

A second rationale for using a mixed methods design was to achieve methodological triangulation to configure the evidence relating to the outcomes of interest and enhance confidence in study findings (Greene et al., 1989; O’Cathain et al., 2010). This involves combining and comparing methods of data collection and analysis, results, and inferences of a study and is considered both a research process and an outcome (Greene et al., 1989; Teddlie, 2009). In this study, as the quantitative sample used to examine PA programme adherence was small, mixing methods and assessing methodological triangulation was considered a method of ensuring validity of findings. Triangulation involves the use of multiple tools to examine the same phenomenon (Farmer et al., 2006; Lincoln & Guba, 1985; Murray, 1999), thus increasing the accuracy of inferences made (Brewer & Hunter, 1989; Farmer et al., 2006; Lincoln, 1985; Morse, 1991; Teddlie, 2009). This can be achieved using the principles of convergence and dissonance as outlined by Famer et al. (2006). The approach to triangulation used in this study is described in Chapter 6 (section 6.2.2).

2.1.2 Design

This was a parallel convergent mixed methods study. There are three basic mixed methods design typologies; the convergent design, explanatory sequential design and exploratory sequential design (Creswell, 2015; Creswell et al., 2003). The appropriateness of each for use in a study is informed by the sequence in which the qualitative or quantitative data collection will be carried out and what priority will be assigned to each strand of evidence based on the nature of the research question (Creswell et al., 2003). For instance, the explanatory design requires that quantitative data is first collected and analysed, then followed by a qualitative analysis to explain the quantitative results. In contrast, the exploratory design begins with the collection and analysis of qualitative data followed by the development of an instrument or intervention based on the qualitative findings which is then further tested (Creswell, 2015). The convergent design involves the concurrent collection and analysis of qualitative and quantitative data, which is then merged to provide an integrated set of study findings (Creswell, 2007). This type of design is typically used to facilitate the merging of results from different methodologies for the purposes of methodological triangulation, and expansion of existing findings (Andrew, 2009; Creswell, 2015; Teddlie, 2009), concurrent with the methodological aim of this study. As the overall thesis aim was to identify the determinants of PA engagement and PA programme adherence in individuals with MCI in response to current gaps in the literature and lack of understanding of this topic, the convergent parallel mixed methods approach enabled the comprehensive gathering, analysing, integration, and interpretation of multiple data sources in line with this aim. Thus, the choice of design was informed by the over – arching aim of this thesis and the objectives and sub – objectives outlined in Chapter 1.

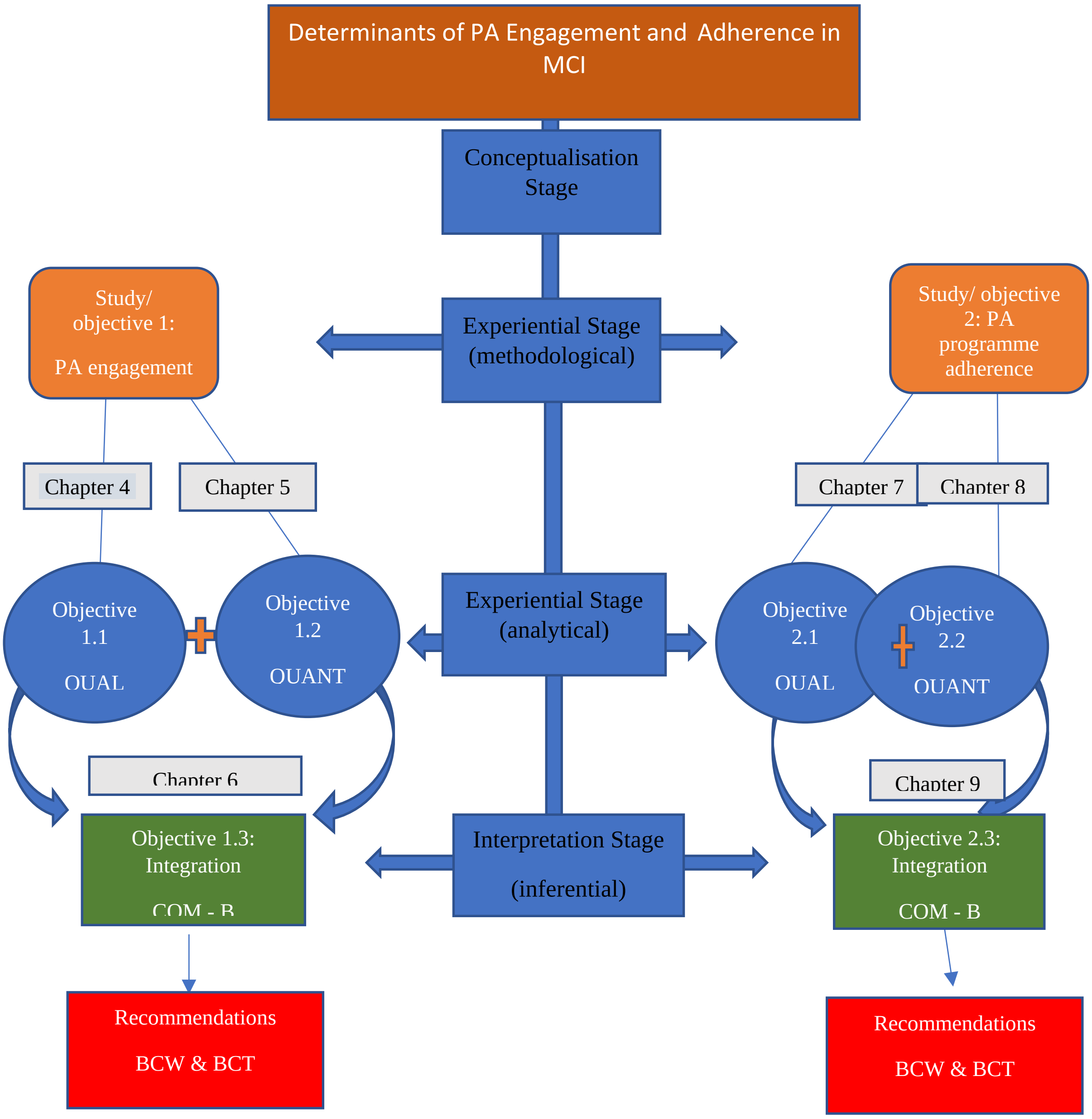
This design comprised 2 main empirical studies to address 2 areas of PA behaviour in individuals with MCI, PA engagement (Study1) and PA programme adherence (Study 2). Study 1 addressed objective 1 (determinants of PA engagement) of this thesis and was comprised of a quantitative analysis of the effect of cognitive, demographic, physical, and psychological variables on PA engagement (sub – study 1.1, sub – objective 1.1, Chapter 4) and a qualitative exploration of the barriers and facilitators to PA engagement (sub – study 1.2, sub – objective 1.2, Chapter 5). Study 2 addressed objective 3 (determinants of PA programme adherence) and contained a quantitative analysis of the effect of cognitive, demographic, physical, programme related, and psychological variables on PA programme adherence (sub – study 2.1, sub – objective 2.1, Chapter 7) and a qualitative analysis of the barriers and facilitators to PA programme adherence (sub – study 2.2, sub – objective 2.2, Chapter 8). The quantitative and qualitative findings of study 1 and study 2 were integrated at the interpretation stage of each study to address sub – objectives 1.3 and 2.3 (Chapters 6 and 9 respectively). The implementation of the convergent parallel mixed methods approach in this thesis is represented in Figure 1.

Originally in the design phase of this thesis an additional study which qualitatively explored the opinions of healthcare professionals such as general practitioners and geriatricians in relation to PA prescribing for individuals with MCI was planned. It was envisioned that this would round out the research by providing another perspective regarding barriers and facilitators to PA promotion in this cohort. Ten interviews were to be carried out with healthcare professionals, and two expert interviews (one geriatrician/ GP and the manager for Services for Older People in the HSE) were conducted to inform a topic guide for subsequent interviews. However, there were a number of obstacles to the implementation of that study. Firstly, a challenge of mixed methods research can be that it can be complex and time consuming for one researcher to conduct methodologically different strands of data collection simultaneously (Teddlie, 2009), and a third qualitative study indeed became challenging within the time frame of this thesis. This was compounded when sampling and recruitment for a study with healthcare professionals was about to begin (February, 2020) but was interrupted by the Covid pandemic.

The national restrictions and additional strain on the healthcare service nationally made the possibility of gaining access for interview purposes unlikely. Indeed, some invitations to participate had already been circulated prior to Covid, but no responses were received. For these reasons, and in consultation with my supervisory team, the proposed study of the opinions of healthcare professionals was not continued.

Figure 1.

Stages and Implementation of the Convergent Parallel Mixed Methods Design in this Thesis.



Note. A generic graphic representation of the stages of the convergent parallel design. Original version in Teddlie et al. (2009, p152).

2.2 Overview of Methods

2.2.1 The Role of the NeuroExercise Study

Participants of the studies described were sampled from the NeuroExercise study. This was a multi- centre randomised control trial of a semi- structured 12-month exercise programme designed to prevent the progression of Mild Cognitive Impairment in adults aged 50 years of age and older. Data collection occurred in three European countries; Ireland, Germany, and Holland. The full study protocol is provided in Appendix E and has been published previously (Devenney et al., 2017). This current thesis analysed a sub sample of these participants from one study site (Dublin, N = 64). Community dwelling individuals with MCI were randomised to one of three conditions. These were a control condition where participants presented at quarterly intervals over a 12- month period for physical and neuropsychological testing only, and two exercise conditions (stretch & tone and aerobic exercise) where participants took part in structured class - based PA sessions on a weekly basis supported by two further home sessions for 12 months.

All participants completed a battery of psychosocial and cognitive assessments at baseline, 6 and 12 months. Physical testing as per NeuroExercise protocol consisted of measures of frailty, fitness, height, weight, heart rate and blood pressure. Demographic information was collected on variables such as gender, age, years of education and medication usage. Neuropsychological measures used were measures of level of cognitive function (MoCA), self - efficacy (GSES), sleep quality (Pittsburgh SI), level of physical activity (LAPAQ and Actigraphy), quality of life (DemQoL) and personality (Neo-FFI). Further detail regarding measures used, recruitment, inclusion and exclusion criteria, sampling, and participants specific to each individual study is provided in Chapters 4 (section 4.2.) and 7 (section 7.2.) and Chapters 5 (section 5.2) and 8 (section 8.2).

2.2.2 Recruitment

Participants were recruited to the NeuroExercise study from a network of memory clinics (n=38) and through community recruitment (n=26) via advertisements in community newspapers and newsletters. Recruitment took place between Feb 2016 and July 2017. Community recruited participants were screened in the Clinical Research Facility, St. James`s Hospital, Dublin. Screening involved the application of a researcher administered survey gathering data related to medical history, medication usage and exercise history. Participants also completed the WMS- IV (Weschler Memory Scale fourth edition) which was administered by a researcher.

2.2.3 Inclusion & Exclusion Criteria

Inclusion criteria for NeuroExercise required that participants had a diagnosis of amnestic Mild Cognitive Impairment due to Alzheimer`s Disease in line with the National Institute on Aging and Alzheimer's Association criteria , scored between 18–26 on the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005), and were classified as having memory decline but not dementia (Clinical Dementia Rating global score = 0.5). Exclusion criteria were having received a formal diagnosis of Alzheimer`s disease or other type of dementia, severe chronic disease, or currently engaging in PA for more than 120 minutes per week during the past two years.

2.2.4 Randomisation

NeuroExercise participants were randomised to one of three intervention arms following baseline assessment using a computer - generated randomisation list generated by an independent statistician. Treatment was assigned using sealed envelopes based on order of recruitment. Outcome assessors and exercise trainers were not blinded to the allocated treatment arm. Participants were not further randomised for inclusion in the individual quantitative or qualitative empirical strands of this thesis.

2.2.5 Ethical Approval

Ethical approval for this current study was granted on the 18/05/17 by SJH/AMNCH Research Ethics committee REC Ref 2015/09/04/ 2017- 05 List 17 (2), by way of a Chairman's Action amendment to the existing ethical approval granted for the NeuroExercise study. One application was submitted and accepted for all components of this current study. The ethics application request form and research ethics committee letter of approval are provided in Appendices F and G, respectively. Serious adverse events that were considered as a rare but possible risks of NeuroExercise were heart attack, stroke, unconsciousness, or other serious injury. To minimise the risk of adverse events, participation was with the consent of the participants doctor and was followed by medical screening and participants were monitored during PA classes. All participants provided written informed consent. Further detail on interview process and setting is provided in Chapter 5. All participant data (quantitative dataset and interview transcripts) was anonymised for confidentiality and kept in a secured file, to be stored for up to 15 years as per the NeuroExercise study protocol. No adverse ethical consequences were foreseen by the researcher in advance of the study and no adverse consequences were experienced by participants during the course of this study.

2.2.6 Sampling

The sampling approach for the NeuroExercise trial was probability sampling. Sample size was calculated using "G*Power", a statistical software program. The effect size was based on effect sizes found in the current literature investigating the effect of PA on cognitive function in individuals with MCI. Based on these calculations a sample size of 75 participants per centre, 225 total participants for the entirety of the multi – centre RCT, was determined (Devenney et al., 2017).

2.2.7 Change from Grounded Theory to Thematic Analysis

Grounded theory is qualitative method of data collection and data analysis with the end goal being to “construct” theory related to a phenomenon or experience that is grounded in the data, thus ensuring that the data is the foundation of the theory (Charmaz, 2006). The purpose of grounded theory is to avoid theory verification in favour of more explanatory and rich theoretical frameworks, thereby allowing a fuller conceptual understanding of a phenomenon (Charmaz, 2006) and achieve the “discovery” of theory from systematic inductive analysis (B. G. Glaser., 1967).

The key components of a grounded theory study are simultaneous data collection and analysis, constant comparison, memo writing, theoretical sampling for theory development not representativeness, and literature reviewing after theory development to avoid preconceived concepts contaminating data (B. G. Glaser., 1967). Thus, the grounded theory method would ensure that the emerging theory was a good fit with the data, easily understandable (provide explanatory power), useful for theoretical advancement, and would be durable and flexible over time (Glaser & Strauss, 1967; Charmaz, 2006). The researcher felt that these objectives of grounded theory would be an appropriate method of data collection and data analysis in this study in line with the pragmatic underpinnings of this mixed methods study.

Glaser & Strauss (1967) state in generating theory it is important not to have pre-conceived ideas which may limit the richness of the theory. Instead, they advocate ensuring that analysis is not influenced by prior knowledge, known as “received theory” through direct interaction with the data by delaying the literature review in a study. In carrying out a substantive literature review before becoming acquainted with the data the researcher is at risk of being led by existing knowledge and the danger is that their study will err on the side of theory verification instead of the aim of theory generation. For this reason, many grounded theorists acknowledge that the literature is not the foundation stone of qualitative research and advocate reserving the literature review until analysis has been completed (Charmaz, 2006; Corbin, 2015). In accordance with this methodology, the full literature review for this study was not conducted prior to data collection as is usual. Instead, a tentative literature review to map the extant literature was undertaken. As such, the topic guides were developed to stimulate conversation surrounding the research questions and not based on a formalised literature review.

However, some challenges to fidelity to the grounded theory method arose within the course of data collection and analysis which required the researcher to reflect on the continued appropriateness of this method. It is recommended for grounded theorists to conduct analysis concurrent to data collection. This is to facilitate the emergence of organic themes and to allow the researcher ample opportunity to amend interview direction to follow up on recurring themes. Interview topic guides were amended to follow the direction the data took however, it was not done immediately following each interview to maximise data collection on every emergent theme. This was due to the method of recruitment employed by this researcher whereby participants were purposively sampled as they presented for their NeuroExercise assessments, and it was necessary to conduct interviews close together leaving little opportunity for transcription and analysis to occur following each interview. As a result, interviews were conducted in batches and then transcribed and analysed. This marked a departure from traditional grounded theory methodology which this researcher felt resulted in a deficit in data sufficient to provide an explanatory theory of the phenomena of interest. This did not become apparent to the researcher until further into the analysis process. This departure from the selected methodology and resulting accumulation of data of a different nature than had been planned for prompted this researcher to reflect on and consider a revision of their choice of methodology.

To resolve this methodological challenge the researcher revisited the overall research question for this qualitative piece which was “what are the determinants of PA engagement and PA programme adherence in individuals with MCI?”. On reflection, it was determined a thematic analysis of the collected data would be a more appropriate to the overarching study aim and still complement the pragmatic philosophical approach taken here. Braun & Clarke (Braun & Clarke,

2006) state that when using thematic analysis, the researchers` philosophical standpoint need not be purist, but that different philosophical beliefs can exist along a continuum.

2.2.8 Data Collection and Data Analysis

Data for the quantitative and qualitative sub – studies were collected and analysed concurrently and separately. The quantitative and qualitative strands were then merged at the interpretation stage of this study and presented as integrated findings for each of the 2 areas of PA behaviour, engagement, and PA programme adherence. Detail regarding the methods of data collection and analyses for individual quantitative sub - studies is detailed further in Chapters 4 (study 1) and 7 (study 2). Detail regarding the methods of qualitative data collection and analysis are detailed in Chapters 5 (study 1) and 8 (study 2). The integration of data and resulting findings are detailed in Chapter 6 (study 1) and Chapter 9 (study 2).

2.2.9 The COM – B Framework of Behaviour Change

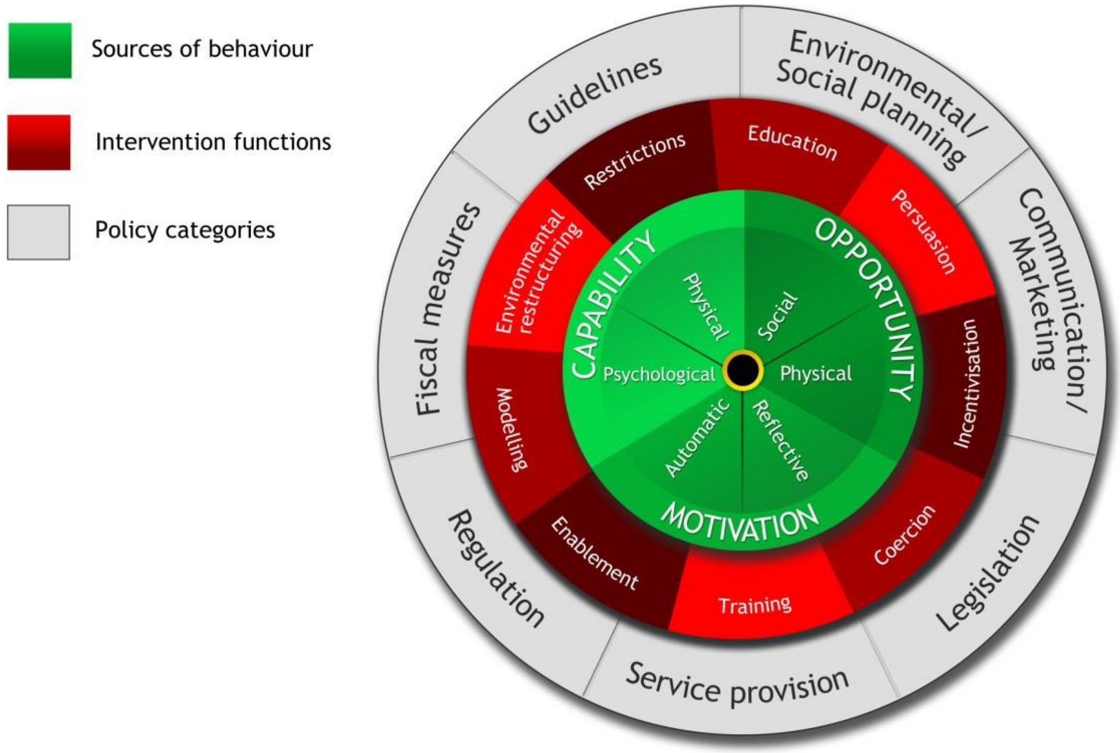
A theoretical framework was chosen to aid in the configuration of individual strands of findings. There are many theoretical models used in the social sciences, but two behavioural theories commonly used in physical activity research, namely social cognitive theory, and the health belief model, were considered for use as frameworks for integrating findings in this thesis. Social cognitive theory (Bandura, 1986) seeks to understand PA behaviour in terms of the individual, the environment, and the behaviour (Shamizadeh et al., 2019). In social cognitive theory, these three modes of agency, referred to as direct personal (the individual), proxy (the influence of others) and collective agency (the influence of direct personal agency and socially interdependent factors) interact to determine the behaviour (Bandura, 2001). It is a useful framework for explaining PA behaviour (Young et al., 2014) and is often used in PA research in many different populations such as older adults (Gothe, 2018), and illness groups such as osteoarthritis (knoll), breast cancer survivors (Mama et al., 2017) and prediabetes (Shamizadeh et al., 2019).

The Health Belief model (Rosenstock, 1966) is commonly used to explain PA behaviour and has been applied in many different settings such as with minority groups (Kosoko-Lasaki et al., 2019), older adults (Fitzpatrick et al., 2008; Fuller et al., 2010; Zhou et al., 2018), pre diabetes (Rossen et al., 2015), multiple sclerosis (Kasser & Kosma, 2012), and cardiovascular risk patients (Al-Ali & Haddad, 2004; Katz et al., 2009; Reges et al., 2013). It attempts to explain behaviour in terms of interactions between the four main components of self- efficacy, perceived barriers, benefits, and threats, and has been found to have utility in the design of health interventions (Skinner et al., 2015). Though the efficacy of both frameworks has been confirmed in the literature, the mixed methods aims of this study were concerned with enhancing understanding of the phenomenon of PA engagement and PA programme adherence in individuals with MCI and to inform PA promotion and PA interventions targeted at individuals with MCI. This aim necessitated the use of a comprehensive framework that both explained behaviour and pointed to intervention design solutions to enhance behaviour.

The Theoretical Domains Framework (TDF) is a behaviour change framework that synthesises key theoretical constructs relating to motivation and behaviour into 14 domains. These are; knowledge, skills, social/professional role and identity, beliefs about capabilities, optimism, beliefs about consequences, reinforcement, intentions, goals, memory, attention and decision processes, environmental context and resources, social influences, emotions, and behavioural regulation (Cane et al., 2012). It is a validated framework for identifying barriers and facilitators to behaviour change in implementation research and for intervention development (Cane et al., 2012). The TDF is useful for offering a theoretical perspective to behaviour change research as it has the advantage of being both comprehensive in coverage of influences on behaviour and allows for theories of behaviour change to be linked to techniques for behaviour change (Atkins et al., 2017; Cane et al., 2012) through application to the Behaviour Change Wheel (Michie et al., 2011). The BCW is a synthesis of framework functions with a model of behaviour at the hub. It contains 9 intervention functions, each with one or more behaviour change functions, and 7 policy categories to enable and support intervention design and implementation. Each component of the framework is linked to an intervention function which is designed to address deficits in behaviour. These are education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling, and enablement. The nine intervention functions of the BCW are linked to a taxonomy of 93 behaviour change techniques (BCT). A BCT is a component of an intervention designed to influence the causal factors that regulate behaviour that is observable, replicable, and irreducible. These are proposed to be the "active ingredients" of an intervention (Michie et al., 2013). These intervention functions are in turn linked to policy categories to be addressed to enhance behaviour. The BCW and intervention functions are presented in Figure 2 and Table 2. Thus, the TDF is useful for identifying areas of focus for intervention implementation. However, it is time and resource - intensive and this can be a challenge for its application (French et al., 2012; Phillips et al., 2015). Another behaviour change framework which also has the advantage of being linked to techniques for behaviour change, the BCW, and identifying ways of navigating implementation problems (Atkins et al., 2017) is the COM B framework of behaviour (Michie et al., 2011).

Figure 2.

The Behaviour Change Wheel



Note. The Behaviour Change Wheel. Reprinted from "The behaviour change wheel: A new method for characterising and designing behaviour change interventions" by S. Michie et al., 2011, *Implementation Science, 6* (1), Copyright 2011 licensee BioMed Central Ltd.

Table 2.

Behaviour Change Wheel Intervention Functions

Intervention Function	Definition
Education	Increasing knowledge or understanding
Persuasion	Using communication to induce positive or negative feelings or stimulate action
Incentivisation	Creating expectation of reward
Coercion	Creating expectation of punishment or cost
Training	Imparting skills
Restriction	Using rules that limit engagement in the target behaviour or competing or supporting behaviour
Environmental restructuring	Changing the physical or social context
Modelling	Providing an example for people to aspire to or imitate
Enablement	Increasing means or reducing barriers to increase capability or opportunity

Note: Adapted from “The behaviour change wheel: A new method for characterising and designing behaviour change interventions” by S. Michie et al., 2011, *Implementation Science*, *6* (1), Copyright 2011 licensee BioMed Central Ltd.

The COM – B framework was a response to a lack of comprehensiveness in explanations of behaviour change by existing behaviour change frameworks (Michie et al., 2011). According to Michie et al. (2011) few existing frameworks were conceptually coherent or clearly linked to a model of behaviour change. Some frameworks assumed that behaviour was primarily driven by beliefs and perceptions, while others placed greater emphasis on unconscious biases or the social environment. Thus, highlighting a need for theories of behaviour change to be brought together in a coherent manner. This framework was developed to address deficits in current frameworks and to account for a wider range of factors and interactions between factors in determining behaviour change. The COM – B framework assumes that behaviour occurs through interaction between 3 necessary conditions; capability (psychological/ physical ability), opportunity (physical and social environment), and motivation (reflective and automatic motivations) (Michie et al., 2011). The "capability" condition assesses the knowledge, skills, and ability necessary to perform a behaviour, and can be psychological (psychological strength/ stamina and knowledge & skills) or physical (physical strength, skills, or stamina) in nature. "Opportunity" refers to external factors that make engaging in a behaviour possible. These can be physical (environment, time, location, resources) or social (cultural norms and social cues) in nature. "Motivation" refers to internal factors that influence decision making (reflective such as making plans, beliefs, evaluations of past events, and automatic such as desires, impulses, and inhibitions). As with the TDF, the COM - B enables comprehensive coverage and understanding of a behaviour to be linked to a model of behaviour, which can then be applied to an intervention design framework, the BCW. However, the relative ease of use of the COM – B framework in terms of the increased time and resource demands of the TDF determined the COM – B to be a pragmatic approach for this current study. Thus, this function of the COM -B framework and BCW were considered the most appropriate method of addressing the aims of this thesis.

The COM - B framework was applied to integrate qualitative and quantitative study findings to facilitate the configuration of findings and make recommendations for maximising PA engagement and PA programme adherence in individuals with MCI. Thus, the framework was utilised at the interpretation stage of this mixed methods systematic review. Quantitative and qualitative findings were individually applied to the COM – B framework using the functions of capability, opportunity, and motivation as a priori themes to enable comparison between qualitative and quantitative findings which were discussed narratively.

The COM – B framework was utilised at the interpretation stage of studies 1 and 2 of this mixed methods thesis. Quantitative and qualitative findings from each study were individually applied to the COM – B framework using the functions of capability, opportunity, and motivation as a priori themes to enable comparison between qualitative and quantitative findings. For example, data was analysed using a joint display to assess convergence, silence, completeness, and dissonance between sets of findings (Farmer, 2006). Findings were discussed narratively and related to the intervention functions component (second layer) of the BCW to form recommendations.

Michie, Atkins, and West (Michie, 2014) outline three stages to intervention development using the BCW. These are: understanding the problem and user preferences; translating research findings into intervention features; and identifying content and implementation options. These can be further subdivided into the sub-stages of 1) defining the problem in behavioural terms; 2) selecting the target behaviour; 3) specifying the target behaviour; 4) identifying what needs to change; 5) identifying appropriate intervention functions; 6) selecting policy categories; 7) selecting behaviour change techniques; and 8) determining the mode of delivery.

Steps 1 – 3 were addressed in the research phases of identifying correlates and barriers and facilitators in Chapters 4 and 5, and Chapters 7 and 8 of this thesis, respectively. In these stages, the problem was defined in behavioural terms, selection and specification of the target behaviour was achieved through identification of barriers/ facilitators. In step 4, the integration phase, the COM – B model was used to identify the areas of PA engagement and PA programme adherence to target to influence change. In step 5, the target areas identified were applied to the BCW which was used to identify the intervention functions most likely to initiate change, i.e., support engagement and adherence. Step 6 linked these intervention functions to their corresponding policy categories. In step 7, intervention functions and policy categories were linked to Michie et als. taxonomy of BCTs (Michie et al., 2013) to select feasible and effective BCTs to recommend for intervention design or policy formation. Step 8 involved translating BCTs into practice by describing the most appropriate mode of delivery of these techniques, informed by current literature regarding the efficacy of PA engagement and support strategies in individuals with MCI. These last steps support the delivery of the intervention functions of the BCW (Michie et al 2014, cite). Further details regarding the use of the framework and analysis of integrated findings is provided in Chapter 6 (study 1) and Chapter 9 (study 2).

2.2.10 Reflexivity & Positionality

Reflexivity refers to the process of researcher introspection, and the acknowledgement of everyday assumptions, especially regarding how these assumptions may have informed the research design and analysis (Creswell, 2015; Finlay et al., 2003). The researcher acknowledges that as a graduate of health psychology with a personal interest in PA and its potential benefits for healthy ageing, the choice of study design, approach to data collection, analysis, integration, and interpretation of the data are influenced to some extent by the researchers` own perspectives and positioning. More specifically, having positive views of PA engagement could influence the interpretation of qualitative findings. This was addressed by maintaining a rigorous approach to thematic analysis and data collection as described by Braun and Clarke (2006). This approach is further described in Chapter 5. In addition, regular discussion with the supervisory team involved in this thesis while data collection and analysis was underway helped ensure the veracity of findings.

2.3 Chapter Summary

This chapter presented the methodology for this mixed methods thesis. A rationale for the methodological approach and study design was provided and the implementation of this approach to address the thesis aims and objectives was described.

Chapter 3: Mixed Methods Systematic Review

3.1 Introduction

A growing body of literature supports the positive effect of physical activity (PA) for maintaining cognitive health, and PA interventions may be beneficial for reducing dementia risk (Vilela et al., 2017). MCI represents an ideal stage for targeted PA interventions to reduce or delay the progression of cognitive decline, as at this stage, individuals with MCI can still undertake many complex tasks (Livingston et al., 2017). However, the cognitive impairment associated with MCI may pose barriers to performing instrumental activities of daily living (Puente et al., 2014; Reppermund et al., 2013) and can be accompanied by deficits in mobility and increased physical frailty associated with cognitive decline (Pedersen et al., 2014). This suggests that engagement in PA and adherence to PA interventions targeting cognitive decline may be negatively impacted by a decline in cognitive and functional ability.

However, the current literature regarding PA in individuals with MCI is inconsistent regarding the cognitive benefits of PA for individuals with MCI, and this may be partly due to variability in reported PA intervention adherence in this cohort. The reasons for variable PA engagement and intervention adherence are currently not well understood (See Chapter 1). Though a small number of quantitative studies have investigated rates of PA engagement or programme adherence and the factors which impact it in individuals with MCI, the reported rates of engagement and adherence, and the factors associated with it are inconsistent. Similarly, the qualitative evidence describing the barriers and facilitators of PA engagement and programme adherence in this cohort is limited.

The aim of this mixed methods systematic review (MMSR) was to configure the current available evidence and identify gaps in the literature regarding PA engagement and PA programme adherence in individuals with MCI in line with objective 1 of this thesis. This was achieved by conducting a convergent segregated mixed methods systematic review (MMSR) to synthesise and integrate the quantitative and qualitative literature regarding the determinants of PA engagement (sub – objective 1.1) and synthesise and integrate the current quantitative and qualitative literature regarding the determinants of PA programme adherence (sub – objective 1.2) in individuals with MCI. A preliminary search of databases found no existing or ongoing reviews on this topic.

3.2 Methods

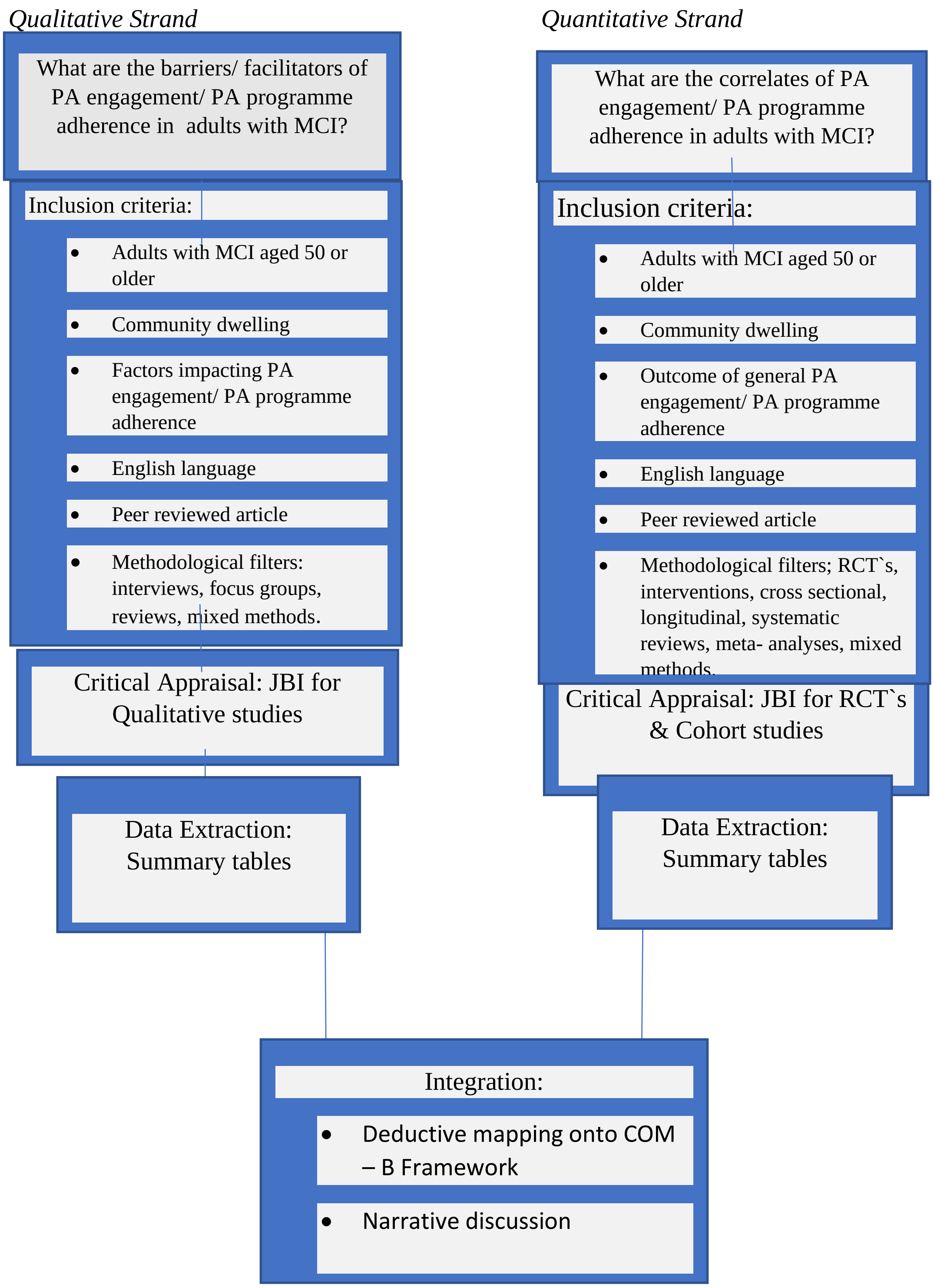
3.2.1 MMSR Design and Rationale

Mixed methods systematic reviews are a method of combining quantitative and qualitative evidence within a literature review to study complex topics and problems to answer complex research questions using various synthesis techniques (Heyvaert, 2017). They are useful where researchers wish to create a “breadth and depth of understanding” of a topic (Lizarondo, 2020). This approach to researching the current literature was employed in this current thesis to facilitate the effective synthesis and configuration of all current evidence to identify the determinants of PA engagement and PA programme adherence in individuals with MCI.

The MMSR design chosen was a convergent segregated approach. In the convergent approach, qualitative and quantitative syntheses are conducted simultaneously (Aromataris, 2020). The segregated approach is useful where research questions address different aspects of the same phenomenon but are essentially seen as separate entities and as such are resistant to assimilation, necessitating that both strands of evidence are synthesised separately (Sandelowski et al., 2006). The methods used to conduct this MMSR adhered to the Joanna Briggs Institute (JBI) framework for conducting convergent segregated mixed methods literature reviews (Aromataris, 2020). Step 1 of this approach involves conducting separate qualitative and quantitative reviews. This is then followed by an integration of both sets of methodological findings by juxtaposing, or merging, the quantitative synthesised data with the quantitative synthesised data and organising the findings into a configured line of argument (step 2). The final step requires the researcher to explore, contextualise and explain the findings of one set of findings using the other to determine how, or if, the results complement each other (Aromataris, 2020; Sandelowski et al., 2006). Complementarity means to compare, explain, or elaborate on one set of findings using another and configuration refers to the arrangement of findings into a cohesive line of argument (Sandelowski, 2000; Sandelowski et al., 2006). A segregated design was chosen for this MMSR as the research questions posed by the quantitative strand differ from those posed by the qualitative strand, and as such require separate methods to extract data. This quantitative strand was concerned with determining the factors associated with PA engagement and PA programme adherence in individuals with MCI, whereas the qualitative strand focused on the barriers and facilitators from the perspective of individuals with MCI and how PA engagement and PA programme adherence are impacted within the context of having MCI. This approach is consistent with the overall methodology of this thesis and allows for the extrapolation of differing strands of data which were integrated at the interpretation stage of this review to provide a comprehensive evaluation of the full range of factors related to PA in individuals with MCI and to identify gaps in the current literature. Figure 3 provides the flowchart for the convergent segregated mixed methods review process.

Figure 3.

Flowchart of the Convergent Segregated Mixed Methods Systematic Review Process

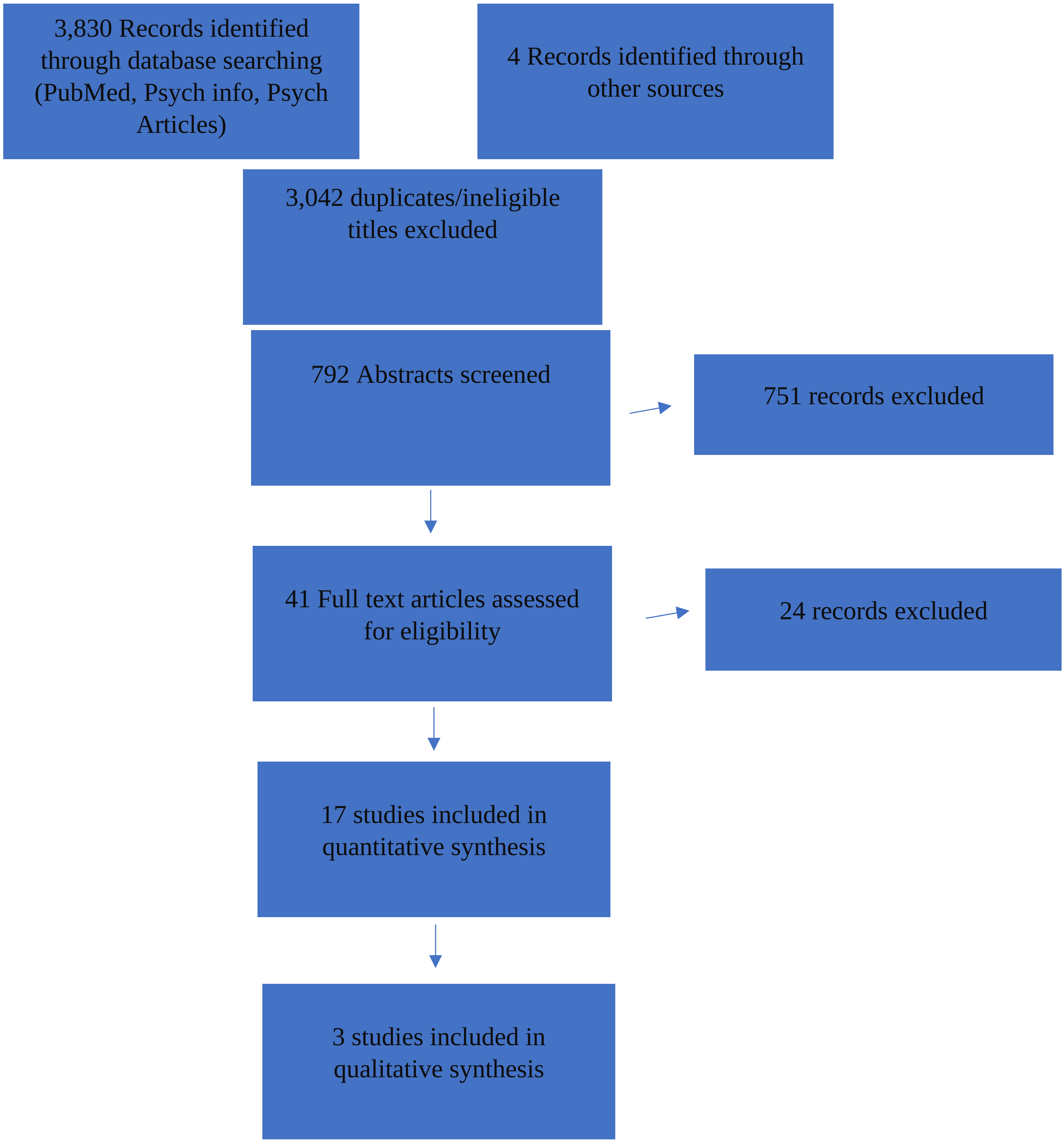


3.2.2 Search Strategy

An exhaustive sampling strategy was employed. This search aimed to find all peer reviewed material. The search was undertaken twice, between 2017 and June 2021. Three databases were sampled (PubMed, Psych Info & Psych Articles). Search terms were developed in consultation with a subject librarian and included relevant key word terms from published studies. The search terms used were DE "Exercise" OR TI ("physical exercise" OR "physical activity") OR AB ("physical exercise" OR "physical activity") AND adult OR AG middle age OR AG adulthood OR AG aged AND DE "Dementia" OR TI (MCI or "mild cognitive impairment" OR "pre dementia" OR dementia) OR AB (MCI or "mild cognitive impairment" OR "pre dementia" OR dementia). The search strategy flow chart is provided in Figure 4.

Figure 4.

PRISMA Search Strategy Flow Chart



3.2.3 Inclusion Criteria (PICO)

Inclusion and exclusion criteria were developed using the PICO (population, intervention/ phenomenon of interest, context, and outcomes) format. This is provided in Table 3.

Table 3.

PICO Table of Eligibility

Criteria	Determinants
Population.	Community dwelling males and females aged 50 or older with MCI. Studies were excluded if they reported on participants in residential (nursing home) or hospital care.
Intervention.	PA programmes/ interventions containing any mode of PA, but not if they included social, cognitive, educational, or behavioural components as part of a multi – modal intervention. Studies of any duration, intensity were included.
Phenomena of Interest	The qualitative component considered studies that examined the phenomena of PA engagement (Study 1) and PA programme adherence (Study 2).
Context.	Qualitative studies which reported on the experiences, opinions, or perceptions of individuals with MCI regarding general PA engagement and adherence to PA interventions were considered for review.
Outcomes	Quantitative studies examining general PA engagement as a primary or secondary study outcome, or reporting on adherence to a structured/ prescribed, home- based or group/ class- based PA programme.

3.2.4 Types of Studies

Studies were included if they were peer reviewed RCT`s, interventions, cross - sectional, longitudinal, systematic reviews, meta- analyses for quantitative data (including quantitative strands of mixed methods studies), and if they were peer reviewed focus group studies, interviews, and qualitative reviews for qualitative data (including qualitative strands of mixed methods studies). English language articles were included.

3.2.5 Study Selection

Endnote X8 reference management software was used to organise data and delete duplicate studies. All screening was completed by one reviewer (LC). The first screening reviewed relevant titles and abstracts. The second screening reviewed relevant full texts. Finally, reference lists were screened for additional material. Full studies that did not meet the review inclusion criteria were excluded.

3.2.6 Methodological Quality Assessment

Quality assessment for individual studies was carried out by one reviewer (LC) using the JBI checklists for analytical cross – sectional studies (Moola S, 2020.) for quantitative studies and the JBI critical appraisal checklist for qualitative research (Lockwood C, 2015) (critical appraisal tools are provided in Appendices A and B respectively). The GRADE and GRADE CerQUAL approaches to quality assessment were not used here in line with JBI guidelines advising against their use in segregated mixed methods systematic reviews (Lizarondo, 2020).

3.2.7 Data Extraction

Data was extracted by one reviewer (LC) using an excel spreadsheet based on the JBI QARI data extraction tool for qualitative research and quantitative data extraction tool for analytical cross sectional studies (Aromataris, 2020). Relevant quantitative data was extracted which included details about the study population, interventions, methods, and outcomes specific to PA engagement and PA programme adherence in individuals with MCI. Data was extracted from qualitative studies which included detail regarding the population, context, study methods, geographical location, and the phenomenon of interest to the review question. Quantitative and qualitative data extraction tables are provided in Appendices C and D, Tables A1 and A2 respectively.

3.2.8 Data Synthesis and Integration

A convergent segregated approach to data synthesis and integration was taken. In the quantitative review, the studies included varied in their reporting of data and of study outcomes and a meta- analysis of the data was not possible. Thus, a narrative approach was used to synthesise quantitative data. Qualitative findings were textually pooled as per guidelines developed by the Joanna Briggs Institute, which follow a 3 step process (Munn et al., 2019). These were the extraction of author's conclusions from studies and rating each conclusion as unequivocal, credible, or not supported (step 1), developing and assigning categories based on similarity of conclusions (step 2) and developing a set of synthesised conclusions from these (step 3).

In accordance with the segregated approach to the integration of findings, data was configured rather than assimilated (Sandelowski et al., 2006). This was achieved through the juxtaposition of both sets of findings to the COM – B framework of behaviour (Michie et al., 2011) and the application of COM – B domains as deductive themes for the categorisation of findings which facilitated the comparison and configuration of the individual strands of findings. A thorough description of the COM – B model and rationale for its use can be found in Chapter 2 (section 2.2.9).

3.3 Results

3.3.1 Methodological Quality

3.3.1.1 Physical Activity Engagement

Seven studies were included in the quantitative review. Four studies met 5 of the 8 criteria for inclusion (Gagliardi et al., 2016; Kobayashi et al., 2016; Stuckenschneider et al., 2018; Wettstein et al., 2015). This was due to the use of group comparisons without controlling for confounding variables. The remaining 3 studies met all 8 of the assessment criteria. Two qualitative papers were included for analysis. These were scored negatively on 4 (Chong et al., 2014) and 2 (van der Wardt et al., 2019) out of a total of 10 checklist criteria.

3.3.1.2 Programme Adherence

Ten quantitative studies were identified for review. Five of the ten studies achieved a JBI critical appraisal score of 8 out of 8. The remaining three were scored 5, 6 and 7 out of 10 and were deemed to be of moderate to good quality. One qualitative paper was critically appraised for inclusion and was scored negatively on one of ten checklist criteria.

3.3.2 Quantitative Synthesis

3.3.2.1 Study Characteristics

Seventeen studies in total were included for review. Seven cross sectional studies were retrieved which analysed PA engagement as an outcome measure in individuals with MCI, with an average age of 73 across studies. Two of these examined PA engagement in participants with MCI only (Rovner et al., 2016; Vancampfort et al., 2018). Four studies examined predictors (O'Connell et al., 2015) or between groups differences (Gagliardi et al., 2016; Kobayashi et al., 2016; Wettstein et al., 2015) in PA engagement between cognitively healthy, MCI and AD groups of adults. One study examined differences in PA engagement between adults with subjective cognitive impairment (SCI) and individuals with MCI (Stuckenschneider et al., 2018).

Ten studies examined PA programme adherence. Four studies were randomised controlled trials (RCTs) (de Oliveira Silva et al., 2019; Lam et al., 2015; Uemura et al., 2013; van Uffelen et al., 2008) and 3 studies were secondary analyses of RCT data (Cox et al., 2013; Tak et al., 2012; van Uffelen et al., 2009). One narrative review reported on the correlates of PA programme adherence (Chong et al., 2020) and one systematic review reported on rates of adherence and intervention characteristics associated with PA intervention adherence (Di Lorito et al., 2020). One systematic review analysed the evidence base for intervention strategies to promote PA programme adherence (van der Wardt et al., 2017), and one paper reported on experiences of using strategies to promote adherence to a PA intervention (Chang et al., 2011).

3.3.2.2 Physical Activity Engagement

3.3.2.2.1 Rates of Physical Activity Engagement. Five papers reported on the level of PA engagement. Two papers reported PA in minutes per day/week. One study reported an average of 162 minutes of PA per week for individuals with MCI (SD = 4.2) (Rovner et al., 2016), and one study reported that mean daily minutes of PA in late MCI adults was 163.6 (SD = 136) and in early MCI adults was 270.1 (SD = 157.1) (Stuckenschneider et al., 2018). Calculation of the overall mean minutes of PA per day for both early and late-stage MCI participants in that study was 216.83 (*SD* = 75.32). However, in the study by Rovner et al. (2016) it was also reported that 20% of the sample engaged in no PA at all. The remaining studies categorised levels of PA engagement and reported % of participants per category. Vancampfort et al. (2018) dichotomised participants from 6 low to middle income countries (LMICs) into “low PA” (under 150 minutes per week) and “meeting or exceeding guidelines” groups (150 or more per week). Prevalence of low PA was 27.4%. Another study reported 11.76% participants met/ exceeded PA guidelines, 41.17% engaged in some but did not meet guidelines, and 47.05% of participants with MCI engaged in no weekly PA (O'Connell et al., 2015). Another study categorised PA as quartiles with the 4th quartile (highest level) being > 119 mins per week. 24.8 % achieved less than 51 mins per week, 28.7% achieved between 52 and 85 minutes per week, 26.7% achieved between 86 and 118 minutes per week, and 19.8% of participants achieved over 119 minutes per week (Gagliardi et al., 2016). However, based on the designation of the fourth quartile it is unclear what percentage of participants had achieved the recommended guidelines for PA in that study.

2.4.2.2.2 Between Group Differences. Four studies reported on differences in PA engagement between groups. Of these, three studies included cognitively healthy, MCI and AD participants in their samples. Two of these studies found that individuals with MCI were less physically active than cognitively healthy adults. In the first study, individuals with MCI and AD engaged in significantly less PA than cognitively healthy adults (Kobayashi et al., 2016). The second study reported that cognitively healthy adults were significantly more active than individuals with MCI and AD (Gagliardi et al., 2016). However, the third study found no group differences for PA (classed as walking behaviour) between cognitively healthy and MCI groups (Wettstein et al., 2015). In addition, this study found no significant relationship between walking distance and walking speed on group membership between cognitively health and MCI participants as measured using GPS tracking (Wettstein et al., 2015).

One study compared participants with subjective cognitive impairment (SCI) and participants with early (EMCI) and late MCI (LMCI). There were significant group differences in daily PA and daily distance walked between groups as measured using actigraphy. LMCI participants had lower mean daily PA than EMCI participants, and SCI participants. LMCI had a lower average distance walked per day in comparison to EMCI, but not SCI participants (Stuckenschneider et al., 2018).

2.4.2.2.3 Unadjusted Analyses of PA Engagement. Two studies assessed the unadjusted correlates of PA engagement. The largest study retrieved during this review was that of Vancampfort et al. (2018) (N = 4,854). This study assessed a range of demographic, physical, psychosocial variables, and the outcome of PA engagement in 6 LMICs). These were China, Ghana, India, Mexico, Russia, and South Africa. Correlational analysis found that demographic, lifestyle (higher rate of non-alcohol consumption, inadequate fruit and vegetable consumption, non-smoking, older age, being part of a larger household, not being married/ cohabiting, being unemployed and living in an urban area), psychosocial (higher levels of depression, sleep problems, and low levels of social cohesion) and physical variables (being underweight, high BMI, bodily pain, angina, asthma, chronic lung disease, hearing problems, stroke, visual impairment, slow gait, weak grip strength, poor self-rated health) were significantly associated with low PA (< 150 minutes per week) (Vancampfort et al., 2018).

Rovner et al (2016) reported the correlates of PA engagement in a sample of African American adults to be demographic (being female, low literacy), physical (chronic disease, not being able to walk two blocks, IADLs) and psychological (depression) in nature.

2.4.2.2.5 Adjusted Analyses of PA Engagement. Three studies used regression modelling to present adjusted correlations. In adjusted analyses of individuals with MCI, demographic and lifestyle (unemployment, older age, alcohol consumption and smoking), psychosocial (depression, lower levels of social cohesion), and physical (underweight, obesity, asthma, chronic lung disease, hearing problems, visual impairment, slow gait, weak grip strength, poor self-rated health) variables were related to low PA in one study (Vancampfort et al., 2018). In adjusted analysis of correlates of PA in adults without MCI compared to individuals with MCI, demographics (older age), physical (being underweight, fall-related injury, slow gait), and psychosocial variables (the presence of depression) were significantly more strongly associated with not meeting PA guidelines among those with MCI (Vancampfort et al., 2018). The variables that were negatively associated with PA engagement as cited by Rovner et al were psychosocial (depression) and cognitive (TMT trail making test B and digit span backwards) (Rovner et al., 2016) .

One study examined the predictors of PA engagement in memory clinic patients with MCI and AD, and caregiver dyads using the self - report Older Persons Attitudes for Physical Activity and Exercise Questionnaire (OPAPAEQ) and status as patient or caregiver as covariates (O'Connell et al., 2015). Status as patient or caregiver was not a significant predictor of PA engagement. Only a belief in vigorous physical activity for health was a significant predictor in the analysis of patients and caregivers together. PA by one half of the dyad was not significantly associated with PA engagement in the other half. Caregivers' belief in vigorous PA was a significant predictor of patient PA. Synthesised correlates of PA engagement are presented in Table 4.

Table 4.

Synthesised Correlates of PA Engagement in Individuals with MCI

Characteristic	Correlate	Domain	Positive significant	Negative significant	Non- significant
Cognitive	MCI	Global cognitive function		(Rovner et al., 2016; Vancampfort et al., 2018)	
		Executive function		(Kobayashi et al., 2016)	
		Stage of cognitive impairment (late MCI/ early MCI, MCI/ AD)		(Gagliardi et al., 2016; Kobayashi et al., 2016; Stuckenschneider et al., 2018)	(Wettstein et al., 2015)
Demographic	Age			(Vancampfort et al., 2018)	(Rovner et al., 2016)
	Gender		(Rovner et al., 2016) (males)		(Vancampfort et al., 2018)
	Level of education				(Rovner et al., 2016)
	Literacy		(Rovner et al., 2016)		
	Marital status		(Vancampfort et al., 2018)		(Rovner et al., 2016)
	Larger household size			(Vancampfort et al., 2018)	
	Employment status		(Vancampfort et al., 2018)		
Health behaviours	Alcohol			(Vancampfort et al., 2018)	
	Smoking			(Vancampfort et al., 2018)	
	Fruit & vegetable intake		(Vancampfort et al., 2018)		

Attitudes	Belief in importance of PA for health	(O'Connell et al., 2015)		
Psychosocial health	Anxiety			(Vancampfort et al., 2018)
	Depression	(Rovner et al., 2016)	(Vancampfort et al., 2018)	
	Sleep		(Vancampfort et al., 2018)	
Physical health	BMI		(Vancampfort et al., 2018)	
	Bodily pain		(Vancampfort et al., 2018)	
	Chronic back pain		(Vancampfort et al., 2018)	
	Fall related injuries		(Vancampfort et al., 2018)	
	Visual impairment		(Vancampfort et al., 2018)	
	Hearing impairment		(Vancampfort et al., 2018)	
	Diabetes			(Vancampfort et al., 2018)
	Stroke		(Vancampfort et al., 2018)	
	Hypertension			(Vancampfort et al., 2018)
	Angina		(Vancampfort et al., 2018)	
	Arthritis			(Vancampfort et al., 2018)
	Asthma & chronic lung disease		(Vancampfort et al., 2018)	
	Presence of chronic conditions		(Rovner et al., 2016)	(Vancampfort et al., 2018)
	Mobility	(Rovner et al., 2016)		
	IADL`s	(Rovner et al., 2016)		

3.3.2.3 Physical Activity Programme Adherence

The average age of participants in RCTs and secondary analyses was 74 years, ranging from 67 – 77 years. The mean sample size was n = 189, ranging from 44 – 555 participants. Five studies sampled individuals with MCI (Lam et al., 2015; Tak et al., 2012; Uemura et al., 2013; van Uffelen et al., 2009; van Uffelen et al., 2008), one study reported results for individuals with MCI and SCI (Cox et al., 2013) and one study reported on a sample of individuals with MCI and AD (de Oliveira Silva et al., 2019). Studies included in this review had a mean of 29 studies (range 12 – 41), and samples included combined MCI and AD or dementia participants (Di Lorito et al., 2020; van der Wardt et al., 2017) and a combined MCI and SCI sample (Chong et al., 2020). PA programmes were primarily 6 months (Cox et al., 2013; Uemura et al., 2013) or 12 months in duration (Lam et al., 2015; Tak et al., 2012; van Uffelen et al., 2009; van Uffelen et al., 2008), and one was of three months duration (de Oliveira Silva et al., 2019). Most of the studies included reported on supervised or group – based programmes, except one which was home – based but telephone monitored (Cox et al., 2013), and one which included a mixture of centre and home – based activity (Lam et al., 2015).

3.4.2.3.1 Rates of PA Programme Adherence. PA programme adherence in this current review was variable, ranging from 53 % - 90 % across RCTs (Cox et al., 2013; de Oliveira Silva et al., 2019; Lam et al., 2015; Lamb et al., 2018; Suzuki et al., 2012; Tak et al., 2012; Uemura et al., 2013; van Uffelen et al., 2009; van Uffelen et al., 2008; Xu et al., 2020). However, this may be the result of differences in programme durations and formats across studies, as well as variation in the number of minutes per week participants were required to attend. For example, one 3 month multimodal PA programme for individuals with MCI and AD achieved 90% adherence (60 minutes of PA twice per week) (de Oliveira Silva et al., 2019) compared with two 12 month walking programmes which achieved 53% (Tak et al., 2012) and 63% adherence (van Uffelen et al., 2008). In contrast with the finding by de Oliveira Silva, adherence was 56%

according to a feasibility study of a 4-month Latin dance programme for individuals with MCI (Aguiñaga & Marquez, 2017). Illustrating the inconsistent findings across studies, one systematic review reported mean adherence for PA interventions for individuals with MCI and dementia to be 90%, ranging from 25% to 90%, with studies using multiple strategies (a tailored approach to the intervention, information for the participants and telephone support) achieving higher adherence (77 - 90%) (van der Wardt et al., 2017). Two studies reported rates of attrition of 15% (van Uffelen et al., 2009) and 23% (Tak et al., 2012) before the programme began, and one study reported an attrition rate of 17 % during the programme (Uemura et al., 2013). One study reported a follow up measure of post – programme maintenance of 28% 6 months after the cessation of the programme (Tak et al., 2012).

3.4.2.3.2 Correlates of PA Programme Adherence. Six studies reported on the correlates of PA programme adherence. A recent systematic review concluded that the relationship between baseline cognitive function and PA programme adherence is inconsistent (Chong et al., 2020). In other studies, better baseline global cognitive function, delayed recall, and memory was positively related to programme adherence (Lam et al., 2015; van Uffelen et al., 2009), but non - significant findings for the association between global cognitive function and adherence have also been reported (van Uffelen et al., 2008).

The impact of programme related factors on adherence were investigated in one study (Uemura et al., 2013). Adherence was significantly associated with intervention type (endurance/resistance training and interventions that did not include walking), but format (group – based or individual) was not significantly related. However, the authors report that adherence was significantly higher in a group - based format. Some sociodemographic and physical correlates of PA programme adherence were reported. Greater self – efficacy and being less physically active at baseline (for males), and living with a partner were positively related (Cox et al., 2013; van Uffelen et al., 2008) and poor mobility and injury were negatively related to PA programme adherence (Cox et al., 2013; Uemura et al., 2013). In the study by Cox et al., injury predicted a reduction in adherence by 43.08%.

3.4.2.3.3 Between Group Differences. One study reported no significant difference in mean adherence between MCI and dementia sub – groups (Uemura et al., 2013). In relation to intervention related factors, contrasting findings have been reported for the effect of intervention condition on PA programme adherence. There were no significant group differences in adherence between programme conditions (moderate intensity walking group versus low intensity activity control group) (Tak et al., 2012) in one study, but another reported significantly higher adherence in a walking group versus a usual PA control group (Cox et al., 2013). In addition, weekly adherence was found to decrease significantly over time (Cox et al., 2013). The findings regarding the effect of gender on PA programme adherence are inconsistent, with both negative and positive associations being reported in the literature (Cox et al., 2013; Lam et al., 2015). Two studies reported the main barriers to PA programme adherence. These were injury/illness, mobility problems (having trouble walking/ moving) and programme intensity (too vigorous) (Cox et al., 2013; Tak et al., 2012). Table 5 presents the quantitative factors associated with PA programme adherence.

Table 5.

Synthesised Factors Relating to PA Programme Adherence in Individuals with MCI

	Characteristic	Domain	Correlate	Yielding significantly positive results	Yielding significantly negative results	Yielding non - significant results
Programme adherence	Cognitive health	Level of cognitive function	MCI vs dementia			(Uemura et al., 2013)
			Baseline cognitive function	(Lam et al., 2015; van Uffelen et al., 2009)		(van Uffelen et al., 2008)
			Baseline delayed recall (memory)	(Lam et al., 2015; van Uffelen et al., 2009)		
	Socio – demographic	Female gender		(Lam et al., 2015)	(Cox et al., 2013)	
		Level of education				(Cox et al., 2013; Lam et al., 2015)
		Age				(Lam et al., 2015)
		Living with partner (males)		(van Uffelen et al., 2008)		
		Self – efficacy		(Cox et al., 2013)		
		Baseline PA (males)			(van Uffelen et al., 2008)	
	Programme – related	Intervention condition	Intervention type	(Cox et al., 2013; Uemura et al., 2013)		(Tak et al., 2012)
			Intervention duration		(Cox et al., 2013)	
			Intensity (too vigorous)		(Cox et al., 2013; Tak et al., 2012)	
	Physical health	Physical function	Mobility/ injury	(Cox et al., 2013; Uemura et al., 2013)		

	Most common reasons for non – adherence	Injury / illness			(Cox et al., 2013; Tak et al., 2012)
			Instructor characteristics	(Tak et al., 2012)	
			Programme contents	(Tak et al., 2012)	
			Intensity	(Tak et al., 2012)	
			Cost		(Tak et al., 2012)
			Perceived progress	(Tak et al., 2012)	

3.4.2.3.4 Intervention Strategies to Promote Adherence. Evidence regarding the effectiveness of PA adherence support strategies is limited. Few studies have examined the effectiveness of adherence strategies employed using an RCT design, thus there is a lack of evidence comparing studies and their effectiveness. For the most part, studies have used participant ratings or interview/ focus groups to assess perceived usefulness or acceptability of adherence support strategies (van der Wardt et al., 2017). In one study, incentives for adherence were not found to be statistically significant, however adherence was higher in studies using incentives (M = 82%; SD=14) compared with those that did not (M = 72%; SD=22) (Uemura et al., 2013). Group based settings have emerged as a preferred format (van der Wardt et al., 2017) and programmes that are less frequent and of shorter duration have also been reported to promote adherence (Di Lorito et al., 2020). Providing targeted educational material and incorporating social interactions into PA programme designs have also been reported to facilitate adherence in adults with SCI and MCI (Chong et al., 2014). Studies using multiple strategies (a tailored approach to the intervention, information for the participants and telephone support) have achieved greater adherence than single – method strategies (van der Wardt et al., 2017). Chong et al. (2020) recommend that PA programmes for adults with SCI and MCI be individually tailored to account for health problems, physical capacity, individual goals, and environment. In addition, a systematic review of strategies to promote PA programme adherence in individuals with MCI and dementia concluded that programmes should be individually tailored, include a learning/ adaptation period, and ensure the provision of sufficient information to participants. They should also use phone calls, exercise logs and/or reminders, and pedometers, as well as supervision and planning to support PA programme adherence (van der Wardt et al., 2017).

3.3.3 Qualitative Synthesis

3.3.3.1 Study Characteristics

Three qualitative studies were included for review. Two studies qualitatively explored the barriers, facilitators, and preferences for PA engagement in individuals with MCI, and one explored PA programme adherence. Both PA engagement studies used semi – structured focus groups to collect data, and thematically analysed the findings using mixed MCI, dementia, and AD samples. The first study included 50 adults aged 60 and over (Chong et al., 2014), 6 of whom had MCI. The second study included 13 participants including 6 individuals with MCI or dementia, 3 family carers and one focus group with 4 clinicians (van der Wardt et al., 2019). The findings relating to clinicians and carers were excluded from the analysis as this present study only concerned factors related to PA engagement from the perspective of individuals with MCI. One qualitative study assessed the factors that impact PA programme adherence (Hancox et al., 2019). This was a thematic analysis of the barriers and facilitators to a 12 – month, home – based strength and balance programme for individuals with MCI, early dementia, and AD. Semi – structured interviews were conducted with 20 adults with cognitive impairment (80% male, mean age 76.6, 1 participant with MCI, 9 with Alzheimer’s disease, 4 with vascular dementia, 4 with mixed dementia, 2 with unknown dementia sub – types, and their carers (n = 19). Themes were deductively applied to the Theoretical Domains Framework (TDF).

3.3.3.2 Physical Activity Engagement

Two qualitative studies reported on PA engagement. Chong et al. (2014) explored attitudes, beliefs, and barriers to PA engagement in individuals with MCI, SCI, AD, and cognitively healthy adults by conducting semi – structured focus groups. Data was analysed thematically and resulting themes were compared for adults with cognitive impairment (MCI and AD) against themes identified by cognitively healthy adults and adults with SCI. Three key themes emerged for individuals with MCI and AD. These were: “attitudes toward doing PA/ exercise”, the “impact of physical activity/exercise on cognitive function and dementia”, and “barriers to PA/ exercise”. The second study under review here (van der Wardt et al., 2019) conducted focus groups with individuals with MCI and dementia and their carers to explore motivators for PA engagement. Five key themes were identified. These were “memory problems”, “self- motivation”, “external motivation”, “design of activities”, and “barriers”(van der Wardt et al., 2019).

Individual study findings were textually pooled to identify 5 main themes common to both studies. These were “memory problems”, “self – motivation”, “external motivation”, “individualising PA” and “barriers to PA”. The theme of “memory problems” refers to issues arising from cognitive impairment such as needing reminders for PA engagement and needing support from others to account for memory loss. For example, needing a companion to ensure they return safely.

Within the second theme of self- motivation, a belief in the physical, social, and cognitive benefits of PA was important for PA engagement. For instance, participants felt that PA was good, important for health, social, enjoyable, and part of their identity, but that there was a need to be careful of potential dangers (i.e., such as falling). Chong et al. (2014) report that participants with MCI and AD more frequently reported a belief that PA was helpful for cognitive function than cognitively healthy participants.

The theme of external motivation was derived from the findings of one study (van der Wardt et al., 2019). Sources of external motivation for PA engagement were owning a dog, encouragement from family, the social aspect of exercising, information regarding the benefits of PA and feedback from clinicians regarding individuals` PA engagement.

Individualising PA was identified as a theme arising in both studies, suggesting that adults with MCI, dementia and AD require PA to be tailored to their individual needs and preferences. In addition, one study highlighted that PA engagement was impacted by “feeling too old”, thus suggesting that perceived ability for PA may be a determinant in this population.

Regarding the final theme identified in this study, “barriers towards PA/ exercise”, participants listed the barriers of health problems/disability, and environment (quality of facilities, accessibility, weather, and lack of time). However, it should be noted that in the study by Chong et al. (2014), these themes were also common in the cognitively healthy sample, meaning that it is difficult to tease apart the extent to which these factors represent barriers to PA engagement in adults in general. Health issues were both actual and perceived according to van der Wardt et al. (2019), with some participants wishing to reduce their physical activity before it became too strenuous. That study also reported that some participants believed themselves unable to complete PA due to “feeling too old” and expressed a fear of falling. Regarding preferences for PA programmes or PA engagement, adults with cognitive impairment (MCI/ AD) reported a preference for PA that was simple, light, and safe (Chong et al., 2014). In addition, outdoor activities or a gym setting, provided there was adequate support for performing exercises, were preferred PA choices (van der Wardt et al., 2019).

There are some limitations with these studies. Although themes were identified by Chong et al. (2014) and attributed to individuals with MCI and dementia where they were more commonly referred to than in cognitively healthy participants, there are two limitations with this study. The first is that adults with cognitive impairment have been merged into one sub – group for analysis, meaning that it is difficult to determine the extent of barriers to or needs for PA engagement specific to individuals with MCI, as distinct from adults with a greater level of cognitive impairment i.e., dementia. The second limitation is in relation to the reporting of relevant themes, which lack further explanatory data in the text of the paper. For instance, it is unclear what type of health problems or mobility issues might limit PA engagement. It is also unclear what is meant by motivation/ personality as a barrier to PA engagement. Another possible limitation to this study is that the focus group format may have influenced the findings. The authors concluded that they were unsure if responses by individuals with cognitive impairment expressed their genuine opinions, if they were led by the group dynamic (i.e., expressing socially desirable responses), or if they were lacking the confidence to dissent to others opinion due to their cognitive limitations.

As with the previous study, this study combined individuals with MCI and dementia, and findings were not attributed to one or other of these sub – groups individually meaning that it is again difficult to assess whether the needs of individuals with MCI are same as the needs of more cognitively impaired individuals. In addition, carers were included in the focus groups and analysis, further confounding the ability to apply findings to an MCI only population. Synthesised qualitative findings are presented in Table 6.

Table 6.

Synthesis of Themes Relating to PA Engagement in Individuals with MCI, Dementia and AD

Author	Population represented	Setting/ context	Conclusion	Illustration	Unequivocal/ Credible/ unsupported	Reviewer conclusions
Van der Wardt et al., 2019	6 adults with MCI and dementia and 3 carers	Community dwelling	Memory problems (needing support/ reminders)	"You [her husband] walk from here to here, and I'll meet you there, he would possibly struggle because of his memory, his short-term memory is so bad, he would forget what the arrangement was.' Mr R's wife.	Credible	Memory problems
			Self – motivation including organisation (planning, habit/ routine, goal setting and control), and benefits of PA (enjoyment, remaining independent, keeping fit and healthy)	'I do always have something in the day, sort of like, little goals and little, little rewards, if you like, little things, if it's something at lunchtime' 'Well, if you're going to keep it up, it needs to be something that you enjoy, in the main' Mr R.'s wife;"	Credible	Self – motivation (describing planning and routine, and belief in the benefits of PA)
			External motivation (family, dog-ownership, socialising with others, feedback from clinicians, gadgets' and 'information)	'For me, you go out, they make you go out, they make you walk, you have to go out, twice a day, you have to do it.'	Credible	External motivation
			Design of activities (tailoring and setting)	'Oh dear, all these good, they are on paper, good ideas, and a different group of people, they might grab those, fantastic. But we're all different, as you'll find, we're all different.'	Credible	Individualising PA
			Barriers (environmental barriers, finances, health issues, conflict with	'…the trouble is, it's all located that far away' [distances to activities]	Credible	Barriers (health, environment (weather/ accessibility), time

			other activities, and believing being unable to complete the exercises or physical activities)			constraints, and perceived ability (feeling too old)
Chong et al., 2014	50 Adults over 60 years with MCI, AD and no impairment	Community dwelling	Attitudes toward PA (good, important for health, social, enjoyable, part of identity, potentially dangerous)	No illustrative quote provided	Not supported	Self-motivation (belief in the physical and social benefits of PA)
			Impact of PA (belief that PA is good for cognitive function)	”I hope so! I haven’t experienced it yet.”	Not supported	Self – motivation (belief in the cognitive benefits of PA)
			Barriers to PA (health/ disability, motivation, environment (weather, accessibility, lack of time), lack of companion, memory problems)	”If I remember to do it.”	Credible	Barriers (health/ disability, environment (weather/ accessibility), time constraints, lack of companion) Memory problems and motivation have been extracted in line with “self – motivation” and “memory problems” themes as per van der Wardt 2019.
			Tailored to individual needs and preferences	“Yes. And I go out in the garden digging, and I come back and next day I’m very, very – the joints have, this is how it comes out, and this – I hate any exertion with weight involved, or speed, to a man of my weight, and to do it intermittently, it’s stupid.”	Credible	Individualising PA

3.3.3.3 Physical Activity Programme Adherence

One qualitative study assessed the factors that impact adherence to a 12 – month, home – based strength and balance for adults with cognitive impairment (MCI, early dementia, and AD) (Hancox et al., 2019). Adherence to the programme was 40% (at 4 months). Five participants were categorised as exceeding adherence expectations (completing prescribed exercises > 5 times per week), 7 as meeting adherence expectations (3 -4 times per week), and 8 as low adherers (< 3 times per week). The authors describe six themes relating to programme adherence. These were routine, practical, and emotional support, memory support, purpose, past - experience, and belief in the benefits of PA. The theme of routine described how consolidation of programme adherence as habitual promoted programme adherence. Developing a routine made adherence less likely to be forgotten. The theme of memory support highlights the need for strategies to aid in reminding participants to complete exercises. This was provided by carers and clinicians in the form of prompts for exercise, or pictures of exercises to remind participants how they are performed. Consolidating a routine was considered a form of memory support. The theme of practical and emotional support referred to the role of carers in socially influencing adherence through helping participants complete programme exercises and providing encouragement. Having a strong past history of sport or exercise and an identity as being active was found to be positively associated with programme adherence, and having a purpose for adherence, such as maintaining physical or psychological health, was a key determinant of programme adherence, as was having a belief that PA was a beneficial activity.

One limitation to this study was that only 1 of 20 participants was categorised as having MCI, with the remainder of the sample being categorised as having dementia. As previously discussed, participants with MCI and early dementia were grouped together in this analysis based on standardised mini – mental state examination scores ((Hancox et al., 2019) (SMMSE (Vertesi et al., 2001)). This tool is sensitive for detecting dementia, but less sensitive in distinguishing normal cognition from MCI, and MCI from early dementia (Molloy et al., 2005). Thus, it is unclear if factors that impact PA programme adherence in this sample reflected MCI specific barriers and facilitators to adherence or were common to individuals with more significant levels of cognitive impairment.

3.3.4 Integration of Quantitative and Qualitative Evidence

3.3.4.1 Physical Activity Engagement

Qualitative and quantitative findings were configured by plotting sets of findings onto the COM – B framework of behaviour (Table 7). The health behaviours of fruit and vegetable intake, smoking and alcohol intake were excluded from the configured findings as these were determined to hold little utility in contributing to the aim of configuring the factors that impact PA engagement in this cohort of adults as they were not applicable to the COM – B domains of either capability, motivation of opportunity. For example, health behaviours may be impacted by psychological capability (e.g., knowledge) and/ or social opportunity (e.g., cultural norms or social cues).

Table 7.

Configured Qualitative and Quantitative Findings for Factors Associated with PA Engagement in Individuals with MCI

COM - B Domain		Qualitative Themes	Quantitative Findings
Capability			
Psychological capability	Psychological strength/ stamina and knowledge & skills	Perceived physical ability/ feeling too old Information	Literacy Depression Sleep Gender Age
Physical capability	Physical strength, skills, or stamina.	Memory problems (needing support, needing reminders) Health/ disability	MCI (global cognitive function, executive function, stage of cognitive impairment) Chronic illness/ pain Fall related injuries Mobility IADLs Visual/ hearing impairment BMI
Opportunity			
Physical opportunity	Environment, time, location, resources	Weather Quality of facilities Accessibility	Employment status Larger household size Marital status

		Design of activities (tailored to individual needs/ ability and preference)	
		Lack of time	
		Lack of companion	
Social opportunity	Social factors such as cultural norms and social cues	Socialising	
		Feedback from clinicians	
Motivation			
Reflective motivation	Making plans, beliefs, evaluations of past events	Believing PA is good for cognitive function	Belief in importance of PA for health
		Organisation (goal setting, reminders, habit/ routine planning)	
		Attitudes toward PA	
		Family support	
		Dog owner	

3.3.4.2 Capability

3.3.4.2.1 Psychological Capability

The domain of psychological capability refers to individual's psychological strength, stamina and knowledge and skills required to perform a behaviour. The qualitative literature highlighted the need for more information regarding how to be physically active, and the cognitive benefits of PA. Although one study stated that a belief in the cognitive benefits of PA were related to PA engagement, another indicated that information on how to safely perform exercise was lacking. One quantitative study found that having a lower level of literacy was related to PA engagement. Although these two concepts are not identical, they may be somewhat convergent as lower levels of literacy may impact how information is disseminated and received and may mediate the success of existing initiatives to disseminate information regarding the benefits of PA engagement in this cohort of adults.

Where qualitative studies identified the sub – theme of perceived physical ability or feeling too old, as a barrier to PA engagement, there was silence regarding this in the quantitative literature as subjective age was not included as a variable in any of the statistical analyses. However, chronological age was determined to be negatively correlated with PA engagement. Similarly, quantitative studies have identified depression, poor sleep, and male gender as being negatively correlated with PA engagement, but these were not themes that have been reported on in the qualitative literature.

3.3.4.2.1 Physical Capability

Physical capability refers to the physical strength, skills or stamina required to perform a behaviour. There was convergence in both strands of literature regarding the negative impact of cognitive impairment on PA engagement. Though qualitative literature reported the negative effect of cognitive impairment on PA engagement in mixed samples of cognitively impaired adults (MCI, dementia, AD, and family carers), two quantitative studies reporting negative associations with the level of cognitive impairment were derived from MCI only samples, supporting the qualitative findings in this instance. In addition, the quantitative literature furthered the qualitative findings, suggesting that chronic illness and pain, mobility issues, problems completing IADLs (instrumental activities of daily living), and visual and hearing impairment may be specific health-related barriers to PA engagement in individuals with MCI. However, these findings require further examination as they are derived from two studies only.

3.3.4.3 Opportunity

3.3.4.3.1 Physical Opportunity

Opportunity here describes the external factors that prompt engagement in a behaviour. Physical opportunity can be the environment, time, location, or resources. Qualitative studies have suggested that weather, the quality of available facilities, accessibility, lack of companion and lack of time are environmental barriers that impact PA engagement in adults with cognitive impairment. Quantitative data is silent regarding these concepts as they have not been explicitly investigated in statistical analysis. However, the correlates that have been identified are employment status, household size and marital status. It may be the case that employment status and household size are proxy indicators of available leisure time for PA, as population based studies have suggested that those in full time employment and with larger families have less free time in which to exercise (Biernat & Buchholtz, 2016; Kouvonen et al., 2005; Tavares & Plotnikoff, 2008). It also may be the case that married participants engage in more PA as having a spouse increases the likelihood of having a companion to exercise with. The qualitative literature suggests that the design of activities, i.e., tailoring activities to meet individual’s needs, abilities, and preferences, can be useful in enhancing PA engagement.

3.3.4.3.2 Social Opportunity

Social opportunity refers to factors such as cultural norms and social cues. Qualitative literature has suggested that the social aspect of PA is important in motivating PA engagement. In addition, feedback from clinicians regarding engagement in PA is helpful in reinforcing engagement through social cues. However, the quantitative research to date is silent on both points.

3.3.4.4 Motivation

3.3.4.4.1 Reflective Motivation

The domain of motivation encompasses internal factors that influence decision making. In the case of reflective motivation this includes making plans, beliefs, and evaluations of past events. Qualitative and quantitative literature converge on the finding that believing that PA is good for health is associated with PA engagement. However, within the qualitative data itself there are dissonant findings on this point, with one study supporting the role of a belief in the cognitive benefits of PA and another stating that awareness of the cognitive benefits is low. Qualitative findings have also shown that attitudes toward PA (believing it is social, enjoyable, important for health, good, careful/ potential danger), family support and dog ownership are also related to PA engagement in a sample of cognitively impaired and non – impaired adults (MCI, AD, SCI, and cognitively healthy adults). However, these factors have not been investigated in the quantitative literature.

3.3.4.4.2 Automatic Motivation

The concept of automatic motivation describes the impact of desires, impulses and inhibitions on behaviour. The quantitative literature is silent regarding concepts related to automatic motivation for PA engagement. The qualitative evidence suggests motivation and personality broadly impact PA engagement, and that remaining independent and keeping fit and healthy are sub – themes within the theme of motivation for PA engagement in individuals with MCI, AD, and their carers.

These configured findings converge in suggesting that memory problems, level of literacy and lack of information, and physical health and function are components of physical capability for PA engagement in individuals with MCI. Physical opportunity for PA engagement is influenced by a lack of time and lack of companion, which may be related to practical time limiting factors such as being in employment, marital status, and household size. Qualitative and quantitative findings also converged in support for the role of having a positive belief in the physical health or cognitive benefits of PA in positively impacting PA engagement.

Although the qualitative literature covers a wider range of factors influencing the outcome of interest than does the quantitative, resulting in silence regarding the statistical contribution of constructs such as the impact of the environment, the social aspect of PA engagement, planning and routine, family support, and motivation for PA.

3.3.4.5 Physical Activity Programme Adherence

Configured findings for PA programme adherence are provided in Table 8.

Table 8.

Configured Qualitative and Quantitative Findings for Factors Associated with PA Programme Adherence in Individuals with MCI

COM - B Domain		Qualitative Themes	Quantitative Findings
Capability			
Psychological capability	Psychological strength/ stamina and knowledge & skills	• Emotional support	• Self – efficacy - Positive association
Physical capability	Physical strength, skills, or stamina.	• Memory issues/ memory support	• MCI - Positive association with global cognitive function and memory • Mobility/ injury and illness - Negative association • Gender - inconsistent positive/ negative associations
Opportunity			
Physical opportunity	Environment, time, location, resources	• Practical support	• Living with a partner - Positively associated (males) • Programme related factors - Exercise type (contrasting findings regarding walking. Resistance training positively associated) - Intensity (too vigorous negatively associated) - Programme duration (negative association with longer duration)
Social opportunity	Social factors such as cultural norms and social cues		

Motivation			
Reflective motivation	Making plans, beliefs, evaluations of past events	• Purpose • Past experience • Belief in the benefit of PA	
Automatic motivation	Emotional responses, desires, impulses, and habit	• Routine	• Baseline PA - Negative association (males)

3.3.4.6 Capability

3.3.4.6.1 Psychological Capability

Integrated findings indicate that emotional support and greater self- efficacy promote adherence to PA programmes, demonstrating convergent findings within the existing evidence base. In the qualitative literature, encouragement from carers and clinicians was important for programme adherence. Regular contact with clinicians were a source of external motivation for PA and helped to allay participants fears relating to PA, such as a fear of falling. Thus, the quantitative findings regarding the positive association between self-efficacy and PA programme adherence is complimentary to this as it suggests that providing greater emotional support may positively impact on individual's self – efficacy and thus promote adherence.

3.3.4.6.2 Physical Capability

There was convergence between sets of findings regarding the components of physical capability (physical strength, skills, or stamina) which impact PA programme adherence. Both studies highlighted the negative association between MCI and adherence. Global cognitive function and poorer memory at baseline were quantitative barriers to programme adherence, and this was supported in the qualitative literature by the identification of the need for memory support for adherence. In that study, lacking memory supports was a key barrier to adherence as participant had difficulty remembering to perform exercises and remembering how to perform exercises. However, in participants who used memory supports, such as reminders or pictures demonstrating exercises, adherence was greater. The authors also state that those with greater levels of cognitive impairment were more likely to need additional external memory support (i.e., from carers or clinicians).

3.3.4.7 Opportunity

3.3.4.7.1 Physical Opportunity

Findings from the quantitative literature indicate that programme related factors, such as intensity, type of exercise and duration were associated with PA programme adherence. In addition, living with a partner was positively correlated with adherence for males. Thus, though the qualitative data does not add to the understanding of how programme related factors negatively impact the behaviour of PA programme adherence, it does suggest that practical support for programme adherence is important for individuals with MCI. For example, supervision from clinicians was important for individual's adherence and support such as prompts and guidance from family carers was a key determinant of programme adherence. This is in support of the quantitative findings that living with a partner was correlated with greater adherence, as it is likely that those living with partners have greater access to this type of practical support. Thus, findings are mostly convergent regarding physical opportunity for PA programme adherence. However, it should be noted that in the paper by Hancox et al. (2019), providing this type of support resulted in a greater level of stress for the carer, and adherence was dependent on the carers willingness or ability to support PA programme adherence.

3.3.4.7.2 Social Opportunity

There was silence in both the qualitative and the quantitative literature regarding the social factors (social cues and cultural norms) for PA programme adherence.

3.3.4.8 Motivation

3.3.4.8.1 Reflective Motivation

The quantitative literature is silent regarding the concept of reflective motivation (plans, beliefs, evaluations of past events) and PA programme adherence in individuals with MCI. However, qualitative literature has highlighted the role of individuals past experiences with PA and beliefs regarding PA (i.e., good for health) as motivators for PA programme adherence. Positive past experiences consolidated individual's identity as being active and having a strong belief that PA was beneficial was a key motivating factors in programme adherence. In addition, having a clear reason or purpose for performing exercises was a facilitator to adherence. Primary reasons identified by Hancox et al. (2019) were for prevention (of physical or psychological ill health), therapy (i.e., to improve balance or reduce falls risk) or facilitation (to help prolong participation in enjoyable activities).

3.3.4.8.2 Automatic Motivation

Routine was identified in the qualitative literature as a facilitator of PA programme adherence in this cohort. Having a routine for completing prescribed exercises was found to help consolidate PA as habitual and promoted adherence. Participants of that study who established a regular time and place to perform exercisers had greater programme adherence than those who did not. There may be support for this in the quantitative literature with the finding that greater baseline levels of PA were correlated with greater PA programme adherence. This seems to be intuitive, as those who habitually perform PA prior to a programme are likely to be sufficiently motivated to be physically active to begin with. Thus, baseline PA may be a useful predictor of PA programme adherence in MCI populations and as such may help identify individuals with MCI in need of greater support for programme adherence.

3.4 Gaps in the Current Literature

Rates of PA engagement in individuals with MCI are variable in the literature and the reasons for this are unclear. One limitation with the current literature relates to how PA data is collected and reported. Most of the studies under review used self -reported PA data. In addition, there was variation between the self -reported questionnaires used, which may have led to the capturing of differing conceptualisations of PA. Five studies under review used validated PA questionnaires including the LASA Physical Activity Questionnaire (LAPAQ) (Stuckenschneider et al., 2018), The Global Physical Activity Questionnaire (GPAQ (Vancampfort et al., 2018), the US – HIS 9 item scale (Rovner et al., 2016), the Older Persons Attitudes for Physical Activity and Exercise Questionnaire (OPAPAEQ) (O'Connell et al., 2015), and the Physical Activity Scale for the Elderly (PASE (Gagliardi et al., 2016)). One study used an unvalidated, semi -structured self – report questionnaire (Kobayashi et al., 2016). Two studies used GPS tracking devices to record distance travelled (Stuckenschneider et al., 2018; Wettstein et al., 2015), but not minutes spent in PA engagement and neither study reported PA engagement based on objective measurement. Self-reported measures of PA have been found to have low – moderate correlation with direct observation of PA engagement in cognitively healthy adults (Prince et al., 2008), and their reliability can be undermined through factors such as cognitive impairment (Cumming & Klineberg, 1994; Helmerhorst et al., 2012), leading to an under – estimation of PA engagement in cognitively impaired populations (Siebeling et al., 2012).

Similarly, there is variation in how PA engagement is reported in the results sections of studies, which makes comparisons of rates of PA engagement and comparisons of between group analyses difficult. For example, PA engagement was expressed as minutes per day and per week in some papers, as METs (metabolic equivalents) in another, and dichotomised based on achievement or not of PA guidelines. In other studies, PA was categorised according to engagement in no weekly PA, engagement in some weekly PA and meeting/ exceeding PA guidelines, and finally one paper grouped participants into quartiles based on the range of minutes of PA engagement per week. This variation in collection and reporting of PA data may explain the wide variation in reported levels of PA engagement across studies, and some of the inconsistent findings regarding correlates and predictors of PA engagement. Thus, there is a need for a consistent method of reporting PA engagement, such as reporting in relation to global PA guidelines, and a need to further investigate the suitability of self – reported methods of PA data collection in individuals with MCI to determine if unreliable PA data may negatively impact reported rates of PA engagement in this cohort. There is also a lack of studies that have examined rates of PA engagement in a sample of Irish individuals with MCI which may be compared with internationally reported PA engagement rates.

Most studies under review here have explored between group differences in PA engagement. Although one study has demonstrated that the stage of MCI (early versus late stage) was significantly associated with PA engagement (Stuckenschneider et al., 2018), only one study has used a measure of cognitive function as a variable in an adjusted analysis (Rovner et al., 2016). Thus, there is a paucity of data to support the role of cognitive function in MCI as a useful predictor of PA engagement, and to determine the impact of cognitive impairment when relevant covariates have been held constant.

In addition, few studies have explored the qualitative factors associated with PA engagement specific to individuals with MCI as mixed MCI, dementia and AD samples of cognitively impaired adults have mostly been used. The result is a limited understanding of the barriers in MCI (as opposed to dementia or AD) that impact PA engagement from the perspective of individuals with MCI. In other words, the participants voice is needed in furthering understanding of how cognitive impairment may influence the outcome of interest in a practical, or “real world” sense. Similarly, there is a lack of mixed methods studies drawing on the findings of both quantitative and qualitative data to address the lack of knowledge regarding this topic. Further research is required to address this gap to improve our understanding of the factors impacting PA engagement in this sub – group of cognitively at-risk adults.

Rates of PA programme adherence in individuals with MCI are also variable, and studies which have examined this in an Irish context are lacking. Data regarding the impact of cognitive variables on PA programme adherence is inconsistent, with some studies demonstrating an effect and others no significant relationship. Variables relating to physical function and health have been cited in the literature primarily recorded and reported as the most common reasons or categories of reasons, for non – adherence but self – reported physical or cognitive health has not been measured quantitatively in relation to adherence. Studies that have analysed the role of physical function, health and PA programme adherence have been limited to mobility and injury, with little evidence of the impact of other indicators of physical function, such as chronic health conditions. In addition, few studies have reported on the effect of psychosocial and demographic variables on the outcome of PA programme adherence, resulting in a limited understanding of the impact of these factors on PA programme adherence. Similarly, there is little evidence regarding the impact of programme related factors such as setting (group versus home – based), mode of PA employed and programme duration on the outcome of PA programme adherence. Finally, there is a lack of mixed methods studies on this topic, and just one study which qualitatively explored the perspective of the individual with MCI regarding PA programme adherence was included in this review. That study included individuals with MCI (n = 1), early dementia (n = 10) and AD (n = 9), meaning that factors specific to individuals with MCI are under – represented in the current literature regarding this topic and further qualitative investigation is necessary to understand this phenomenon.

3.5 Discussion

Rates of PA engagement are variable in the current literature. This may be due to inconsistencies in definitions of PA, methods of PA data collection and reporting across studies. The integrated findings of this current review suggest that memory problems, level of literacy, lack of information regarding PA and physical health and function, as well as perceived physical ability impact capability for PA engagement in this cohort. Time constraints, environmental factors, lack of companion for exercise impact opportunity for PA engagement. In addition, PA engagement is impacted by self- motivation (planning/ routine and a belief in the benefits of PA) and sources of external motivation, such as encouragement from family member. These findings point to the need for PA to be tailored to the individual needs of people with MCI. However, the qualitative evidence regarding the determinants of PA engagement in this cohort is scarce. Further, there is a lack of mixed methods studies regarding this topic, and a further lack of studies in a cohort of Irish adults.

In addition, rates of PA programme adherence are low and variable across studies. This may be due to differences in intervention design and formats across studies, as the studies included in this review varied in programme design, modes of PA, and definitions of programme adherence. Similarly, there were no mixed methods studies investigating PA programme adherence and no data pertaining to Irish adults. Capability for PA programme adherence was determined by memory problems, mobility/ injury and illness, self – efficacy and the need for emotional support. Practical support and living with a partner impact individuals programme adherence in terms of opportunity for adherence. In addition, motivation for programme adherence is impacted by factors such as believing in the benefits of PA, establishing a routine, and having a purpose for PA.

This study identified a number of gaps in the current literature regarding PA engagement and PA programme adherence. Most studies reported that MCI was negatively associated with PA engagement. However, there is a lack of studies investigating the impact of MCI on engagement when covariates are accounted for. The evidence relating to the impact of MCI on programme adherence is less consistent, but similarly there is a lack of studies assessing the impact of covariates on this association. Further, in terms of studies investigating PA engagement in this cohort, self- reported PA is the most common form of PA data collection and its accuracy in individuals with MCI remains to be assessed.

With regard to the qualitative literature exploring barriers and facilitators to PA engagement and PA programme adherence, there is a lack of MCI specific data. For instance, most of the qualitative studies included in this review have used mixed samples comprised of individuals with MCI, dementia, and AD, making it difficult to identify the needs of individuals with MCI for PA engagement and programme adherence from the current literature.

Finally, few studies have investigated the impact of programme related factors on PA programme adherence in this population, and with inconsistent findings. Given the variability in reported rates of programme adherence and the similar variability in programme design in the literature, these factors remain to be investigated as determinants of PA programme adherence in this group of individuals.

3.6 Conclusions

This MMSR shows that further research is needed to understand the variability in rates of PA engagement and PA programme adherence in individuals with MCI. There is a lack of research on this topic relating to an Irish context that should be addressed. Assessment of the accuracy of self – reported PA data in MCI groups is also needed. Further clarification of the impact of cognitive function on engagement and adherence, and the effect of covariates on this association requires further investigation. Additionally, knowledge regarding the barriers and facilitators to PA engagement and programme adherence specific to individuals with MCI is lacking and further exploration is needed to understand these phenomena. There is currently a lack of mixed methods studies that have explored this topic, and future research may benefit from drawing on the strengths of multiple methods to address the lack of understanding of the determinants of PA engagement and programme adherence in individuals with MCI.

3.7 Chapter Summary

This chapter presented a mixed methods systematic review on the current literature regarding PA engagement and PA programme adherence in individuals with MCI. A description of the current quantitative and qualitative literature on the topic of PA engagement in individuals with MCI and of the current quantitative and qualitative literature regarding adherence to PA programmes in this cohort. Integrated findings showed identified a lack of mixed methods research on this topic, and a lack of research in an Irish context. It also showed that the impact of cognitive, demographic, physical and psychological variables on engagement and adherence in individuals with MCI is not well established, and MCI populations are under – represented in the qualitative literature.

Chapter 4: Correlates of Physical Activity Engagement in Individuals with MCI

4.1 Introduction

According to global physical activity guidelines, adults aged 18- 64 should engage in at least 30 minutes of moderate intensity PA a day five days per week, or 150 minutes per week, or any combination of both in bouts of at least 10 minutes duration. In addition, those aged 65+ should perform activities to enhance balance for prevention of falls on at least 3 days per week (WHO, 2010). Despite evidence regarding the benefits of regular PA for brain health in individuals with MCI (Cai & Abrahamson, 2016; Strohle et al., 2015; Zheng et al., 2016), the evidence regarding levels of PA engagement in individuals with MCI and the factors that are associated with it is limited and inconsistent (Gagliardi et al., 2016; Rovner et al., 2016; Stuckenschneider et al., 2018). Additionally, evidence regarding the demographic, physical and psychological correlates of PA engagement in individuals with MCI is also scarce and unclear, and there is currently a lack of data regarding the individual contribution of variables to the relationship between cognitive function and PA engagement.

For example, just 4 correlational studies included in the MMSR of this thesis investigated the effect of cognitive function on PA engagement. The findings showed cognitive function to be negatively associated with PA engagement in 3 studies (Kobayashi et al., 2016; Stuckenschneider et al., 2018; Vancampfort et al., 2018), contrasting one non – significant finding (Wettstein et al., 2015). Domains relating to physical health and physical function have also been associated with PA engagement in individuals with MCI, though the number of studies that have investigated these correlates is low and the findings are contradictory (Rovner et al., 2016; Vancampfort et al., 2018). The evidence regarding the associations between demographic variables and PA engagement is also sparse and inconsistent (Rovner et al., 2016; Vancampfort et al., 2018), with contradictory findings arising regarding the impact of age, gender, and level of education. However, the latter studies found negative correlations with PA engagement and depressive symptoms among those with MCI.

Thus, the current literature suggests that cognitive, demographic, physical health and psychological health variables may be associated with PA engagement in MCI. However, there are a number of limitations with the current literature in this area. Firstly, in addition to a dearth of longitudinal data, few studies have reported on the relative contribution of demographic, physical and psychological variables on PA engagement among those with MCI. Many of the variables tested as correlates in previous studies, such as age, physical frailty, mobility, depression, low education and chronic disease, have been independently related to both MCI (Atti et al., 2010; Boyle et al., 2010; Caracciolo et al., 2008; Frisoni et al., 2000; Gonzales et al., 2016; Pedersen et al., 2014) and engagement in PA in older adults (Kaplan et al., 2001; Peterson et al., 2009; Rockwood et al., 2004; Sun et al., 2013), indicating possible interaction effects between cognitive function and PA engagement. Thus, the impact of possible covariates on the outcome of PA engagement in this sub – population of individuals remains to be clarified.

Furthermore, previous studies in MCI and dementia populations have been limited by indirect measurement of PA (Gagliardi et al., 2016; van Alphen et al., 2016). Indeed, most of the studies have used self- report questionnaires (Rovner et al., 2016; Stuckenschneider et al., 2018; Vancampfort et al., 2018) which have low – moderate correlation with direct observation of PA in adults (Prince et al., 2008), and their reliability can be undermined through factors such as cognitive impairment (Cumming & Klineberg, 1994; Helmerhorst et al., 2012). Indeed, self-reported PA data can be prone to underestimation in cognitively impaired populations (Siebeling et al., 2012), whereas objective measurement using accelerometry has received support as a reliable method of PA assessment in individuals with MCI and early dementia (Vidoni et al., 2016). In the MMSR for this thesis (Chapter 3), two studies used objective recording via GPS devices and triaxial accelerometry to track walking distance (Stuckenschneider et al., 2018; Wettstein et al., 2015), which, although is a proxy measure of PA, does not indicate minutes spent in moderate to vigorous PA (MVPA). In one of those studies (Stuckenschneider et al., 2018), a validated PA questionnaire was also used (LAPAQ). However, as both methods of data collection recorded slightly different phenomenon (time spent in PA versus steps walked per day), a comparison of these measures for the purpose of assessing convergent validity between PA measures was not conducted. Thus, there is a need for studies to assess convergent validity between objective and self- report measures of PA in this cohort to ensure that measures used accurately characterise PA in individuals with MCI.

Finally, the literature review conducted for this thesis highlighted a lack of data regarding rates of PA engagement and the determinants of it in Irish adults with MCI. This may have implications for the generalisability of the current knowledge to an Irish context, as findings have been mixed in previous geographically diverse samples, demonstrating possible heterogeneity in the determinants of PA engagement between countries. For example, one large study sampling individuals with MCI from 6 LMIC`s found cognitive function was related to PA engagement only in Ghanaian men, and secondary level education was negatively correlated with PA in Chinese adults, but positively correlated in Ghanaian adults (Vancampfort et al., 2018). Thus, levels of PA engagement and the factors associated in Irish individuals with MCI remains to be determined.

4.1.1 Aim

This study aimed to address objective 1, sub – objectives 1.1.1, 1.1.2 and 1.1.3 of this thesis as part of a convergent parallel mixed methods investigation of the determinants of PA engagement in individuals with MCI.

4.1.2 Objectives

Sub – Objective 1.1

To use hierarchical multiple regression to analyse the relationship between minutes of PA per week and global cognitive function (MoCA), controlling for age, and years of education, physical health (number of medications), physical frailty (handgrip), and psychological health (depression and quality of life) in a sample of adult aged 50 + with MCI (n = 62).

Sub – Objective 1.1.1

Use a one- sample t – test to compare levels of PA in MCI sample to global Physical Activity Guidelines.

Sub – Objective 1.1.2

Analyse the relationship and level of agreement between subjective (LAPAQ physical activity questionnaire) and objective (Actigraph triaxial accelerometer) measures of PA engagement in individuals with MCI.

4.1.3 Hypotheses

It was hypothesised that higher levels of cognitive function would be positively associated with engagement in PA after controlling for demographic, physical and psychological covariates. It was also hypothesised that PA engagement in this cohort would be below the global recommended PA guidelines of 150 minutes per week based on previous literature regarding PA trends in older adults. Finally, it was hypothesised that there would be a statistically significant lack of agreement between objective and subjective measures of PA engagement in this cohort.

4.2 Methods

4.2.1 Design

This was a descriptive cross- sectional study of secondary data from the NeuroExercise study of a 12 – month PA intervention on the outcome of cognitive function. NeuroExericse study participant enrolment took place between February 2016 and July 2017. Baseline data for 62 participants was included in this study. The independent variable of interest was cognitive function. The variables of age, gender, years of education, number of medications as a proxy measure of illness, handgrip strength as a proxy measure for physical frailty, depression, and quality of life were treated as covariates in this analysis. The dependent variable was PA engagement in minutes per week, measured using the LAPAQ physical activity questionnaire and the Actigraph triaxial accelerometer device.

4.2.2 Participants

Participants were recruited the community (n=26) and from memory clinics (n= 36). Inclusion criteria were a diagnosis of amnestic MCI due to AD based on the Albert et al. criteria (Arredondo et al., 2016), a Montreal Cognitive Assessment (MoCA) score of 18- 26, and age of 50 years +. Participants were excluded if they had received a diagnosis of severe chronic disease, dementia, or history of major psychiatric disorder. Full criteria are available in the NeuroExercise Study protocol (Devenney et al., 2017) and are summarised in Appendix E.

4.2.3 Measures

4.2.3.1 Physical Activity Engagement

Physical activity was measured using the self- report LASA Physical Activity Questionnaire (LAPAQ) and the Actigraph triaxial accelerometer device. The LAPAQ is a researcher administered recall survey which records MVPA, including daily activities which contribute to PA, for the previous 14 days. It is designed for use in older populations and is valid and reliable in older adults (Harris et al., 2009; Stel et al., 2004). The Cronbach alpha coefficient was .44, demonstrating low internal reliability in this sample. Scoring is calculated by totalling minutes spent in each activity. Weekly totals were calculated to achieve minutes per seven days. See Appendix H for full LAPAQ.

The Actigraph GT3X (Actigraph, Pensacola, Fl, USA), is a medical - grade triaxial accelerometry device worn on the hip for seven consecutive days. The Actigraph measures PA by detecting dynamic accelerations in response to ambulatory movement. It is a reliable tool for measuring PA in non – impaired adults (Aadland & Ylvisaker, 2015) as validated against other activity tracking devices (Barrett et al., 2017; Ozemek et al., 2014). The data pertaining to Freedson bouts (periods of MVPA for 10 minutes or longer) was taken as the objective measure of PA and is a valid and reliable method for estimating PA engagement (Leinonen et al., 2016). Data was extracted and analysed using ACTi life software Version 6.13.12. Participants completed the LAPAQ questionnaire as they attended for study testing at baseline. Actigraph devices were also provided at this time to record PA data for the following 7 days. This means that the LAPAQ and Actigraph did not record data for the same 7 days.

4.2.3.2 Cognitive Function

Cognitive function was measured using the Montreal Cognitive Assessment (MoCA) for global cognitive function and working memory, covering the domains of visuospatial and executive function, naming, verbal memory registration and learning, attention, abstraction, delayed verbal memory, and orientation. It is a 30- item researcher administered test, with scores ranging from 0 to 30. A score of 26 or higher is considered to show normal cognitive functioning. It has been validated for use in the detection of MCI (Freitas, 2012; Nasreddine, Phillips, Bedirian, Charbonneau, Whitehead, Collin, Cummings & Chertow, 2005) in various populations such as stroke (Wu et al., 2019)and Parkinson’s disease (Hendershott et al., 2019; Hoops et al., 2009), MCI and dementia in elderly populations (Abd Razak et al., 2019). Sample questions include a clock drawing exercise and a trail making test. The full questionnaire is included in Appendix I.

Other cognitive measures that were taken as part of the NeuroExercise study were not chosen as variables in this analysis for two main reasons; i) the small sample size was insufficiently powered, and number of variables were consciously reduced to avoid increasing the risk of Type II error through multiple comparisons, and ii) the MoCA questionnaire is comprised of many elements of those same measures. For example, the trail making test and measure of verbal fluency were already included in the MoCA assessment.

4.2.3.3 Psychological health

4.2.3.3.1 Quality of Life. Health - related quality of life was measured using the 28 – item, researcher administered Quality of life for Dementia questionnaire (DemQoL) version 4, which has demonstrated validity, acceptability, and reliability in individuals with dementia (Smith, Lamping, Banerjee, Harwood, Foley, Smith, Cook, Murray, Prince & Levin, 2005) and MCI (Ni Mhaolain et al, 2012). In the current study, the Cronbach alpha coefficient was .89. Questions are scored on a 4 – point Likert scale. Higher scores indicating better health related quality of life. A sample question is "In the past week, how often have you felt anxious?," with responses ranging from "a lot" to "not at all." (See Appendix J).

4.2.3.3.2 Depression. Depression was measured using the Centre for Epidemiologic Studies Depression scales (CES- D) , a 20 - item researcher administered questionnaire measuring symptomatic depression (Radloff, 1977) that has been validated as a screening instrument in older adults (Irwin et al., 1999). In this current study, the Cronbach alpha coefficient was .79. It is scored on a 4 – point Likert scale, with a score of 16 or over indicating presence of depression. A sample statement regarding participants feelings in the preceding week was "In the past week I was bothered by things that usually don't bother me," and that can be rated as "rarely or none of the time," "some, or a little of the time," "occasionally, or a moderate amount of the time" or "all of the time". The full questionnaire is presented in Appendix K.

4.2.3.4 Physical Health

4.2.3.4.1 Number of Medications. Number of medications was used as a proxy measure of chronic illness. In the current study, all medications taken regularly were recorded by researchers and medication counts performed, excluding vitamin supplements, over the counter eye and nasal drops and herbal treatments as per previous studies (Agostini et al., 2004). This method has been previously used in individuals with MCI to measure presence of chronic illness (Rovner et al., 2016).

4.2.3.4.2 Physical Frailty. Measurement of handgrip strength is a reliable proxy measure for overall muscle strength (Bohannon et al., 2012). It has been shown to have predictive value as a measure of all – cause and disease specific mortality and future function and has utility as a means of identifying older adults at risk of poor health status (Bohannon, 2019). It was used here to indicate frailty status using a Jamar Digital Dynamometer.

4.2.4 Sample

This was a secondary analysis of NeuroExercise RCT data. The NeuroExercise study had an intended sample size of n= 75 calculated for the purpose of investigating the effects of an intensive exercise intervention on the progression of MCI. The estimated effect size for that study was 0.4 and was derived from previous studies examining the effect of PA on cognitive function in individuals with MCI (Devenney et al, 2017). This study`s sample size was n= 62. Power calculations using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) shows that the sample size needed (assuming an alpha value of .05 and estimated medium effect size of 0.15) for this study to be sufficiently powered is n = 166. Therefore, by these parameters this study may have been underpowered for testing the main hypotheses of this current study.

Participants were recruited from the community, and via memory clinics. Memory clinic participants were approached by the study principal investigator on presentation for check- ups at St. James`s Hospital, Dublin, or by their primary physician at presentation to other community memory clinics. Community recruitment took place via newspaper advertisement and community group newsletters. A visual inspection of means confirmed there was no significant difference in level of cognitive function or any other variables between participants recruited from memory clinics and from community recruitment drives. Further inspection of scatterplots indicated that there was no linear association between recruitment source and PA engagement or level of cognitive function (Figure A1, Appendix L). Therefore, recruitment source was not included as a variable in any further analyses.

4.2.5 Missing Data

Missing data was identified using the Frequencies option in SPSS. Overall, missingness was low: two participants failed to complete the CES- D, one was unable to complete the handgrip left measure, two were unable to complete the handgrip right measure and ten participants failed to supply Actigraph data. Little’s (1998) test of Missingness Completely at Random was not significant, $x2$ = 105.82 , DF = 101 , p = .352, therefore it was determined that the missingness of data was unrelated to any other variables and was treated as missing at random. Table 9 provides an overview of all missing data. A pairwise method of deletion was used to best preserve the available data and not further detract from the statistical power of the analysis. Pairwise deletion means that only data relating to each pair of missing variables is excluded from analysis rather than excluding the entire case.

Table 9.

Overview of Missing Data

Missing Data (Total number of cases: 62)	n (%)	%
CES- D	3	4.8
DemQol	0	0
MoCA	0	0
Age at screening	0	0
LAPAQ	0	0
Actigraph	10	16.1
Years of education	0	0
Handgrip	2	3.2
Number of medications	2	3.2

4.2.6 Statistical Analysis

Data was analysed using SPSS V.25. Descriptive statistics were used to describe the distribution of the data. Kolmogorov – Smirnov values were inspected to assess normality of the distribution of scores (Table A3, Appendix M).

Boxplots were inspected for the presence of outliers. Age, years of education and number of medications had one outlier each, which on closer inspection was retained as the outstanding values did not lie outside of expected ranges PA engagement as measured using the LAPAQ had two outliers, which were also not removed from the dataset as closer inspection showed that they fell within normal expected ranges. Further inspection of the trimmed means for these variables showed that the values were not too dissimilar from the remaining distributions. Boxplots for age, years of education, number of medications and the LAPAQ are presented in Appendix N (Figures A2 – A5). Inspection of scatterplots was conducted to test for linearity between the IV`s and the DVs of interest (Appendix O, Figure A6 & Appendix P, Figure A7).

In terms of inferential statistics, to address sub - objective 1.1, hierarchical linear regression analyses were used to explore associations between independent and dependent variables. Two regressions were conducted, one using the LAPAQ physical activity questionnaire as the dependent variable and the other, the Actigraph accelerometer data. The MoCA was the main independent variable, and demographic (age, years of education), physical (handgrip strength, number of medications) and psychological health (CES – D, DemQol) variables were entered as covariates in separate blocks in a hierarchical approach to assess the individual contributions of these variables and the contributions of these variables as domain constructs.

To address sub - objective 1.1.1, a one-sample t test was used to assess differences in means compared to recommended physical activity guidelines. Finally, to address objective 1.1.2, a Bland -Altman plot was used to analyse level of agreement between objective and subjective measures of PA engagement. This approach is useful in identifying systemic bias between measures in addition to level of agreement and can indicate whether proportional bias exists. Proportional bias is when one method gives values that are either lower or higher than the other in an amount that is proportional to the average values of the variable under assessment. Alpha level was set at .005 following Bonferroni adjustment for ten multiple comparisons.

4.3 Results

4.3.1 Descriptive Statistics

Variables that met the assumptions of normality were LAPAQ scores, age, years of education, handgrip strength scores, CES -D scores, and DemQoL scores. Variables that violated the assumptions of normality were number of medications, MoCA and Actigraph scores.

The majority of participants had 13 or more years of education (59.4%). The average years of education in the Irish population is 12 (Kearney et al., 2011). Participants had a mean age of 70.53 (*SD* = 6.34), and a median MoCA score of 23 (*IQR*: 20,24). A score of 26 or above is considered cognitively normal. The sample was 53.2% female (33 women). The mean amount of PA engaged in per week were 51.72 (*SD* = 22.82) (LAPAQ) and 111 (*SD* = 94.30) (Actigraph data). The mean handgrip score was 35.36 (*SD* = 7.96) for men and 20.92 (*SD* = 5.62) for women. The mean depression score was 10.14 (*SD* = 6.21). A score of 16 or higher indicates depressive symptomology. The mean score for quality of life was 92.48 (*SD* = 10.42). The mean number of medications was 3.61 (*SD* = 2.46). The average number of medications for Irish adults over 50 is 2.35 (Peklar et al., 2017). Means, medians, standard deviations and interquartile ranges are presented in Table 10, with normative data where available. Frequencies for all variables are presented in Appendix Q (Tables A4 – A11).

Scatterplot matrices were created to explore the linearity between each DV and the IVs. Bar charts were used to inspect potential patterns in each IV across the categorical IVs (gender, recruitment source). Visual inspection showed scores were similar when stratified. Bar charts are presented in Appendices R (Figure A8) and S (Figure A9).

Table 10.

Means, Medians, Standard Deviations & Interquartile Ranges for Study Variables

Current study							Normative values			
Variable	*Md* (*IQR*)	*M* (*SD*)	Range					*M* (*SD*)		
			Min	Max						
Recruitment source										
Memory clinic	36									
Community	26									
Age in years	71 (IQR: 67, 75)	70.53 (6.339)	54	84						
Years of education	13 (IQR: 11, 15)	13.34 (3.188)	7	22						
MoCA	23 (IQR: 20, 24)	22.27 (2.504)	18	26				24.6 (3.2)****		
PA in minutes per week									%	
LAPAQ	47.25 (IQR: 35.88, 64.88)	51.72 (22.82)	14	111	0% ≥ 150 mins	100% <150 mins			28% ≥ 150 **	72% <150 mins**
Actigraph	75 (IQR: 23.25, 178.75)	111 (94.30)	0	353	34.62% ≥ 150 min	64.38% <150 min				
Handgrip males (in Kg)	34.80 (IQR: 29.6, 42.03)	35.36 (7.96)	20	48			Males <173cm	31.8 (6.7)****		
							Males > 173cm	36.1 (7.1)****		
Handgrip females (in kg)	20.85 (IQR: 16.97, 25.28)	20.92 (5.62)	9	32			Females < 160cm	19.1 (3.9)****		
							Females > 160cm	21.6 (4.4)****		
Number of medications	3 (IQR; 2, 5)	3.61 (2.46)	0	12				2.35 (2.55)***		
CES- D Scores	11 (IQR: 6, 14)	10.14 (6.21)	0	26				9.35 (9.13)*****		

Dementia Related Quality of Life (DemQol)	94 (IQR: 86, 100)	92.48 (10.42)	65	110

Note. *Population norms for educational attainment of Irish adults derived from TILDA data (Kearney et al., 2011). ** % of Irish adults aged 70 – 74 years achieving 150 minutes of PA per week derived from TILDA data recorded using the IPAQ physical activity questionnaire (Murtagh et al., 2015). *** Data cited by Peklar et al. (Peklar et al., 2017) for Irish adults aged 50 years + obtained from TILDA. **** Normative muscle strength and MoCA values for adults 70 years + derived from TILDA data stratified by height (Kenny et al., 2013). ***** Population norms for Australian adults aged 25 – 90 years (Crawford et al., 2011).

4.3.2 Sub - Objective 1.1

4.3.2.1 Hierarchical Regression for Outcome 1; LAPAQ Scores.

Hierarchical multiple regression was used to analyse the relationship between the outcome measure of minutes of PA per week (LAPAQ) and cognitive function (MoCA) controlling for covariates and to assess the relevant contribution of each block of independent variables. Based on inspection of scatterplots, the variables of age, years of education (Block 1), number of medications and muscle strength (handgrip) (block 2) , depression (CES – D) and quality of life (DemQoL) (Block 3) satisfied the assumption of linearity and were used as covariates in this analysis. The MoCA was entered in Block 4. Due to multicollinearity between the variables of handgrip left and handgrip right, one value relating to dominant handedness was used in the model. Alpha level was set at .005 following Bonferroni correction for multiple comparisons in both regressions.

The model as a whole was not statistically significant *R2* = .09, Adjusted *R2* = -. 03, *F change* (7, 49) = 2.16, *p* = . 661. No individual variables made a statistically significant contribution to the outcome of PA. Age (*Beta* = -.53, *p* = .276) and years of education (*Beta* = .760, *p* = .431) (model 1) explained 4 % of the variance in PA, *R2* = .04 , Adjusted *R2* = -.00, *F* change (2, 54) =. 98 , *p* = . 384. Number of medications (*Beta* = -.104, *p* = .939) and handgrip (*Beta* = -.112, *p* = .738) (model 2) explained 4% of the variance in the outcome, *R2* = .04 , Adjusted *R2* = -. 04 , *F change* (4, 52) = .07, *p* = .732. Model 3 which included quality of life (*Beta* = -.23, *p* = .571) and depression (*Beta* = -.63, *p* = .378) explained was 5%, *R2* = .05, Adjusted *R2* = -. 06, *F change* (6, 50) = .41, *p* = .675. When cognitive function was added to the model in Block 4 the total variance explained by the model was 9%, *R2* = .09, Adjusted *R2* = -. 04, *F change* (7, 49) = 2.16, *p* = .661. Regression coefficients are presented in Table 11.

Table 11.

Hierarchical Regression for Self – Reported Physical Activity (LAPAQ)

	Model 1					Model 2					Model 3					Model 4				
Variable	*B*	*SE B*	*β*	*t*	*p*	*B*	*SE B*	*β*	*t*	*p*	*B*	*SE B*	*β*	*t*	*p*	*B*	*SE B*	*β*	*t*	*p*
Age	-.53	.48	-.15	-1.10	.28	-.54	.52	-.15	-1.04	.30	-.45	.53	-.12	-.84	-.45	-.60	.54	-.17	-1.12	.27
Years of education	.76	.96	.11	.79	.43	.85	1.01	.12	.84	.41	.65	1.05	.09	.62	.6	.93	1.06	.13	.88	.38
Handgrip						-.11	.33	-.05	-.34	.74	-.12	.34	-.05	-.36	-.121	-.02	.34	-.01	-.06	.95
Number of medications						-.10	1.34	-.01	-.08	.94	.11	1.39	.01	.08	.11	.54	1.41	.06	.38	.71
Depression											-.63	.70	-.17	-.89	.38	-.79	.70	-.22	-1.12	.27
Quality of life											-.23	.39	-.10	-.57	-.23	-.22	.39	-.10	-.57	.57
MoCA																-2.06	1.40	-.23	-1.47	.15
R2	.04					.04					.05					.09				
F for change in R2	.98					.07					.39					2.16				

Note. **p* = < .005

4.3.2.2 Hierarchical Regression for Outcome 2; Actigraph Scores.

A second hierarchical regression was conducted for outcome 2 (Actigraph scores of PA minutes) and global cognitive function (MoCA). Based on inspection of scatterplots, the variables of age, years of education (Block 1), number of medications and muscle strength (handgrip) (block 2) , depression (CES – D) and quality of life (DemQoL) (Block 3) satisfied the assumption of linearity and were used as covariates in this analysis. The MoCA was entered in Block 4.

The model as a whole was not statistically significant $R2$ = .19, Adjusted $R2$ = .05, F *change* (7, 41) = 2.50, p = . 24). No independent variables made a statistically significant contribution to the model. Model 1 (age (*Beta* =1.27, p = .56) and years of education (*Beta*= -1.19, p =.79)) accounted for .9 % of the variance in physical activity $R2$ = .01 , Adjusted $R2$ = -.03, F change (2, 46) = .21 , p = . 81. Model 2 (number of medications (*Beta* =-12.62, p = .04) and handgrip (*Beta* =.24, p = .87)) accounted for 11%, $R2$ = .11 , Adjusted $R2$ = .03 , *F change* (4, 44) = 2.41, p = .28. Model 3 (quality of life (*Beta* = 1.66, p = .34) and depression (*Beta* = 3.90, p = .20)) explained 14%, $R2$ = .14, Adjusted $R2$ = .20, *F change* (6, 42) = .86, p = .34. After the entry of the MoCA in model 4 (*Beta* = -9.37, p = .13) the total variance explained by the model as a whole was 19%, $R2$ = .19, Adjusted $R2$ = .05, *F change* (7, 41) = 2.46, p = .24. Regression coefficients are presented in Table 12.

Table 12.

Hierarchical Regression for Objectively Measured Physical Activity (Actigraph)

		Model 1					Model 2					Model 3					Model 4			
Variable	*B*	*SE B*	*β*	*t*	*p*	*B*	*SE B*	*β*	*t*	*p*	*B*	*SE B*	*β*	*t*	*p*	*B*	*SE B*	*β*	*t*	*p*
Age	1.27	2.19	.09	.58	.56	2.62	2.23	.18	1.14	.25	2.08	2.28	.14	.91	.37	1.37	2.29	.09	.59	.55
Years of education	-1.19	4.35	-.04	-.27	.79	-1.28	4.36	-.04	-.30	.77	-.17	4.51	-.01	-.04	.97	1.12	4.51	.04	.25	.81
Handgrip						.23	1.44	.03	.16	.87	.33	1.46	.04	.23	.82	.79	1.47	.08	.54	.59
Number of medications						-12.62	5.81	-.33	-2.17	.04	-13.78	5.98	-.36	-2.31	.03	-11.84	6.01	-.31	-1.97	.05
Quality of life											1.66	1.70	.18	.98	.34	1.67	1.67	.18	.99	.33
Depression											3.90	3.01	.26	1.29	.20	3.15	2.99	.21	1.05	.30
MoCA																-9.37	5.98	-.25	-1.57	.12
R2	.01					.11					.14					.19				
F for change in R2	.22					2.42					.86					2.46				

Note. **p* = < .005

4.3.3 Sub - Objective 1.1.1

4.3.3.1 Levels of PA Engagement in Relation to Global PA Guidelines

The mean minutes of PA per week were 51. 72 (+/-*SD* = 22.82) for the LAPAQ and 111 (*SD* = 94.30). for the Actigraph. Frequency data shows that 29% of participants achieved 150 minutes or greater of PA engagement per week according to Actigraph data versus 0% of participants according to LAPAQ data. The LAPAQ data shows that no participants reported engaging in greater than 112.5 minutes of PA per week, whereas the highest level of engagement according to the Actigraph was 353 minutes per week. Frequencies for the LAPAQ and Actigraph data are presented in Table 13.

Table 13.

Frequencies of PA Minutes Per Week Using Actigraph and LAPAQ data

	Actigraph		LAPAQ	
Minutes per week	N	%	N	%
0 -37.5 mins	15	24.2	18	29.5
37.6 - 75 mins	12	19.4	35	57.4
75.6 - 112.5 mins	1	1.6	8	13.1
112.6 - 150 mins	6	9.7	0	0
150 + mins	18	29	0	0
Total	52	83.9	61	100
Missing	10	16.1	1	1.6
Total	62	100	62	100

A One – Sample t Test setting Alpha level at showed that levels of PA engagement differed significantly from the recommended guidelines of 150 minutes per week (*M* = 111.38, *SD*= 94.29) as recorded using the Actigraph (t (51) = -2.95, p = .005), and the LAPAQ questionnaire (*M* = 51.70, *SD* = 22.80), t (61) = -33.94, p = < .001). Table 14 presents descriptive statistics for participants who achieved recommended levels of PA per week versus those who did not as measured using Actigraph data.

Table 14.

Means for Independent Variables Stratified by Physical Activity Level using Actigraph Data

		Inactive (<150 mins)			Active (≥ 150 mins)	
Variable	N	Mean	SD	N	Mean	SD
MoCA	34	22.97	2.15	18	21.28	2.65
Age	34	70.32	6.42	18	71.72	6.04
Years of education	34	13.56	3.21	18	13.5	2.81
Number of medications	33	4.27	2.52	18	2.83	2.20
Handgrip	33	28.3	11.22	18	26.62	8.59
CES – D	32	10.06	6.65	17	9.65	6.86
DemQol	34	92.35	10.97	18	94.83	8.63

Note. *Active denotes activity levels of 150 minutes or greater of PA per week. Table represents n = 52 participants accounting for 10 missing cases of Actigraph data.

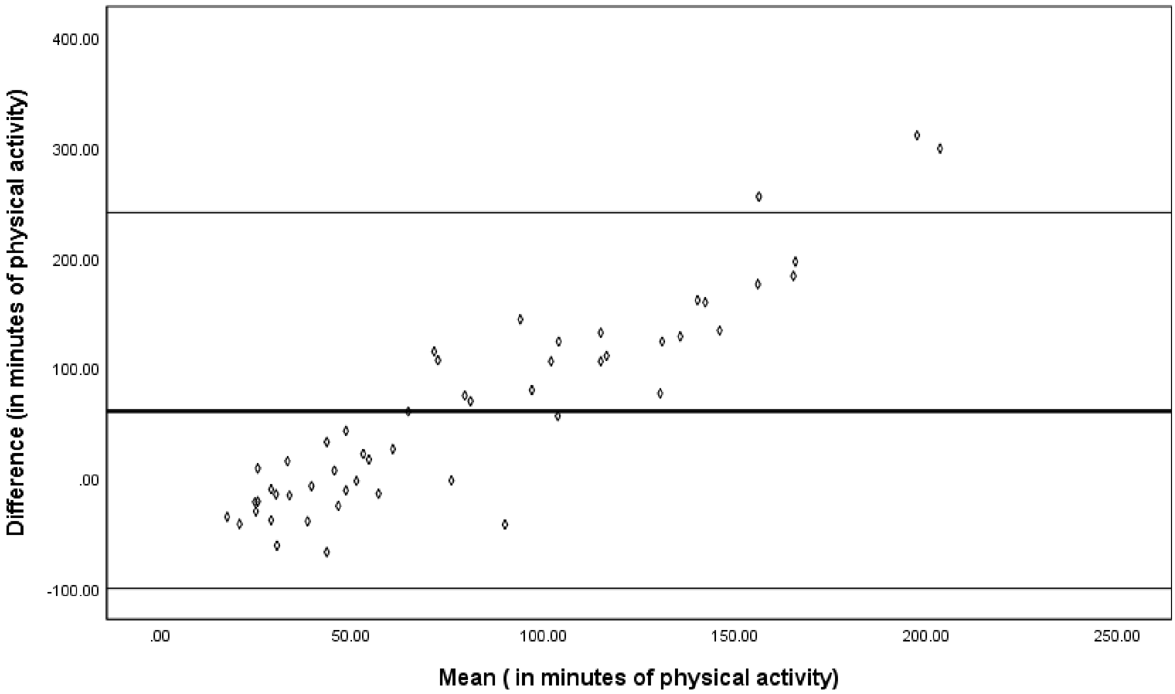
4.3.4 Sub - Objective 1.1.3: Assessment of the Relationship and Level of Agreement in Levels of PA Engagement Between Subjective (LAPAQ Physical Activity Questionnaire) and Objective (Actigraph).

The Spearman rho correlation coefficient was used to assess the level of agreement between measures. Preliminary analyses were performed to ensure no violation of the assumptions of linearity and homoscedasticity (Appendix T, Figure A10). There was a medium positive correlation between variables (r = .33 , n = 52 , p = .015) indicating a moderate level of agreement between the LAPAQ questionnaire and the Actigraph.

A Bland - Altman scatterplot (Bland & Altman, 1986) was generated to further investigate the level of agreement between measures of PA engagement (Figure 5.). In a Bland – Altman analysis the X – axis represents that average and the Y – axis represents the difference between two measurements. The scatterplot shows that the limits of agreement expressed using 95% confidence intervals were wide (240.84, -118.98), indicating that measures were not equivalent. Proportional bias shows the relationship between discrepancies between measured values and true values, with the presence of proportional bias indicating that the measures do not agree through the range of measurement. A simple linear regression showed the presence of proportional bias (*M* = 1.68, *SD* = 35. 97), indicating a high level of disagreement between measures (*R2* = .85, *p* = < .001). A one sample t- test was used to demonstrate the mean bias between measures, where 0 indicates an ideal level of agreement between measures. In this case, analysis showed that the mean difference was not close to zero (*M*= 60.93, *SD* = 91.79) indicating the presence of bias and demonstrating a large level of difference between measures.

Figure 5.

Bland – Altman Scatterplot of Agreement Between Actigraph and LAPAQ Measures of Physical Activity



4.4 Discussion

The objectives of this study were to analyse the relationship between cognitive function and PA engagement in individuals with MCI and to assess the relative contribution of covariates. In addition, this study aimed to describe levels of PA engagement in an Irish cohort of individuals with MCI relative to global PA guidelines, and to assess the level of agreement between objective and subjective PA data.

Global cognitive function was not found to be associated with level of PA engagement in this study, even after controlling for demographic, physical and psychological covariates. A high proportion of participants of this study were not sufficiently physically active in accordance with

PA guidelines, with 71% not achieving the recommended weekly levels of PA. Although there was a moderate positive correlation between objective and subjective measures of PA in this sample, Bland – Altman analysis showed that there was a high level of disagreement between PA as measured using the Actigraph accelerometer and the LAPAQ physical activity questionnaire.

It was hypothesised that cognitive function would be positively associated with the outcome of PA engagement after controlling for these covariates. This study found no associations as measured using either the Actigraph or LAPAQ, therefore we fail to reject the null hypothesis. However, beta coefficients suggest a high level of variance in cognitive function in both regressions after controlling for covariates, albeit higher in regression two where the outcome was objectively measured. This is also true of number of medications where the beta value was high in models two, three and four in regression two using Actigraph data. These findings are unexpected, as previous studies have reported a positive association between cognitive function, stage of MCI and PA engagement in MCI populations (Kobayashi et al., 2016; Stuckenschneider et al., 2018; Vancampfort et al., 2018). In comparison to these previous studies, the sample used was smaller (n = 62) whereas sample sizes in previous studies have ranged from 121 participants (Stuckenschneider et al., 2018) to 4,854 participants (Vancampfort et al., 2018). The small sample size and lack of statistical power may account for the lack of a significant association in this case. It is also generally accepted that correcting for multiple comparisons, while reducing risk of type I error, can inflate the risk of type II error in small data sets (Biau et al., 2008; Knudson & Lindsey, 2014; Perneger, 1998) and it is possible that these issues may have influenced this finding. Levels of PA engagement were also relatively low in this sample which may serve to mask any effects in the data. Further research in larger samples of Irish individuals with MCI is needed to overcome this limitation.

It was also hypothesised that levels of PA engagement would be below 150 minutes per week. Both subjective and objective measures of PA confirm that participants of this study did not achieve the recommended 150 minutes of PA per week. 29% of participants as recorded objectively (18/ 52 available objectively recorded cases) and 0% of participants as measured subjectively (0/62 self-reported questionnaires) achieved the recommended levels of PA. Therefore, in this case we reject the null hypothesis. This finding is in contrast with previous MCI studies, which report low/ no physical activity (< 150 minutes per week) in between 20 – 27 % of individuals with MCI (Rovner et al., 2016; Vancampfort et al., 2018), and another which reported mean PA levels of between 164 – 270 minutes of PA per day (Stuckenschneider et al., 2018). The latter study was conducted among German individuals with MCI and was one of the three sites which contributed to the NeuroExercise study, the Irish arm of which was used as the sample for this current study. In the study by Stuckenschnieder and colleagues the average level of daily activity measured using the LAPAQ far exceeded the levels achieved in our sample who had similar MoCA scores (*M* = 24 in Stuckenschnieder et al. versus *M* = 23 in this current study) and age (*M* = 72.6, *SD* = 6.3), although minutes of PA was not measured objectively in that instance to verify the validity of the LAPAQ in that sample. It is possible that PA engagement was overestimated when measured subjectively in that sample. The study setting may have influenced the differences in self – reported PA engagement in the study by Stuckenschneider et al., and socially desirable responding may have occurred. For instance, this current study took place in a clinical setting (St James`s Hospital, Dublin) compared with a sports orientated setting (The German Sports University, Cologne), possibly priming participants to positively respond to questions regarding PA. Our findings indicate that PA engagement in this sample of Irish individuals with MCI is much lower than in previously sampled MCI cohorts in other countries. However, PA engagement in Irish adults in general has also been found to be low. Murtagh et al. (2015) report that 62% of cognitively healthy Irish adults do not engage in 150 minutes of PA per week and this is supported by a recent report which stated 67% of Irish adults over 18 years are insufficiently active (achieving < 150 minutes per week) (WHO, 2018). It may be the case that the low level of PA engagement seen in this study is reflective of normative population values among Irish adults. Studies of global levels of PA broken down by region confirm that Irish adults are less physically active than their European (35% are inactive), American (43%), African (28%) and Southeast Asian (17%) counterparts (Hallal et al., 2012). As low levels of PA has been shown to account for 2% in the population attributable risk for development of dementia (Livingston et al., 2020) and exercise has been found to help support brain health in individuals with MCI (Gomes-Osman et al., 2018; Lautenschlager et al., 2019) and may reduce the risk of progression to dementia (Gallaway et al., 2017), this demonstrates a potential area for improvement in public health initiatives designed to address and promote brain health in ageing.

It was hypothesised that there would be significant differences between objective and subjective measures of PA in individuals with MCI. Although correlational analysis showed a significant association between the measures, assessment of levels of bias and agreement indicated the presence of a high level of bias and lack of agreement between the two, suggesting an overall lack of convergent validity and resulting in a rejection of the null hypothesis. The Bland Altman scatterplot shows that there is a trend toward the difference between measures decreasing as the mean values get higher, suggesting that at lower levels of PA engagement there is less disagreement between measures. The level of variability of data points in the centre of the graph would also suggest this is the case. These findings may be due to the fact that the maximum value of the LAPAQ recorded was far below that recorded objectively. It may also suggest that participants in this sample under – estimated the level of PA that they engaged in or did not accurately recall past activity. This is in contrast with previous research in cognitively healthy older adults which found the LAPAQ questionnaire to be valid and reliable (Harris et al., 2009; Stel et al., 2004) and shown reliability between objective and self – report measures of PA (Durante & Ainsworth, 1996; Helmerhorst et al., 2012; Kowalski et al., 2012; Skender et al., 2015). However, it is in line with one study in cognitively impaired adults which found that self – reported PA data is prone to underestimation in this cohort (Siebeling et al., 2012). Considering the internal reliability of the LAPAQ was low in this sample, and that previous studies of PA in Irish samples, in addition to previous reports of PA engagement in MCI cohorts, were more consistent with the findings of levels of PA engagement as recorded via Actigraph (30%), it is likely that objective measures of PA engagement are more accurate in this case. It may be that participants had difficulty in accurately recalling past PA engagement as required by the LAPAQ, but it may also be the case that there were inherent differences in the units of measurement. For example, the Actigraph records all bouts of sustained activity of 10 - minute durations or longer, whereas the LAPAQ recorded activity in terms of specific tasks and estimates of time spent in these tasks which may not have considered time spent in PA which did not conform to these specified areas.

4.5 Limitations

This study may have been limited by two factors. Firstly, the sample size used for analysis was small (n = 62) which both increased the risk of Type II error and reduced statistical power. Secondly, the slight variation in how PA was recorded in this sample may have impacted the outcome. Participants were supplied with an accelerometer after completing the PA recall questionnaire, meaning that LAPAQ and Actigraph data do not capture the same time period. Also, the application of the LAPAQ prior to the participant receiving the Actigraph may have primed participants favourably toward PA behaviour. Skender et al. (2015) suggest that wearing an accelerometer may promote PA through increasing participant motivation.

4.6 Conclusions

In conclusion, the results of this study were unable to support a relationship between cognitive function and demographic, physical and psychological variables, and the outcome of PA engagement. However, it is surmised that statistical significance in this case suffered from the lack of power and inflated risk of type II error due to the small sample size which was a limitation in this current study. It is recommended that future studies gather data from larger samples with the possible inclusion of non – impaired control groups to enable more in- depth analysis that can further elaborate on the contribution of various factors to PA engagement in MCI.

PA engagement was lower than has been reported in previous MCI studies and generally below the global PA guidelines but is in line with levels of PA in the general Irish population suggesting a population wide lack of sufficient PA in relation to the physical activity guidelines.

Finally, it was established that the LAPAQ physical activity questionnaire and the Actigraph accelerometer device do not demonstrate convergent validity in this sample, and that the LAPAQ questionnaire may result in an under – estimation of PA engagement in individuals with MCI, possibly due to inaccurate recall of past PA. Based on this finding and previous estimates of PA engagement in Irish adults, objective measurement of PA engagement may be a more reliable method of measurement in individuals with MCI, though the use of both methods may be prudent.

4.7 Chapter Summary

The objective of this chapter was to assess the relationship between cognitive, demographic, physical and psychological variables, and PA programme adherence in individuals with MCI, to describe and assess levels of PA engagement in this sample and to assess the level of agreement between self- reported and objectively recorded PA data. No variables were significantly associated with engagement, but the study was limited by a small sample size. Participants were insufficiently active relative to global PA guidelines. Self -reported and objectively recorded PA data was not convergently valid and using both modes of PA data collection is advised.

Chapter 5: An Exploration of the Barriers and Facilitators of Physical Activity Engagement in Individuals with MCI

5.1 Introduction

There is some evidence to suggest that individuals with dementia and AD are less physically active than their cognitively healthy counterparts (van Alphen et al., 2016; Watts et al., 2013). However, the reported rates of PA engagement in individuals with MCI have thus far been inconsistent and the reasons for this are not well understood. This may be because few studies have qualitatively explored the topic of PA engagement in individuals with MCI resulting in a lack of understanding of this phenomenon from the perspective of the cognitively impaired individual. Since regular PA may be beneficial for brain health in individuals with MCI (Cai & Abrahamson, 2016; Strohle et al., 2015; Zheng et al., 2016), and may also reduce the risk of dementia in later life (Livingston et al., 2020), understanding the barriers and facilitators of PA engagement in this at – risk group is key as it could help optimise PA engagement and inform intervention design, and thus help support brain health in this population.

Two previous studies have presented findings from samples which included individuals with MCI (Chong et al., 2014; van der Wardt et al., 2019). A synthesis of these two studies (see Chapter 3, section 3.3.3) identified five key themes impacting PA engagement: memory problems, self – motivation, external motivation, individualising PA, and barriers to PA. Memory problems negatively impact PA engagement, and individuals report needing reminders for engagement and support from others to account for memory deficits, and to ensure safety (i.e., needing a companion for PA). Self – motivation is associated with PA in that having positive beliefs in the social, physical, and cognitive benefits of PA was a determinant of engagement. Motivation may be enhanced through external factors, such as being encouraged to be physically active by family members, and clinicians (through the provision of information and feedback), and the social aspect of PA. Barriers to PA engagement in the current literature are health problems and disability, and environmental factors such as lacking time for PA, weather, and the quality of facilities available. Both studies concluded that PA should be individualised based on the needs and abilities (both actual and perceived) of the person.

Therefore, the current literature suggests that memory issues present a barrier to PA engagement in cognitively impaired adults, and that motivation, both self and external motivation, are key determinants. In addition, these studies suggest that cognitively impaired individuals require support and encouragement from family members and clinicians, as well as information regarding PA, to be physically active. However, there are limitations to these findings. Both studies discussed sampled individuals with MCI and dementia, and in the case of Chong et al. (2014), included non – impaired adults demonstrating that individuals with MCI are under-represented. Thus, it remains unclear what the barriers to PA are, specific to individuals with MCI as distinct from dementia. In addition, there is a lack of knowledge regarding barriers to PA engagement in a cohort of Irish adults with MCI that needs to be addressed.

This study aimed to address sub – objective 1.2 of this thesis. This was to explore the barriers and facilitators of PA engagement in a sample of Irish adults with MCI in response to the current gaps in the literature, to contribute to the overarching thesis aim of identifying the determinants of PA engagement and PA programme adherence in this group of individuals.

5.2 Methods

5.2.1 Design and Rationale

This sub– study (1.2) addressed the research questions of interest using a thematic analysis approach (Braun & Clarke, 2006) underpinned by a pragmatic philosophy. Further detail on the pragmatic paradigm is provided in Chapter 2 (2.1.2). Thematic analysis is a useful method of gathering and analysing experiential data regarding the phenomenon of interest from the participants perspective (Creswell, 2015; Ritchie, 2003.). In thematic analysis, findings remain grounded in the data, and patterns, or themes, can be used to provide an interpretation of the data (Braun & Clarke, 2006). This approach allowed for the gathering of data regarding the factors that impact on PA engagement within the context of having MCI from the participants point of view.

5.2.2 Participants and Sampling

Participants were 12 individuals with MCI (n = 5 female and 7 male) recruited from the NeuroExercise study. Participant ages ranged from 60 – 83 years (*M* = 70.8, *SD* = 6.9) with a mean MoCA score of 23.3 (*SD* = 2.5). Participants engaged in a mean of 80. 4 (SD = 74) minutes of PA per week, ranging from 14 – 213 minutes per week, measured at baseline using the Actigraph GT3X (Actigraph, Pensacola, Fl, USA). A full description of NeuroExercise is presented in Chapter 2 (2.2.1) of this thesis. Participants were eligible for inclusion if they had been randomised to the control condition of NeuroExercise, and if they consented to be interviewed following study enrolment but before randomisation occurred. Participants were excluded from the study if they had been randomised to the aerobic or stretch and tone programme conditions.

Participants were sampled using a purposive sampling approach. Purposive sampling is used in qualitative research to ensure data is collected from those with specific insight into the phenomenon under investigation (Creswell, 2015). As this sub – study aimed to gather data regarding general PA engagement in this cohort, i.e., habitual PA engagement as distinct from engagement in the NeuroExercise PA programme, this was purposively based on either participants' inclusion in the control condition of the intervention or status as having just enrolled in the study but not yet having taken part in an intervention condition. In other words, participants were selected based on not having had experience with the PA programme at the time of interview, so as to capture data related only to general PA engagement under normal daily conditions. Four participants were approached to participate in this study as they enrolled in the NeuroExercise study and were interviewed at baseline (T0) and nine participants had been randomised to the control condition and were approached to take part in this study as they presented for NeuroExercise testing at either 6 months or 12 months (T1 and T2). There were no specific criteria regarding gender or age, the latter as the requirement for age as per the NeuroExercise protocol of 50 years or over matched the criteria for this current study.

5.2.3 Recruitment

Participants of this sub - study were recruited from the NeuroExercise study between June 2017 and July 2018. Participants were briefed on the study by one researcher (LC) and invited to take part when they presented for baseline NeuroExercise assessments. Participants were provided with a Patient Information Leaflet (PIL and consent form are provided in Appendix U) outlining the study aims and detailing the role of the participant and researcher. Participants were contacted by the researcher (LC) within a few days to arrange an interview. All participants who were approached for interview consented to participate in this study.

5.2.4 Data Collection and Analysis

Semi- structured interviews took place in a private room in the Clinical Research Facility in St. James`s Hospital, Dublin, and were conducted by one researcher (LC). Participants were familiar with the location and the researcher in advance through participation in the NeuroExercise study. Written informed consent was obtained prior to commencement of each interview.

5.2.4.1 Topic Guide and Piloting

A topic guide was developed to stimulate discussion regarding factors that impact PA engagement. The topics were participants feelings about physical activity, participants experience of MCI and its impact on PA, and their level of knowledge regarding the association between brain health and physical activity. These topics were designed to facilitate the collection of inductive data as is common in grounded theory studies and so were not developed from the extant literature but based on the research aim of exploring the factors that impact PA engagement inductively. Further detail on the change from the Grounded Theory methodology is provided in Chapter 2 (2.2.7). The topic guide was piloted prior to data collection and amended based on feedback from one lay person and two research colleagues. The topic guide is presented in Appendix V.

5.2.4.2 Interview Process

Interviews took place between June 2017 and August 2018. Interviews were scheduled for within one week of baseline NeuroExercise assessment if participants enrolled in the study during that period, or within one week of the 6- or 12-month assessments in the case of participants who were currently enrolled in the intervention control condition during that time. Participants were advised that interviews may last up to 1 hour. The average interview time was 30 minutes (between 21 and 45 minutes). All interviews were conducted, audio recorded and later transcribed verbatim by one researcher (LC). Typically, only the interviewer and participant were present for the interview, with the exception of one case where a spouse observed. Participants were interviewed once.

5.2.4.3 Analysis Strategy

Analysis followed the approach to thematic analysis laid out by Braun and Clarke (Braun & Clarke, 2006). This approach includes the 6 phases of familiarisation, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and writing the analysis. A "code" is the term used here to denote labels that identify a feature of the data that is interesting (Boyatzis, 1998) and "theme" refers to the label given to patterns of meaning across the dataset, i.e., clustering similar codes together (Braun & Clarke, 2006). Data was analysed at the semantic level. A semantic approach identifies themes within the explicit data, whereas latent analysis goes further to theorise on the underlying causes that are hypothesised to "shape" the semantic content (Braun & Clarke, 2006).

The processes of searching for associations and patterns across cases (i.e., participants), searching for associations between phenomena within cases, and searching for associations in phenomena between groups of cases were carried out iteratively throughout analysis to ensure veracity of findings, and that they remained grounded in the data (Ritchie, 2003). Cases were grouped on the basis of age, gender, level of cognitive impairment (MoCA), level of PA engagement and frailty (grip strength). Analysis was performed using the qualitative data analysis software package NVivo version 12.

Coding was conducted by one researcher (LC) and reviewed by a second researcher (AW). Transcription and initial reading of transcripts facilitated familiarisation. Line- by – line coding of the full dataset was conducted to capture potential codes (i.e., generating initial codes). Data was labelled and sorted based on similarity of content using in vivo code labels derived from the data as code descriptors (i.e., searching for themes). Examples of initial line by line coding is presented in Table A12, Appendix W. Early themes were used to develop a coding matrix to enable interrogation and comparisons of patterns within cases and across different cases, and through case classifications to examine patterns and associations within and between cases (i.e., reviewing themes). For example, early themes and codes were entered into an excel spreadsheet and examined for each participant to analyse the range and depth of themes. An example of early theme development is provided in Table A13, Appendix X. Cases were classified according to level of MCI (MoCA), and level of PA engagement (Actigraph) based on the focus of the research question under investigation. Themes were adjusted as needed and tested against coding indices to ensure that themes and codes were robust and representative of the data (i.e., defining themes and naming themes). Finally, detailed accounts were written for themes and codes to ensure they were coherent, easily understandable and fitted with the narrative of the data. The thematic analysis process was guided by Braun and Clarkes 15 – point checklist of criteria (Braun & Clarke, 2006). This checklist ensures the quality of the analysis by ensuring rigour is maintained in data transcription, coding, analysis, and the written report. This checklist has been provided in Appendix Y (Table A14).

5.2.4.4 Data Saturation

Data saturation, the cessation of data collection (Garrett et al., 2012), was determined when it was thought that "informational redundancy" (Sandelowski, 1995) had been achieved, meaning that no additional insights were being provided. To this end, saturation occurred following 11 interviews, and data collection ceased once 13 interviews had been completed.

5.3 Findings

Two main themes were developed. These were barriers and motivators for PA engagement. Themes, sub – themes and codes are presented in Table 15.

Table 15.

Table of Themes, Sub – themes and Codes

Theme	Sub – theme	Code
Barriers	Physical barriers	Physical capability
		Injury
	Cognitive barriers	Memory issues
	Practical barriers	Lack of time
		Weather

	Knowledge	Cognitive benefits
		Ways of maintaining cognitive function
Motivators	Enjoyment	Social aspect
		Being outdoors
		Goal/ purpose
		Defining physical activity
		Acceptable pace
	Health	Physical health
		Psychological health

5.3.1 Barriers to Physical Activity Engagement

Barriers to engagement with PA were practical, physical, or cognitive in nature and a lack of knowledge regarding PA. Practical barriers include bad weather and lack of time for PA. Physical barriers were physical ability, including injury. Cognitive barriers were memory issues.

5.3.1.1 Physical Barriers

5.3.1.1.1 Physical Capability. Some participants spoke about noticing physical decline that has resulted in them "slowing down". This physical decline and need to regulate pace was thought of as a natural consequence of ageing. This suggests a level of acceptance of decline as it was felt by some that it was just a by - product of getting older.

"I suppose I didn't occur to me because I knew I was getting forgetful, but I said "I`m getting older too", you know, and that's the reason." 019.

Some participants referred to the fact that they are "on the way out", meaning that they felt that due to advancing age it was too late for them to meaningfully engage in PA to offset physical decline. Instead, they chose to regulate their activity and pace to account for this slowing down necessitated by advancing age. As a result, some participants felt that they were happy to be less physically active to meet this slowing down.

“Well, I find I`ve got a lot slower, but I regulate what I do to the pace I can keep, and I just do that bit…”. 057.

This is supported by 020 when they speak about their partner feeling that at their age they should be "just sitting now", a sentiment the participant shared until they recently learned more about the benefits of being physically active at any age. Older age was mentioned by some participants as a barrier to engaging in their preferred physical activities, even where injury was not present.

“To a certain extent, yeah, those kinds of activities (playing football) did, yeah…because when I got so old… there too old… I didn’t even want to go to a match anymore. I`d watch… prefer to watch it on the television. Too lazy, you know…”. 062.

“I`ve played doubles in tennis maybe, but… no, I don’t think I would, no. I don’t know if anybody would want me on a team. I mean, I wouldn’t want to be on a team with geriatrics either, you know?” 045.

This may limit participants in the amount and type of PA that they engage in, as they feel they cannot do what they prefer to do or are interested in. For example, 045 would like to play team sports but feels that their age is a barrier to it as others would not want him on their team, the sense being that as he is older he would not be useful to them.

5.3.1.1.2 Injury. A key practical barrier to PA engagement in this sample was participants reporting that they were suffering from injury. Participants` reported being limited in their ability to either be physically active or limited in how they are physically active because of injury. Pain, such as back pain or knee pain may also determine how intensely participants can exercise and what types of activity they can do. For example, participant 062 decided to give up the activity they preferred doing (tennis) because of tight hamstrings, and never found an acceptable replacement activity to engage in.

“Ah my knees get me after a while, you know, so…oh I have a little trouble with my toes, they get very sore at times, and the knees of course, but I manage… I manage grand.” 039.

In addition, some participants reported having many different ailments concurrently which posed barriers to PA. For example, participant 039 has a number of injuries that limit the type and duration of PA they engage in, as does participant 062. Participant 012 also has many injuries such as hearing and vision problems, an Achilles injury, and a hammer toe which can make walking painful, thus limiting their ability to engage in PA, and precluding them from activities which they previously engaged in.

“I`d do certain exercises every day without fail, but then what happened… I got this problem in my arm, and it spread to other parts of my body…. The ear as well, and as a result of that I had to stop for a while and… I`m trying to get back onto it now again but that’s… good few weeks now without doing the exercises properly, I used to do before…” 062.

In contrast, some participants reported few injuries or illnesses that impact on PA engagement. Participant 014 reported having no ailments that would limit PA engagement, and this participant was very physically active. However, this participant spoke about not liking exercising in a gym atmosphere for fear of becoming injured from using equipment they were not familiar with, thus fearing injury was a concern. In addition to injury, illness may also prevent engagement in PA. For example, 045 spoke about having depression and the negative impact this had on their ability to engage in PA through low motivation.

“I didn’t think they gave too much… very much attention to me on the machines and I reckon I could have been doing myself an injury because I really didn’t know what I was supposed to be doing on them, nor did I even know what it was supposed to be doing for me, the actual machine, no one quite explained. They sort of said that’s how you do it and that was about it. And eh… so from that point of view, I never got a good feeling when I left that (the gym).” 014.

“ Since (partner) died I`m doing very little. I… I was doing very little and it`s increasing, so, you know, I`ll get back into it again, but I just haven’t had the… just haven’t had the Oomph to do it, you know. I have had to get out and walk, and get relatively well that way, but not to do the other things and … you`re meeting new people and that’s ok, but I`m just not… I`m just not there yet, you know?.” 045.

These excerpts suggest that being injured or ill (including psychologically), as well as fearing injury may impact the types of activities and ways in which participants chose to be physically active, choosing safe and familiar activities instead.

5.3.1.2 Cognitive Barriers

5.3.1.2.1 Memory Issues. Though some participants report expecting and accepting cognitive decline, many describe their reactions to having MCI in terms of being worried about the future, being self – conscious, feeling awkward in social situations due to forgetting words or trains of thought, and feeling psychological upset or depression because of their cognitive impairment.

"Now, as I said that bothers me. Sometimes I feel people are looking at me, you know, because I go to say something and the words aren't coming or ….It doesn't embarrass me with my family, and it doesn't embarrass me with my two close friends but as I said, if I was in a group of people I suppose my confidence would go down there. I`d be afraid to say something in case the words would come wrong, or I do find sometimes… some days my speech is fine and other days it isn't. Em… if I'm tired at all I'm finished (laughs). So that's that, but em… I don't dwell on it… em…. I don't… you know, just in the moment when it happens I`d be self- conscious." 058.

For the most part, participants reported experiencing symptoms of MCI in terms of forgetting names or other incidental information, with most participants considering that this level of impairment did not negatively impact on PA engagement.

"But I was worried about it myself for a while because I have difficulty remembering things that I normally would. But basically, it`s myself all along. I knew there was a problem of some description, you know…… and this thing here has affected me to some extent, but I should be able to do my exercises, no I will, I`m going to do them one way or another." 062.

However, there were cases where participants did find that memory impairment negatively impacted PA engagement. This manifested in an inability to remember to perform planned PA. One participant spoke about implementing reminders for themselves, but then forgetting to check their reminders and still forgetting regardless.

"Now, that's because I haven't been doing the exercises but for…. I don't seem to have the energy, you know, or the concentration, you know, to wake up and say, "oh I must do my exercises now", you know, and they just go. I don't remember them. We`ll even put a note up, you know that I`ll see it and I`m doing something else, and I`ll go "oh I`ll do it when I`m finished", and then I forget it." 012.

Other participants also reported a need to "think ahead" and plan activities in general to account for impaired memory. Some used diaries to schedule activities, including PA. Participant 058 reported having difficulty with procedural memory i.e., forgetting how to drive the car.

"Everything's in the diary. If I hadn't got that diary, like the day of the week and who`s coming…". 058.

Although most participants did not report that these factors posed a significant barrier to PA engagement, one participant recounted a time when they got lost while out walking because they were unable to remember their way back. This event was frightening, and as a result that participant is reluctant to go out walking alone apart from routes that they are very familiar with such as to and from work.

"No. I don't think so unless I can't remember where to go. Once I`m brought to a place or whatever… that would be my only thing. I`ll always walk. I love walking, yeah. Now I`m going away in May. I have my best friend, we never went away together, and it's to a house, and her husbands a walker, so I`ll walk with him and leave the other two to it. I`d be afraid that I`d walk… which I done it before and I got lost, and I`d no… couldn`t remember the name of the hotel that I was in. Oh I`ll never forget it! And I`d no money, no nothing, you know? I was in an awful state!". 053.

While other participants in this sample did not report getting lost, there were other practical difficulties related to MCI. For instance, 020 reported having difficulty remembering things like ATM passcodes which they described as mildly annoying. This participant was also unclear about the specifics of their involvement in the NeuroExercise study and how they came to be involved, suggesting that memory impairment may be a significant barrier in everyday life.

In this sample, the objective measure of cognitive function (MoCA) did not correspond with participants reports of how problematic MCI symptoms are for them. The classification of stage of MCI based on MoCA scores as subjective (> 25), early (22 – 25) or late stage (19 – 21) as has been used in previous MCI samples (Stuckenschneider et al., 2018). For example, three participants who subjectively reported experiencing MCI symptoms that interfered with daily life had MoCA scores of between 22 and 25, classed as early MCI. Just one participant who reported symptoms that interfered with daily life had a MoCA score of under 20 (classed as late MCI) that was reflective of their objective stage of MCI. One participant was classed as having subjective MCI with a score of over 25. Thus, in this sample, stage of MCI as determined by objective cut off points was not reflective of how problematic participants considered their symptoms to be. One participant's objective stage of MCI and reported symptoms corresponded with each other however, and in that case MCI posed a safety risk as the participant was afraid they might lose their way. This was the only participant to report such problematic MCI related symptoms presenting obvious limitations to their ability to engage in PA.

5.3.1.3 Practical Barriers

5.3.1.3.1 Lack of Time for PA. Lacking free time for PA was a commonly cited barrier to engaging in PA. Many participants described how being an informal carer for an ill spouse or family member limited the time they had to be recreationally physically active.

“For the last 10 years I`ve been looking after my mum who was an invalid, and I haven’t had time to do actually any exercise.” 061.

Participants 014 and 057 both referred to not having "freedom" in their role as carers for engaging in PA, but where for 057 the carer role was a significant barrier, 014 ensured they scheduled their PA around their carers duties and chose activities which could fit into shorter durations to circumvent this barrier. It may be that as someone who enjoys being very active in general, they are prioritising their PA as it is important to them to be active.

“I don’t have the appetite for it… I have the responsibility of caring for a handicapped daughter so… I don’t have the freedom.” 057.

“An odd time I meet people and they`ll say “going walking?” and I`ll say “join me”, if I met them at the park and we`d go round together, but I never organise to go with anybody because I never know what time I`m going at. It depends on X at home (husband) what time I would leave, you

know, and my mornings are kind of "freedom mornings" as I call them, and I do everything nearly in the mornings in that respect, because he`s in bed until about two O`clock." 014.

Work and family commitments were also commonly cited barriers to regular PA engagement. For example, being involved in childcare, i.e., looking after grandchildren, being in full time employment, regular travel such as long-distance journeys to visit family and general housework tasks all limited the amount of time participants had for recreational PA. Participant 012 spoke about the frequency of various medical appointments that they must attend being a significant barrier to PA as hospital visits were found to be time intensive. Similarly, participant 053 recounted limitation on their time which negatively impacted PA engagement.

"Oh yeah, my friend got me into a gym. Now in saying that, I`m not getting the time. It's too far for me, and she paid for it so I couldn't say nothing. She wanted me to go today, and I said, "well if I have time I`ll go", because the only days I have off is Tuesday and Wednesday, and I have so much to do at home because my hours, when I come home I`m just exhausted. And my son and his partner are living with me until their house is ready, so I`ve double the work, do you know what I mean?" 053.

Thus, having free time to engage in PA can be difficult in this cohort due to being employed or having other home, family, or health related commitments.

5.3.1.3.2 Weather. The weather was cited by many as a common practical barrier to engaging in PA. Most commonly, participants reported not wishing to exercise outdoors in cold weather or in the rain. One participant, who was very active in general, reported compensating for bad weather by performing exercises at home to assuage feelings of guilt and laziness. However, this was not the norm in this sample.

"I mightn`t walk today now. I won't go out in the rain. If its windy its fine, but not rain." 045

Most participants displayed a preference for outdoor PA. As a result, walking was the most commonly performed activity among this sample. It is unsurprising then that unsuitable weather conditions would have an adverse impact on PA engagement.

5.3.1.4 Lack of Knowledge

5.3.1.4.1 Cognitive Benefits of PA. Few participants mentioned engaging in PA to benefit their cognitive health. This is unsurprising given the lack of knowledge of the cognitive benefits of PA among participants. All but two were unaware of the global physical activity guidelines, meaning that they were unaware of how much PA it was recommended that adults regularly engage in. Similarly, knowledge of the positive effects that PA can have on the brain were also limited. Most participants viewed the benefits of PA as being purely physical and did not associate cognitive health with PA.

"Well, eh… well it`s good for your heart anyway, I know that…and it's good for your breathing… eh… and its certainly good for the bones and the joints." 039.

Many participants reflected that they had never considered that PA could impact MCI, suggesting that this information is not well known in this sample of individuals with MCI. One participant explained that they never needed this information before as it was not relevant to them before they began experiencing cognitive impairment, unlike the benefits of PA for maintaining physical health which were known.

“I wouldn’t have thought of it in terms of brain because I didn’t need to. I needed to think about it in terms of being the age I am and the potential to get some of the things I`ve got (health conditions) and keeping on the move is better than being sedentary or whatever the word is, and sitting at home doing nothing, you know?” 045.

However, some participants stated an intention to engage in PA going forward with the purpose of positively impacting their cognitive health based on recently becoming aware of the possible benefit of PA for MCI through their participation in this study or through personal research prompted by involvement in this study.

“But then I didn’t need to know it, until I started to forget things, and then I was told that it does (by the study) so now I`m really interested in the fact that it does, and I’ll keep exercising.” 045.

As one participant put it, people would be more motivated to engage in PA if it was known that PA was of direct benefit to them.

“I mean if you were sick and you had to do exercise for the sickness, then I`d say people would tend to do it a bit more, you know. if its beneficial to the memory I think it should be done alright.” 039.

In this way, engaging in PA was associated with knowledge of the benefits of PA for cognitive health.

5.3.1.4.2 Ways of Maintaining Cognitive Function. Most participants felt that activities that were cognitively stimulating, as opposed to physically stimulating, were the sole lifestyle activity they could engage in for cognitive health and thus made an effort to engage in these to address MCI. Some of the activity's participants chose to engage in were puzzles, Bridge, Sudoku, Scrabble, and online brain games.

"I wouldn't have known anything about it! I would have never… in all honestly. I think I would never have thought of my brain when I thought of exercise. All I would think of was my body." 014.

This demonstrates a general lack of knowledge regarding the potential cognitive benefits of engaging in regular PA and a tendency to associate PA with physical benefits and "cognitive activity" with cognitive benefits. Although it is known that knowledge does not always translate into health behaviour, promoting the message regarding the association between PA and cognitive health may nonetheless help to enhance PA engagement through establishing the relevance of it to a cognitively impaired population. For example, as previously demonstrated, some participants found that new knowledge regarding the cognitive benefits of PA served as a source of motivation for further PA.

5.3.2 Motivators for Physical Activity Engagement

Participants reported a number of reasons for engaging in PA, but for most, the main purposes for being active were for enjoyment and for improving or maintaining physical health. Engaging in PA at an acceptable level, being outdoors, having a goal or purpose and providing social opportunities enhanced enjoyment of PA. Individual definitions of PA impacted motivation for PA. Physical and psychological health were motivators for PA engagement.

5.3.2.1 Enjoyment

Enjoyment of PA was a key motivation for engaging in PA, impacting how often participants engaged and what types of activities they engaged in. Most participants reported engaging in activities because there was a particular aspect of it that they found enjoyable. Conversely, certain activities were disliked or considered boring by participants and thus they avoided them, illustrating how participants must be favourably disposed to an activity in order to engage in it. Enjoyment was characterised by the preferences of participants for it to be social in nature, outdoors, purposeful or goal orientated, and to be performed at a pace that is acceptable to participants i.e., at a moderate level. Participants also displayed variations in how they conceptualised, or defined, PA, and there was a distinction between the concepts of being physically active and engaging in "exercise", which impacted participants willingness to perform certain activities. In this way, the elements that contribute to enjoyment, and thus PA engagement, are variable at the individual level.

5.3.2.1.1 Social Aspect. The majority of participants expressed a preference for engaging in PA either with a partner or in a group setting because they liked the social aspect of PA with others. For some, this was because engaging in PA with others helped to relieve the boredom of exercising alone and helped to enhance motivation.

"Ah it`s better doing it with people really. I think so, yeah, but em… I like, I mean I think people get strength from one another, don`t they?". 062.

Many participants considered engaging in PA to be more enjoyable either with a partner or as part of a group. Group activities in particular were valued for the social opportunity they afforded, as they provided a welcome social outlet for some. Speaking about group hill walking excursions, one participant described how their group would regularly go away on weekends to various locations to walk. In this description they spoke about the value of the activity in terms of social opportunity and having company, rather than the physical activity in itself.

“The hiking was great in that respect, particularly the weekends going to the Dublin, in the mountains, the Wicklow (mountains)… or else you`d get a weekend and we`d all go away…… go to different parts. And it didn’t have to be… one weekend we just went to Wexford and just stopped in a small house near the sea…… and that was just… it was company". 057.

Other participants described the social aspect of group activities in much the same terms, with emphasis on the group experience rather than on the intention to be physically active. For most, engagement in these activities was motivated by the enjoyment of the social aspect of group activities.

"Well, we go down the west three times a year. One of the lads arranges a walk. It`s usually down in Westport or something like that, you know. We do that… the Westport… we walked down from Westport to… you know the mountain up there? You know the one you walk up if you`re religious? Croagh Patrick! It’s a good walk out now… it`s a good few miles out, so we walk that. We wouldn’t go up it now (laughs)… we go… we go… to the pub (laughs)…". Nex39.

In contrast to those who prefer to have a partner for PA, participant 014 preferred to engage in PA alone to keep their PA routine flexible to match their home commitments as a carer to an ill spouse. In the case of this participant, the primary goal of being physically active was for enjoyment of being active in itself, not because of the added social benefits as expressed by other participants. In either case, enjoyment was a key motivator but for the majority of participants that enjoyment was derived from the setting rather than the activity per se.

"An odd time I meet people and they`ll say "going walking?" and I`ll say "join me", if I met them at the park and we`d go round together, but I never organise to go with anybody because I never know what time I`m going at." 014.

For another participant, preferring to engage in PA with others was for safety rather than enjoyment as has previously been discussed in the case of participant 053 as there was a fear of getting lost when out alone. This suggests that a social setting may provide a sense of safety that may make some activities more accessible to some individuals with MCI.

5.3.2.1.2 Being Outdoors. There was a clear preference from most participants for PA to be outdoors, as it was considered that being in the "fresh air" contributed to the enjoyment of the activity. This was the most commonly cited reason for the mode of PA engaged in by most participants most frequently, which was walking. The possibility of being bored was a frequently cited issue and participants spoke about enjoying the countryside and being able to vary their routes and scenery which helped to alleviate boredom.

"You know… it's not doing it in the house. Like I mean I`ve been doing three or four minutes on the bike. I doubt if I`ve hit five minutes in the last week, but em I`ve been on the bike and … its ok but it's boring. Whereas out walking is lovely, you know you`re watching the trees, you`re seeing the greenery… see people passing by…" 019.

Being out in the "fresh air" was seen to be enjoyable and invigorating, in contrast with descriptions of the perceived atmosphere of the gym or the experience of using home exercise equipment.

“Like that I wouldn’t enjoy the gym eh… I’d love to get back to cycling… em out in the fresh air, that’s the kind of thing I like… yeah, yeah I’d get bored in the gym. I`d… I mean I did try them years ago, but I would be just bored with it… on the treadmill (laughs)…” 058.

5.3.2.1.3 Having a Goal or Purpose. The negative perceptions of engaging in PA in a gym atmosphere may be associated with the perceived purpose of the activity that is being performed. In the above section, participants expressed their preference for activities that are outdoors and in a social setting. This was clarified with reference to these preferences being a method of avoiding boredom, either through having company or enjoying and admiring ones` surroundings, thus providing a purpose for PA. The need for PA to be purposeful is further illustrated by participants assertions that engagement in PA without an end goal was considered “mindless”. For example, there was a distinct dislike of PA, and this often was described with reference to participants perceptions of gym activity as being pointless and boring.

*“What I see in the gym in X are sort of stressed, strained people…… eh now when I`m in the mountains with X, he`s Japanese (inaudible), we`re sweating like pigs but we`re absolutely engrossed in what we`re doing and what’s around us, and the exercise is only the object… only a means to get to the object, you know, the exercise is not to get fit, the exercise is to get the seed or the nuts off of that tree or whatever…it`s a by- product, yeah. And it’s a measurable by- product, you just say “sh*t, we nearly killed ourselves to get up there”, but the object was to get the seed, not to exercise.” 060.*

5.3.2.1.4 Defining Physical Activity. It was apparent that what some participants considered enjoyable and purposeful may be perceived as otherwise by others. For instance, though many participants expressed a preference for walking as their main form of activity, participant 061 in the extract above expresses a dislike for walking, which to their mind is unproductive. In addition, participant 060 reported not wishing to engage in PA in accordance with recommended PA guidelines. Yet they spoke about enjoying being quite physically active through their work as a landscape gardener, which was goal orientated.

"No, I`m not because… sort of… the activities that I have read of that are recommended I would find just mindless." 061.

This is further compounded by evidence of a level of variation in how participants defined PA. Many participants displayed a tendency to draw a distinction between "exercise" as a descriptive term and the various forms of PA they report enjoying and engaging in.

"Just what you see on television, it's crazy…They go and they`re lifting all of these heavy weights…" 057.

Some participants described how they dislike "exercise" in and of itself but describe it as necessary to achieve their goals. In other words, "exercise" is a means to an end, where the end goal is to be able to engage in the physical activity that they enjoy, yet the two were seen as distinct concepts. For example, some participants spoke about their love of playing sports, but their dislike of the training required to play these sports to the best of their ability. In addition, one participant equated exercise with pain but also spoke about particularly enjoying walking for PA. This is their response when asked how they define exercise:

"I`ve always hated exercise … always, right from the very start… I don't know why but I just… I`ve always hated having to do it. It`s a necessary evil if you want to… well from my point it`s a necessary evil, if you want to get fit enough to be good at the tennis". 060.

The above quotation illustrates the views of some regarding the concept of exercise, yet the participant reported enjoying other activities they engaged in. This suggests a possible disconnect between participants understanding of the concept of being physically active versus a perceived definition of "exercise" as being too formal or daunting.

"In ways its only recently it`s become all very, not too theoretical but theoretical and scientific and purposeful. It's not just exercise. Just like the GP, you must get exercise, and you don't hear the word exercise for 20 years or more sort of … what's that to me". 057.

When asked if they thought people who exercised regularly were healthier than those who did not, this participant continued:

"They`re probably more healthy but with a very limited span. If they give it up at all they just… they collapse, their body collapses". 057

Thus, there was a tendency for some participants to differentiate between enjoyable physical activities and "exercise", the latter having negative connotations for some. This suggests that there may be misconceptions regarding what constitutes PA in terms of achieving the recommended PA guidelines. This is illustrated by participants 019 and 020 who differentiated between the concept of "exercise" and activities that they enjoy and engage in regularly.

"We don't exercise for exercise, or perhaps we do. We could drive to mass, we could drive over to the park, but we go for an enjoyable walk, you know? and you know, that way… I never think of exercise for exercise` sake ." 020.

"I`m doing a lot of things, but it's not constant exercise, you know like hoovering or weeding or gardening or something, you know…I do actually like walking, and I love gardening… and I do love house - work". 019.

These are all activities that are acceptable forms of PA as per the PA guidelines, yet the participants described them as being distinct from "exercise". Later in the interview participant 019 spoke about needing to be more active but finding that needing to complete housework is a barrier to PA engagement. Given that some PA questionnaires such as the LASA physical activity questionnaire (LAPAQ) include housework as an acceptable form of PA this illustrates a lack of awareness of what is defined as PA.

5.3.2.1.5 Acceptable Pace. PA must match the participants ability and expectations to be enjoyable, i.e., moderate for some, intense for others, depending on their preferences and definitions of PA. Thus, there was a preference for PA to be performed at a pace that was acceptable in the sense that it was still enjoyable to the participant. For some participants this meant that they preferred to engage in PA at a moderate level, and until they felt that they had done enough. For example, one participant (057) stated that they wanted PA to match their physical ability, slow and gentle.

"Well, the only thing I really dislike about it is relying on it… or doing far too much of it. I don't want to be… or reach a stage of compulsion about it, like you have to do it. You (should) do it when you feel like it and you are enjoying it, that'd be my… and take it easily…And gently, whether I get out for half an hour and do half the block… I don't want to do the whole block so that's enough for me." 057.

Physical ability also impacted the acceptability of types of PA, such as in the case of participant 058. They recounted joining a Pilates class and not enjoying it because it was beyond their physical ability and resulted in pain, making the experience a negative one. Similarly, they had a negative experience with a PA class which surpassed that participants` own level of ability. They followed up by saying they would rather do an activity that they find enjoyable.

"My sister… or sorry, my daughter… was doing keep fit classes and she asked me to come along and eh… oh I wasn't able for it (laughs). It was really pumping… em… aerobics and eh… I stayed at the back of the class (laughs)… but eh I think my blood pressure shot through the roof (laughs)… and I said to her "no, I can't do it", she says "you're grand mam", and I said "no…",.. so, I gave that up after two weeks. I just couldn't enjoy it." 058.

Participant 019 spoke of how they tried to use an exercise bicycle at a high intensity but did not enjoy it, saying they would prefer a less intense level of PA that wasn't so exhausting. In contrast, participant 014 spoke about enjoying being pushed physically and how they try to increase their performance in the gym based on electronic feedback which they find motivating.

"Oh yeah, I mean I do work. You go up and look how you did at the end of the session, and I kind of get really… and it tells you then when you click in, you put in your key to start your new session the next day and it'll say "oh you`re down by two points" or something, and I`ll go "hmm what did I do wrong?", and then I`ll go a bit harder sort of thing that day." 014.

The difference may be that participant 014 enjoys this sort of intense activity, in contrast with the other participants mentioned above, suggesting that enjoyment is the moderating factor here. These examples illustrate how enjoyment impacts on levels and intensity of PA performed and thus results in preferences for PA that is suited to participants individual ability and pace.

5.3.2.2 Physical and Psychological Health

The types of issues that participants were addressing with PA ranged from being active for weight loss, cardiovascular health, mobility, and flexibility, feeling that body parts need to be used to maintain fitness and a general wish to maintain good health i.e., to help manage other conditions.

"I really need to do the exercise for my blood pressure more than anything else, I suppose." 039.

There was a repeated sentiment among some participants that they should be more physically active than they are. The reasons for feeling that they should be doing more PA are vague and a few participants reported engaging in PA "just because they should", but some clarify that they feel that they should be engaging in PA because it is good for them. In this way, participants motivations for being physically active may be associated with their knowledge regarding PA and having a sense that being active is generally beneficial but in a manner that they feel vaguely relates to their overall health.

"I haven't thought much about it now until you asked me (laughs). I do it just because we should." 020.

In this way, physical health as the main purpose for being active is underpinned by a general feeling that participants “should” be active. This may be the result of an interaction with the theme of Knowledge, in that participants displayed a vague knowledge of the health benefits of PA generally which may be the reason for the common sense that PA is good and thus should be performed.

“Well, it’s not top of my list, but I`m not… I realise it’s there to be done and I should be doing more of it, but…”. 039.

Although not distinctly aware that PA is beneficial for cognitive health, many participants spoke about engaging in PA for psychological health. It was perceived that the psychological benefits of PA indirectly positively impact on cognitive health and thus participants see this as the route through which PA impacted cognitive function. Some participants spoke about feeling that PA was good for the "mind" or beneficial "mentally", meaning that they felt that it promoted good psychological health. That is to say, participants spoke about PA being beneficial in terms of relieving stress and frustration, clearing your mind, or “feeling” good.

“Oh, it does because I can go out for a walk and I start thinking “ah Jesus”, you know what I mean, it`s not all about me. It`s about stuff like that, you know, so…and then everything is over and then everything is fine.” 062.

"Well, if you`re frustrated about something you go for a walk and all of a sudden you feel a bit better, you know." 014

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5.3.3 Interactions Between Themes

5.3.3.1 Barriers

There was an interaction in the data between participant`s reporting of milder symptoms and practical barriers to PA. Participants who reported milder cognitive symptoms more commonly reported experiencing the barriers of lack of time (through being a carer, minding grand - children and travel), and weather, but not injury. They were not impacted significantly by physical or cognitive barriers. For participants who reported more problematic symptoms affecting daily life, PA engagement was more commonly impacted by the practical barrier of lack of time (work or being a carer), the physical barrier of injury, and the cognitive barrier of having more problematic MCI symptoms. This suggests that adults who experience more problematic symptoms of cognitive impairment also more commonly experience physical limitations to engaging in PA than those whose symptoms are confined to minor forgetting (i.e., forgetting names).

5.3.3.2 Motivators

There was also the suggestion within the data that the motivator of psychological health was associated with the motivator of engaging in PA for enjoyment, specifically through the route of being outdoors and enjoying fresh air. This aspect of being outdoors enhanced motivation for PA engagement through the outcome of "feeling good afterwards", which enhanced psychological health for some.

Definitions of PA are likely associated with participants knowledge of PA (benefits and recommended guidelines). There was variation in what was considered PA and what was considered "exercise", with the latter containing negative connotations. Some participants reported enjoying certain types of PA, but disliking "exercise". These subjective interpretations of concepts related to PA determined what activities participants chose to engage in and whether they thought of themselves as physically active or not.

5.4 Discussion

This analysis aimed to explore the barriers and facilitators of PA engagement in a sample of Irish adults with MCI. Findings were presented as barriers to and motivators for PA engagement. Barriers were practical such as lack of time and bad weather, physical such as physical capability or being injured, cognitive such as having memory issues, and a lack of knowledge. Motivators for PA were enjoyment, which was determined by participant preferences for outdoor activity, a social setting and PA that has a purpose and is performed at an acceptable pace. Physical and psychological health was the main health related motivating factor. In addition, knowledge of the recommended guidelines and types of activities that were included in the guidelines was low.

Practical barriers such as bad weather and lacking time have previously been reported in the literature as barriers to PA engagement in individuals with dementia (van der Wardt et al., 2017) and in mixed MCI and dementia groups (Chong et al., 2014; van der Wardt et al., 2019) in support of the findings of this analysis. The barrier of memory issues identified in this analysis is supported by previous findings in individuals with dementia (van Alphen et al., 2016) and mixed MCI/dementia groups (Chong et al., 2014; van der Wardt et al., 2017). The finding of this study suggest that although it is considered that MCI typically does not interfere with activities of daily living (Petersen et al., 2014), memory issues associated with MCI can pose a significant barrier to PA engagement in this cohort. Some participants of this current study reported cognitive limitations to engaging in PA such as the possibility of getting lost or forgetting to exercise. However, it is interesting to note that this study found that participants objectively measured level of cognitive function did not correspond with their reports of how problematic they perceived their memory issues to be. This has implications for interventions to promote PA engagement in individuals with MCI as it implies that participants experience symptoms at differing levels that are not fully captured by assessment of stage of impairment, suggesting that PA promotion should be tailored according to participants perceived impairment in addition to objectively measured impairment.

Motivators for PA engagement included enjoyment, knowledge and being active for physical and psychological health. The social aspect of PA, a sub – theme of enjoyment in this current analysis, is supported in the literature. For example, Chong et al. (2014) detail both enjoyment of PA and preferring social settings as components of their theme of “attitudes”. Similarly, a preference for PA that is social is noted by van der Wardt et al. (2019) under the theme of “external motivation”. In addition, the theme of “acceptable pace” in this current analysis is reflective of van der Wardt et al.`s concept of “design”, which demonstrates how aspects of PA itself can make engagement appealing or not.

Finally, the findings from Chong et al. (2014) are concurrent with the findings of this current study with regard to how participants perceive PA to be of benefit to them. Although there was a lack of knowledge regarding the cognitive benefits of PA in this sample, there was a commonly held opinion among participants that PA was beneficial for psychological health, and that this extended to cognitive health. This is also reported by Chong et al. when they speak about participants views that PA was “good for the mind” (Chong et al., 2014). Other studies have found that positive belief in the cognitive benefits of PA to be motivator (van der Wardt et al., 2019) and this current study found some evidence to support this. Although participants in this study did not report being physically active to improve cognitive health, some participants stated that newly acquired knowledge about the cognitive benefits of PA would motivate them to be more active going forward. This may suggest that individuals’ belief in the benefits of PA may be positively impacted through acquiring knowledge.

Overall, the impact of the lack of knowledge regarding PA and it`s cognitive benefits /usefulness as a way of maintaining cognitive function should be addressed in PA promotion for individuals with MCI. The lack of knowledge regarding PA among this sample interacted with other motivators such as being active for health and enjoyment and promoting this message may strengthen these motivations for PA engagement if it was more commonly known.

Previous PA studies in dementia populations have reported findings similar to those of this current study. For example, physical and mental limitations, such as ill health, lack of time, and problems with attention and memory have been reported as common barriers to PA engagement in individuals with dementia (van Alphen et al., 2016; van der Wardt et al., 2017). In addition, being motivated to maintain mental and physical health, and the availability of preferred PA options were motivators for PA (van Alphen et al., 2016). Therefore, the barriers and facilitators of PA engagement in this sample of individuals with MCI were similar to those impacting PA engagement in adults with dementia. This suggests that individuals with MCI may have similar support needs for PA engagement as individuals with greater cognitive impairment, as clinically defined.

Another finding of this study was that participants with milder memory issues more frequently reported the barriers of time and weather, whereas participants with more problematic memory issues more often reported the barriers of time, memory issues and physical limitations. This findings may indicate that physical capability for PA engagement may decrease as level of memory impairment, at least as perceived by the individual, progresses. However, this finding is tentative and requires further investigation.

Finally, these findings showed that in this sample, participants had varying definitions of the concept of physical activity. In some cases, a differentiation was made between PA that was seen as required and PA that was incidental to activities that the individual enjoyed doing. These subjective interpretations of concepts related to PA determined what activities participants chose to engage in and whether they thought of themselves as physically active or not. This distinction may have repercussions for subjective self- reporting of PA in this cohort, as participants may misunderstand or not report the entirety of their activity and therefore provide inaccurate accounts.

5.5 Conclusions

These findings have added to our understanding of the determinants of PA engagement by demonstrating that the barriers to PA engagement in this sample of Irish individuals with MCI were cognitive (memory issues), physical (capability/ injury) and practical (lack of time/ weather). Motivating factors were enjoyment (social aspect, being outdoors, having a goal/purpose, defining PA, acceptable pace), health (physical, psychological), and knowledge (cognitive benefits of PA, ways of maintaining cognitive function). Individuals with more problematic memory issues were more likely to experience cognitive and physical barriers to engagement. In general, there was a lack of knowledge surrounding PA, and the association between PA and cognitive health, as well as a lack of awareness of the PA guidelines. Enhancing awareness of PA and especially the cognitive benefits for individuals with MCI may help support PA engagement in this cohort.

5.6 Chapter Summary

This chapter discussed the findings of an exploration of the barriers and facilitators to PA engagement in individuals with MCI. Barriers consisted of cognitive, physical, and practical limitations to engagement. Facilitators were enjoyment, health, and knowledge. These findings and those from the previous chapter (Chapter 4) are integrated in Chapter 6.

Chapter 6: An Integrated Analysis of the Determinants of Physical Activity Engagement in Individuals with Mild Cognitive Impairment

6.1 Introduction

Regular PA in mid – late life, may be beneficial as an intervention to support cognitive function in individuals with MCI (Cai & Abrahamson, 2016; Strohle et al., 2015; Zheng et al., 2016) and reduce future risk of dementia (Ahlskog et al., 2011; Chu et al., 2015; Gallaway et al., 2017; Tolppanen et al., 2015). However, there is a lack of consistency in the reported rates of PA engagement in this cohort, and a scarcity of research examining the correlates and barriers and facilitators of PA engagement. Further, there is a lack of mixed methods research drawing on findings from these two perspectives to inform our understanding of the determinants of PA engagement which is needed to inform future research and effective PA intervention design targeting cognitive health. The purpose of this study was to integrate qualitative and quantitative findings from study 1, sub – studies 1.1 (Chapter 4) and 1.2 (Chapter 5) of this thesis as part of a parallel convergent mixed methods design to expand the depth of knowledge regarding this topic and to generate new insight. Thus, this chapter addresses objective 1, sub - objective 1.3 of this thesis.

6.1.1 Mixed Methods Research Questions

- Do the qualitative findings explain why PA engagement was low (i.e., participants were not achieving the physical activity guidelines)?
- Do the qualitative findings explain the lack of agreement identified in the quantitative results between objective (Actigraph) and subjective (LAPAQ physical activity questionnaire) measures of PA engagement?

- Does the quantitative data explain why participant accounts of severity of memory issues differ from objectively measured cognitive function?
- Does the quantitative data explain why physical capability was identified as a theme in the qualitative data but was not significantly related to PA engagement in the quantitative data?
- What results emerge from comparing qualitative and quantitative findings regarding the correlates and barriers and facilitators of PA programme engagement in individuals with MCI?

6.2 Methods

6.2.1 Design and Rationale

This was a convergent parallel mixed methods study (Creswell, 2015; Creswell, 2007; Teddlie, 2009). This approach contributed to the overarching thesis aim of furthering understanding of the determinants of PA engagement in individuals with MCI as it involves abductive reasoning that combines findings from each methodology that were not analysed together in individual studies to theorise connections and increase understanding of a topic (Sandelowski et al., 2012). Abductive reasoning refers to the process of hypothesising relationships between sets of findings that at first appear unrelated and forming a model of the relationship (Sandelowski et al., 2012). The convergent approach involves separate synthesis of qualitative and quantitative data which are integrated in a third synthesis, in this case in the interpretation (or inferential) phase of analysis, by merging both sets of findings (Creswell, 2015; Teddlie, 2009) (see Chapter 2, section 2.1.2, Figure 3 for a graphic illustration of the convergent parallel approach in this thesis). Integration was achieved using a top - down approach (Sandelowski et al., 2012) to data synthesis. This means that an existing framework of behaviour change (COM – B) was used to merge findings in a joint display (see Chapter 2, section 2.2.9 for more detail on this model). This is in contrast with the bottom – up approach which generates new themes arising from the configured data. Methodological triangulation was used to assess convergence, dissonance and silence between sets of findings and enhance the validity of findings (Aromataris, 2020; Bazeley, 2018; Farmer et al., 2006).

6.2.2 Data Analysis

Analysis was informed by questions arising from the separate quantitative and qualitative analyses. As is common in mixed methods research integration, the research questions arising from individual analyses were addressed iteratively between methodological strands to answer these mixed methods questions. The COM – B framework domains of capability, opportunity and motivation (Michie et al., 2011) formed a priori themes to create a joint – display (Thomas et al., 2004) to facilitate the configuration of determinants of PA engagement which were applied to the Behaviour Change Wheel (Michie et al., 2011). Farmer et al. (2006) outline a number of steps to achieve methodological triangulation which were adopted in this study. These were: sorting (this was achieved by separately analysing the methodological strands and separately mapping each set of findings onto COM – B to identify areas of divergence), convergence assessment (comparing findings to assess areas of convergence), and completeness assessment (comparing the scope and coverage of the topic areas of each data source and reporting on completeness of findings).

Integrated findings were discussed narratively (Sandelowski et al., 2006) and then applied to the corresponding intervention functions of the middle layer of the BCW using an eight step approach outlined by Michie, Atkins, and West (Michie, 2014). This approach is outlined in more detail in Chapter 2 (2.2.9) of this thesis. This current analysis applied steps 4 – 8. The COM – B was used to identify the areas of behaviour to target to influence change (step 4), and then applied to the BCW to identify the intervention functions most likely to initiate change (step 5). Intervention functions were then linked to their corresponding policy categories (step 6) and both were then cross referenced with Michie et als` taxonomy of BCTs (Michie et al., 2013) to select feasible and effective BCTs to recommend for intervention design/ policy (step 7). The BCW and the BCT v1 are described in more detail in Chapter 2 (2.2.9). From this, the most appropriate mode of delivery of these techniques was suggested and related to evidence- based adherence support strategies (step 8).

6.3 Integrated Findings

6.3.1 Physical Activity Engagement

PA engagement was low. Participants did not achieve the recommended levels of weekly PA as per PA guidelines according to quantitative data. In the qualitative sample (n = 13), four participants achieved greater than 150 minutes of PA as recorded objectively ranging from 166 to 257 minutes in a 7-day period. This showed 36% of participants achieved PA guidelines compared with 29% in the quantitative findings. In Chapter 4 the lack of agreement between objectively measured (Actigraph) and self – reported (LAPAQ) levels of PA engagement is discussed. That study found that self – reported PA was underestimated. LAPAQ data for the qualitative sample also showed an underestimation of PA engagement compared with Actigraph data demonstrating that the samples were homogenous.

The following section outlines the integrated findings narratively using the COM-B framework themes of capability, opportunity, and motivation. Qualitative findings captured data regarding all sub – domains of the three COM – B domains. However, when quantitative results were mapped onto the framework they were found to relate only to the concepts of physical and psychological capability for PA engagement and were silent in relation to the remaining themes. Qualitative findings were mapped to the framework on a sub – theme level, as higher-level themes were too broad to map efficiently to the a priori themes. However, where applicable higher-level themes from the qualitative findings are discussed to provide comprehensive coverage of the concepts covered in the COM – B framework. For example, the theme of enjoyment presented in the qualitative findings contains the sub – theme defining PA. In this instance, the sub – theme of defining physical activity may be attributed to psychological capability and to reflective motivation on the COM – B model. In this way, the theme enjoyment occupies both spaces through the association with its sub – themes. Configured findings are presented in Table 16.

Table 16.

Joint Display for Synthesis of Qualitative and Quantitative findings

COM - B Domain		Qualitative Barriers	Qualitative Facilitators	Quantitative Findings
Capability				
Psychological capability	Psychological strength/ stamina and knowledge & skills	• Poor Knowledge - PA and brain health link - How to maintain cognitive function	• Enjoyment • Differing definitions of PA • Knowledge - PA and brain health link - How to maintain cognitive function • Being active for health - Physical health - Psychological health	• Depressive symptoms - Not significant • Education - Not significant
Physical capability	Physical strength, skills, or stamina.	• Physical barriers - Physical capability - Injury - Perception of being too old for PA • Cognitive barriers - Memory issues	• Enjoyment - Acceptable pace	• Cognitive function - Not significant • Frailty - Not significant • Chronic illness - Not significant • Age - Not significant • Health related quality of life - Not significant
Opportunity				
Physical opportunity	Environment, time, location, resources	• Practical barriers - Lack of time - Weather	• Enjoyment - being outdoors	

Social opportunity	Social factors such as cultural norms and social cues		• Enjoyment - Social aspect
Motivation			
Reflective motivation	Making plans, beliefs, evaluations of past events	• Knowledge - Ways of maintaining cognitive function	• Enjoyment - Defining physical activity • PA for health - Physical health - Psychological health
Automatic motivation	Desires, impulses, and inhibitions		• Enjoyment - Having a goal/ purpose - Acceptable pace

6.3.2 Capability

6.3.2.1 Psychological Capability

6.3.2.1.1 Knowledge and Education. Qualitative findings highlighted the role of lack of knowledge regarding PA in engagement. There was the suggestion that knowledge could be a facilitator to PA engagement. For example, participants reported not knowing that PA was beneficial for cognitive health, but also stated that having greater knowledge in that area would motivate them to be more physically active. However, most participants lacked knowledge regarding PA in general, including its cognitive benefits and knowledge of the PA guidelines. Participants varied in their definitions of PA, which was coded as a component of enjoyment in the qualitative findings, but also further demonstrates a lack of knowledge surrounding PA. For instance, many participants spoke about being physically active for the purpose of enjoyment as distinct from exercise performed deliberately for health purposes. Education was not a significant variable in quantitative analysis. Further, participants in the quantitative sample had slightly higher years of education than normative population values (13 and 12 years respectively). Thus, it can be assumed that lack of knowledge regarding PA is not reflective of lower levels of education in this sample.

6.3.2.1.2 Depressive Symptoms and Health Related Quality of Life. In the quantitative analysis, regression modelling suggested that depression and health related quality of life together accounted for 14% of the variance in PA engagement ($R2$ = .14, Adjusted $R2$ = .20, *F change* (6, 42) = .86, p = .34), though this was not statistically significant. In the qualitative data, one participant reported experiencing depressive symptoms and stated that these negatively impacted motivation for PA engagement. Thus, although the regression model attributed high variance to depression and health related quality of life as a variable, a relationship is not supported statistically, or in the qualitative findings to any great extent. Thus, the association between depression, health related quality of life, and PA engagement remains unclear.

6.3.2.2 Physical Capability

6.3.2.2.1 Cognitive Function. Cognitive function was not related to PA engagement according to the quantitative results. However, the quantitative analysis concluded that there was an increased risk of type II error in those findings arising from a small sample size and repeated measurements. Indeed, when cognitive function was added to the regression model it explained 19% ($R2$ = .19, Adjusted $R2$ = .05, *F change* (7, 41) = 2.46, p = .24) of the variance in PA engagement (Actigraph), though not statistically significantly. This may also be because the level of impairment objectively recorded categorised most participants as early - stage MCI (mean MoCA = 22.3, *SD* = 2.5) which may have masked an effect given the low proportion of late – stage MCI cases in the quantitative sample. In contrast, qualitative findings showed that participants subjective accounts of memory issues posed a significant barrier to PA engagement in those who reported more problematic memory complaints. Participants spoke about barriers posed by memory issues such as getting lost or forgetting to exercise. The qualitative findings also showed that the impact of memory issues were more strongly associated with PA engagement than the objectively measured MoCA score, and classification of stage of MCI derived from the MoCA scores, which were used in between and within subject qualitative analysis. These dissonant findings between data sets suggest that cognitive impairment as a barrier is related to participants individual experience that was not fully captured here by objective measures of cognitive function. The qualitative data furthers the understanding of the non – significant quantitative finding and suggests that individuals` capability for PA engagement may be more influenced by participants subjectively experienced memory issues than by objectively based cognitive tests such as the MoCA.

6.3.2.2.2 Physical Capability and Injury. Quantitative measures of physical health were chronic illness (measured indirectly by number of medications) and physical frailty (as measured by handgrip strength). These were not significantly associated with PA engagement. However, hierarchical regression coefficients showed that these accounted for 11% of the variance in PA engagement ($R2$ = .11 , Adjusted $R2$ = .03 , *F change* (4, 44) = 2.41, p = .28). Participants` age was also not a statistically significant covariate. As discussed previously, the small sample size and underpowered quantitative analysis may have masked an effect of physical function on the outcome of interest. Indeed, qualitative findings were dissonant with the non – significant quantitative results, supporting the assertion that physical capability was associated with PA engagement. For instance, in the qualitative analysis participants reported various injuries that limited their PA engagement. Some participants also reported fearing becoming injured during PA as a barrier to engagement. Older age was reported by some participants as limiting engagement in their preferred activity, and others reported needing to “slow down” due to advancing age and injury. These resulted in a preference for performing PA at an acceptable pace in accordance with their perceived physical capability. Thus, there is dissonance between the methodological strands of data here. It may be the case that the measures of physical health used in the quantitative analysis were not sensitive enough to capture limitations in function that related specifically to PA engagement. For instance, handgrip strength was used as a proxy measure of frailty in this study, thus upper limb function was used to test for a relationship without consideration for the impact of lower limb function in PA engagement. In addition, these findings suggest that physical health may not be as indicative of PA engagement as physical capability, which is most commonly measured using a measure of walking speed in addition to grip strength (Cooper et al., 2010), and often include measures such as postural control, chair rise time, standing balance time and Timed Up-&-Go (TUG) (Cooper et al., 2015; Sanders et al., 2021). In addition, it is possible that participants perceptions of age and age-related physical ability was more of a determinant here than chronological age. Again, this supports the idea that

PA engagement may be better understood through an appreciation of individual level influences on engagement in individuals with MCI.

6.3.3 Opportunity

6.3.3.1 Physical Opportunity

Qualitative findings showed that lack of time, weather conditions and enjoying being outdoors were related to PA engagement. However, the quantitative data was silent in this case as no quantitative measures of physical opportunity were obtained for analysis.

6.3.3.2 Social Opportunity

Similarly, qualitative findings identified enjoyment of the social aspect of PA engagement as a facilitator, but there were no quantitative variables analysed with which to compare these findings.

6.3.4 Motivation

6.3.4.1 Reflective Motivation

Knowledge surrounding PA has previously been discussed as a component of psychological capability for PA engagement in this chapter. In addition, how participants defined PA impacted their motivation to engage in it. Definitions of PA were also associated with enjoyment, as many participants distinguished between the terms physical activity and exercise based on what they considered to be enjoyable, with exercise mostly being considered unenjoyable. There is silence regarding reflective motivation in the quantitative data as these constructs were not quantitatively measured. However, the qualitative themes suggest that motivation is a key determinant of PA engagement in MCI and further quantitative research may be able to confirm this finding.

6.3.4.2 Automatic Motivation

There were no quantitative measures of automatic motivation that can be compared with qualitative findings here, but qualitative findings showed that PA that was goal orientated or purposeful was preferred by many participants. This added to the enjoyment of the activity, which enhanced motivation for engagement. Enjoying PA in general was also associated with being more physically active.

6.3.5 Triangulation of Findings

Table 17 presents the assessment of convergence, dissonance, and silence for the integrated findings. Comparison of self- reported PA engagement showed that participants in the qualitative sample also under – reported their engagement relative to objectively measured engagement, converging with this finding in the quantitative data. Overall, there was silence in the quantitative data regarding the impact of knowledge surrounding PA, practical barriers to PA, enjoyment, varying definitions of PA, the social aspect of PA, and having a goal or purpose to be physically active. This is not unexpected, as those constructs were not actively assessed within the quantitative data and are more easily captured using qualitative methodologies, but as the variables tested statistically were derived from the literature this suggests that quantitative research may be missing valuable predictors of PA engagement which qualitative exploration has been able to identify. As the qualitative study was an inductive study, these are the issues that arose as barriers/ facilitators to PA engagement from the participants perspective. In this way, the qualitative findings supplement the quantitative findings by putting forth constructs that had not previously been considered and that can now be further tested quantitatively.

There was dissonance between sets of findings regarding the role of physical and cognitive health in determining PA engagement. According to the quantitative data, there was no relationship between objective measures of either, yet participants highlighted the barriers posed by subjectively described memory problems and poor physical health. This disagreement between findings suggests that participants' perspectives regarding their perceived health are key determinants of PA engagement and should be accounted for in future research on this topic.

Quantitative and qualitative data did not converge on any other of the reported findings. This suggests a disconnect between what we as researchers regard as factors related to PA engagement and what participants perceive to be actual barriers to engagement. This is an indicator of a lack of completeness within these current findings, which may now be addressed with further research guided by these qualitative findings. For example, further research into the role of perceived or self - rated age (i.e., feeling too old for PA), physical health, and cognitive impairment on PA engagement in individuals with MCI may be a useful area to help further understand this topic.

Table 17.

Triangulation of Qualitative and Quantitative Findings; Assessment of Convergence, Dissonance, Silence and Completeness

Com – B Domain	Convergence	Dissonance	Silence
Psychological capability			Quantitative - silent regarding knowledge of PA/ benefits for physical and cognitive function Qualitative – silent regarding depressive symptoms and education
Physical capability	Both samples under – estimated PA engagement in self - report	Dissonant regarding the impact of cognitive and physical health/ function, and age	Quantitative – silent regarding acceptable pace
Physical Opportunity			Quantitative – silent regarding practical barriers and enjoyment
Social Opportunity			Quantitative – silent regarding social aspect
Reflective Motivation			Quantitative - silent regarding knowledge and definitions of PA
Automatic Motivation			Quantitative – silent regarding having a goal/ purpose and acceptable pace

6.4 Discussion

This study addressed sub – objective 1.3 of this mixed methods thesis. That was to integrate the findings of sub – study 1.1 and sub – study 1.2 regarding the correlates of and barriers and facilitators of PA engagement in individuals with MCI to expand the depth of the current understanding, and to form evidence-based recommendations to promote PA engagement in this cohort. Several research questions arising from the individual analyses of quantitative and qualitative sub – studies were to be addressed. These were: do the qualitative findings explain why PA engagement was low?, do the qualitative findings explain the lack of agreement identified in the quantitative results between objective and subjective measures of PA engagement?, does the quantitative data explain why participant accounts of severity of memory issues and physical issues differ from objectively measured cognitive and physical function?, and what results emerge from comparing qualitative and quantitative findings regarding the correlates and barriers and facilitators (individual perspectives) of PA programme engagement in individuals with MCI?

Previous studies have demonstrated that adults with subjective cognitive impairment and MCI (Gagliardi et al., 2016; Miyawaki et al., 2017; Vidoni et al., 2016) are not sufficiently physically active. Both qualitative and quantitative findings concur with the literature on this point, demonstrating that PA engagement was below the recommended levels of weekly PA. The qualitative findings of this current study demonstrated that physical and cognitive limitations experienced by individuals with MCI negatively impact capability for PA, and thus PA engagement. For instance, experiencing memory issues, physical illness and injury may explain low levels of PA engagement in this cohort of individuals with MCI.

These findings are in agreement with the current literature which suggests that self – reported PA has low – moderate correlation with direct observation of PA in cognitively intact populations (Prince et al., 2008) and can be negatively influenced by cognitive impairment (Cumming & Klineberg, 1994; Helmerhorst et al., 2012), resulting in underestimation of PA in individuals with MCI (Siebeling et al., 2012). These integrated findings support the assertion that self – reported measures may not fully capture PA engagement individuals with MCI and suggest that under – estimation may occur due to memory issues which negatively impact recall of past PA engagement. Although participants were mostly early-stage MCI, those who reported greater subjective memory issues often spoke about “forgetting” (i.e., appointments, or to exercise). It is not unreasonable to assume therefore that forgetfulness can lead to inaccurate reporting of PA. The finding of this integrated analysis go further to show that participants displayed a poor understanding of what constituted PA, with examples of participants stating that they do not engage in regular PA but then detailing activities they regularly perform, which unknown to them are accepted forms of PA as per the PA guidelines. This lack of consistency in individual's definitions of PA would likely contribute to the underestimation of PA engagement that is seen here, and it highlights a gap between self -reported PA measurement and PA perceptions or knowledge.

Findings regarding the impact of MCI on PA engagement was dissonant between strands of data in this study. Qualitative findings from this current study are in line with other qualitative studies that have identified the theme of memory problems (Chong et al., 2014; van der Wardt et al., 2019) as barriers to PA engagement in mixed MCI and AD samples, and problems with attention and memory, and difficulties with planning and organisation in adults with dementia (van Alphen et al., 2016). However the non - significant quantitative cognitive findings with PA engagement in this current study are in agreement with one study that reported no relationship (Wettstein et al., 2015) but in contrast to other reported findings (Kobayashi et al., 2016; Stuckenschneider et al., 2018; Vancampfort et al., 2018). This may in part be due to the small sample size which resulted in a lack of statistical power which has already been discussed in Chapter 4 (4.6). Alternatively, discrepancies between perceived memory issues that were reported, and objectively measured level of cognitive function may suggest that the MoCA may not be sensitive enough as a measure to capture how problematic memory loss is perceived to be by the individual and thus its impact on PA engagement. Therefore, based on the findings of this current study and in accordance with the current literature, memory complaints are a key determinant of PA engagement in this cohort and individuals with more problematic memory complaints are at greater risk of low PA engagement. Individualising assessment to account for subjectively perceived memory complaints may help refine the early targeting of at - risk individuals for PA intervention and may result in improved cognitive outcomes (Sperling et al., 2011).

Participants reported physical limitations for PA engagement, yet this was not found in the quantitative data. This may be because the quantitative measures of physical health used in this current study were not sensitive enough to capture capability for PA engagement. Current quantitative literature regarding the impact of chronic conditions on PA engagement are mixed (Rovner et al., 2016; Vancampfort et al., 2018), but mobility and handgrip strength have been negatively related (Rovner et al., 2016; Vancampfort et al., 2018). In qualitative studies of mixed MCI and AD groups, health problems and disability have been found to negatively impact PA engagement (Chong et al., 2014; van der Wardt et al., 2019), and physical limitations and ill health negatively impacts engagement in adults with dementia (van Alphen et al., 2016). Future studies of PA engagement in individuals with MCI should use more comprehensive measurement of physical capability for PA engagement such as walking speed in addition to grip strength (Cooper et al., 2010), postural control, chair rise time, standing balance time and the Timed Up and Go (TUG) test (Cooper et al., 2015; Sanders et al., 2021). Measuring self - rated health (SRH) may also provide a useful insight into capability for PA in individuals with MCI. SRH is a widely used indicator of subjective health (Kondo et al., 2009) and greater SRH has been positively related to PA engagement in healthy adults, older adults, and cancer survivors (Meyer et al., 2014; Peralta et al., 2018; Zhang et al., 2021). Some studies have investigated SRH and cognitive function with inconsistent results (Combalbert et al., 2018; Ganguli et al., 2019), but there are few studies investigating SRH in the context of being a predictor of PA engagement in individuals with MCI and this gap in the current literature could be addressed in future studies of PA engagement in this population.

Similarly, age was not found to be correlated with the outcome of interest, yet participants in the qualitative sample reported feeling too old to be physically active as a barrier to PA engagement. Subjective age, feeling older than ones chronological age, is negatively associated with cognitive function (Stephan et al., 2014; Stephan et al., 2016) and has been found to be a predictor of MCI and dementia over 4 years in healthy adults (Stephan et al., 2017). However, there is scant literature regarding the relationship between subjective age and physical activity engagement in individuals with MCI. Based on the findings of this study regarding the dissonant findings between participants age related perceptions and PA engagement, and the non – significant correlation between chronological age and PA engagement, incorporating a measure of subjective age, in addition to chronological age, may be informative in future PA research in individuals with MCI.

6.5 Recommendations

Integrated findings were applied to the BCW and cross- referenced with related BCTs from the taxonomy of behaviour change techniques. Based on this process and in conjunction with the limited literature regarding PA engagement support strategies in MCI groups, 3 key recommendations aimed at promoting PA engagement in individuals with MCI were developed. These are to increase knowledge regarding PA in this cohort through a media and primary care-based awareness campaign and the provision of adequate facilities in the community to address barriers to PA engagement at a policy level, and at the intervention level, the provision of group-based instructor led PA interventions is recommended. The formation of recommendations process is represented in Table 18, and recommendations are discussed below.

It should be noted that the following recommendations are primarily derived from qualitative findings rather than quantitative analysis as an unintended function of this study's design, i.e., the quantitative study was found to be underpowered and thus its contribution to identifying barriers and facilitators to PA was less definitive than originally intended. As such, these recommendations, and those in Chapter 9 (9.5) may more productively be understood as suggestions for future research and practice that require further elucidation from quantitative sources.

Table 18.

Recommendation Development Process; Mapping of COM – B and BCW Components to the BCT v1

COM _ Domain	Sub – Theme	Intervention Function (BCW)	Policy Category (BCW)	Example of BCT (BCT v1)	Actions	Recommendations
Psychological Capability	• Participants lacked consistent definition of PA • Participants lacked knowledge regarding PA for brain health • Participants lacked knowledge of how to maintain cognitive function	• Modelling • Environmental restructuring	• Fiscal measures • Guidelines • Recommendations	• 4.1 Instruction on how to perform a behaviour • 5.1 Information about health consequences • 6.1 Demonstration of the behaviour • 6.2 Social comparison	• Media/ health care provider coverage/ promotion of the recommended guidelines for adults and older adults • Coverage/ promotion of the cognitive benefits of PA • Providing suggestions on how to be active with friends or family	• Awareness campaign (2 phase; media, primary care)
Physical Capability	• Participants had physical injuries that limited PA engagement and necessitate PA to be at an acceptable pace	• Environmental restructuring • Education	• Guidelines • Environmental/ social planning	• 12. 1 Restructuring the physical environment • 4.1 Instruction on how to perform the behaviour • 3.2 Social support (practical)	• Provision of instructor led community PA initiatives to cater for physical capability • Recruiting "partners" for individuals with memory issues	• Instructor led, group – based community PA classes (individualised PA, providing reminders) assessment) • Awareness campaign (primary care)

	• Participants experienced memory issues that limit PA engagement			• 7.1 Providing prompts/ cues	• Provision of safe environments for PA engagement	
Physical Opportunity	• Lack of time was a barrier • Being outdoors was a facilitator but was weather dependent	• Incentivisation • Persuasion	• Communication/ marketing • Environmental/ social planning	• 8.2 Behaviour substitution • 8.3 Habit formation • 12.1 Restructuring the physical environment • 12.5 Adding objects to the environment	• Encourage adults to go for a walk instead of watching TV. • Prompt adults to form a PA routine • Provide reminders • PA programmes less frequent/ shorter duration • Increase the availability of all-weather exercise facilities	• Awareness campaign (media and primary care) • Instructor led, group – based community PA classes (enforcing routine)
Social Opportunity	• Participants enjoyed PA that was social in nature	• Persuasion	• Communication / marketing • Environmental/ social planning	• 3.2 Social support (practical) • 3.3 Social support (emotional) • 12.2 Restructuring the social environment	• Encourage adults to recruit partners for exercise • Provide group – based PA classes	• Awareness campaign (primary care) • Instructor led, group – based community PA classes (providing social and practical support)
Reflective Motivation	• Participants believed only cognitive tasks aided	• Training	• Legislation • Service provision	• 4.1 Instruction on how to perform the behaviour	• Public health campaign focused on PA education	• Awareness campaign (media and primary care)

	cognitive function • Participants believed that "exercise" was not enjoyable			• 6.1 Demonstration of the behaviour • 5.1 Information about health consequences	• Enforce PA message through healthcare providers	
Automatic Motivation	• Having a goal/ purpose motivated PA engagement • Being able to exercise at an acceptable pace facilitated PA engagement	• Enablement • Training • persuasion	• Regulation • Service provision	• 3.3 Social support (emotional) • 12.2 Restructuring the social environment • 4.1 Instruction on how to perform the behaviour • 6.1 Demonstration of the behaviour	• Encouraging partners/ group exercise • Provision of PA classes/ programmes at a local level	• Instructor led, group – based community PA classes (individualised for ability, providing goal/purpose)

6.5.1 Recommendation 1: Increase Awareness

Lack of knowledge was identified as a determinant of PA engagement in this study. Application of this finding to the BCW indicated that modelling and environmental restructuring are modes of targeting a lack of knowledge to promote a behaviour, and the BCT further identified the actions of providing instruction on how to perform a behaviour and information about the behaviour as evidence-based methods of increasing the target behaviour, in this case PA engagement. Therefore, the development of a two – pronged public health awareness campaign is recommended to address the current lack of knowledge and promote PA engagement. On a national level, this campaign should focus on promoting PA guidelines and increasing awareness of the benefits of PA for all older adults, including cognitive benefits and ways of being physically active, through the media. This would take the form of television and radio advertisements for national coverage. On a local level, health care providers who come into contact with older adults such as general practitioners, practice nurses, geriatricians and physiotherapists should reinforce this message through providing information and educational material to their patients, especially those with MCI. Suggestions on how to keep active, encouraging the recruitment of a partner for PA and encourage the development of a PA routine, and the substitution behaviours (i.e., encourage going for a walk instead of watching TV) could also be provided. This approach is supported in the literature, with targeted educational material and encouragement from health care providers being found to support ongoing PA engagement in individuals with SCI and MCI (Chong et al., 2020; van der Wardt et al., 2017).

6.5.2 Recommendation 2: Provision of Facilities in the Community

The qualitative findings of this study demonstrate the need for PA assessment and prescription to be individualised based on capability, and this should be applied at a community level to enhance opportunities and access to PA for individuals with MCI. To address the need for an individualised approach to address cognitive and physical barriers to PA engagement, the

BCW identified the intervention functions of environmental restructuring and providing education which target capability and can be achieved through environmental and social planning at a policy level. The BCT identifies targeted restructuring of the physical environment as a viable behaviour change technique in this instance. For example, physically impaired individuals may require specialised equipment and tailoring the environment to participants needs may support PA adherence (Chong et al., 2020). Additionally, tailoring PA to an individual's cognitive needs might require an understanding of their subjective level of cognitive function. The provision of PA interventions in the community provided by instructors trained in catering for differing levels of cognitive and physical capability for PA can address this need. In addition, there is a lack of knowledge regarding PA that can be addressed by providing PA interventions that are guided by an instructor, as in this context an instructor can provide instruction and demonstrate how to perform a behaviour. Therefore, it is suggested that at a health policy level, provision be made for community-based facilities such as the provision of instructor led PA classes for older adults perhaps based in community centres, outdoor parks, or local gyms, which at a local level then would necessitate the running of these types of PA initiatives in communities across the country and the recruitment of trained staff to encourage and enable PA engagement.

6.5.3 Recommendation 3: Group Formatting in Intervention Design

From an intervention design perspective, the provision of PA in an instructor led group – based format is advised to address a number of barriers identified in this study. Physical limitations and memory issues were barriers to PA engagement in this cohort, and as discussed an individualised approach to PA assessment and prescription is recommended. In accordance with the BCT, actions to achieve behaviour change based on these types of barriers require environmental restructuring (such as providing specialised equipment, tailoring exercises to ability), and practical support (such as providing reminders, enforcing routine, safe location) which can be provided in a format that is instructor led and supervised. Some support exists for this approach in the literature, as tailoring PA according to ability and incorporating systemic reminders such as phone calls, exercise logs and pedometers may support long term PA intervention adherence in adults with MCI (Chong et al., 2020; van der Wardt et al., 2017).

Providing PA classes in a group format is also likely to promote ongoing engagement through social interaction. The qualitative findings of this study suggest that having a social aspect to PA enhanced motivation for engagement, in line with the current literature (van der Wardt et al., 2019). According to the BCW, social planning is indicated as a mode of enhancing social opportunity for a behaviour. The behaviour change techniques of restructuring the social environment and providing practical and emotional social support to promote a targeted behaviour were identified from the BCT v1 as actions to achieve this. Some tentative support can be found for this in the current literature, as group – based formats are reportedly a preferred PA intervention format among individuals with MCI (van der Wardt et al., 2017).

6.6 Conclusions

Low PA engagement in this cohort may be determined by cognitive (memory issues), physical (injury/ capability) and practical (lack of time/ weather) barriers and a lack of knowledge regarding PA. However, objectively measured cognitive and physical data may not be sensitive enough to assess capability for PA engagement. Therefore, an understanding of the severity of memory and physical issues from the perspective of the individual with MCI is advised. Thus, it is suggested that PA assessment be individualised in this cohort, and the use of self – rated measures of cognitive and physical health may be necessary. Memory issues, in conjunction with a lack of knowledge regarding what is considered PA may have impacted the accuracy of self – reported PA, offering a possible explanation for the lack of agreement between subjective and objective PA data. It is suggested that collection of objective as well as subjective PA data may be necessary in individuals with MCI to gain a holistic view of PA engagement.

Based on these findings we suggested that at the policy level, focus on raising awareness of PA supported by reinforcement of that message within primary care and on the provision of community-based facilities such as group – based instructor led PA initiatives to promote engagement is advised. PA intervention design could incorporate systemic reminders, instruction and demonstration of PA and provide a group – setting to provide cognitive, physical, and practical support for PA engagement.

6.7 Chapter Summary

This sub – study (1.3) concluded the final phase of Study 1, a mixed methods analysis of the determinants of PA engagement in a sample of Irish individuals with MCI. This chapter presented an integrated synthesis of the findings of sub – studies 1.2 (Chapter 4) and 1.2 (Chapter 5), and recommendations were provided. The integrated findings highlighted the importance of understanding the cognitive and physical determinants of PA engagement from the individual perspective and suggest that an individual approach to assessment of capability for PA is needed, and self – rated measures of health may be useful. Two policy recommendations were presented (increasing awareness and the provision of facilities), and recommendations for future PA interventions are suggested.

Chapter 7: Physical Activity Programme Adherence in Individuals with Mild Cognitive Impairment

7.1 Introduction

There is good prospective (Ahlskog et al., 2011; Andrade & Radhakrishnan, 2009) and cross - sectional evidence (Gallaway et al., 2017; Geda et al., 2010) that regular mid and late life PA is associated with a reduced risk of MCI, dementia and AD. However, systematic review evidence from experimental studies has been less consistent. Many RCTs have found no significant effect of PA on cognitive function in non - impaired populations (Kelly et al., 2014) and a number have reported insufficient evidence for a beneficial effect on cognitive function in people with dementia (Forbes et al., 2008). In addition, some reviews have found no consistent evidence to support the role of PA in preventing or delaying MCI or dementia (de Souto Barreto et al., 2018; Kane et al., 2017). In contrast, a number of systematic reviews have concluded that PA interventions benefitted cognitive function in non – impaired adults (Barha et al., 2017; Northey et al., 2018) and in those with MCI (Loprinzi et al., 2019; Song et al., 2018).

The reasons for these inconsistent findings in RCT`s may be because of methodological differences between studies, such as differences in study and programme design (e.g. duration/ mode of PA), outcome measures (Kelly et al., 2014; Song et al., 2018), follow up times (Kane et al., 2017) and differing definitions of PA across studies (Rockwood & Middleton, 2007). Another possible reason for these inconsistent findings may be that the variability in PA programme adherence reported across studies has impacted RCT results (Kane et al., 2017; Kelly et al., 2014). As greater PA programme adherence has been associated with better cognitive outcomes in individuals with MCI (van Uffelen et al., 2008), understanding its determinants is an important area of focus to address inconsistent adherence and inform intervention design targeting cognitive decline.

As previously discussed in the mixed methods systematic review of this thesis (Chapter 3, section 3.3.2.3), rates of PA programme adherence and its determinants in individuals with MCI are difficult to interpret due to considerable methodological differences in programmes under investigation (Di Lorito et al., 2020). For instance, there was considerable variation in reported rates of PA programme adherence which ranged from 49% - 90% across studies (de Oliveira Silva et al., 2019; Tak et al., 2012) possibly resulting from differences in intervention design factors such as duration (ranging from 3 – 12 months) (Cox et al., 2013; de Oliveira Silva et al., 2019), modes of PA employed (multi – modal, walking, strength and balance) (Cox et al., 2013; Di Lorito et al., 2020; Hancox et al., 2019) and level of supervision (home – based, class – based or home – based and telephone monitored) (Cox et al., 2013; Hancox et al., 2019; Lam et al., 2015). However, there is a lack of data regarding the impact of programme related factors on the outcome of PA programme adherence in individuals with MCI.

In addition, few studies have examined the correlates of PA programme adherence in MCI cohorts and research on PA programmes in community dwelling adults often excludes those with cognitive impairment (Logsdon et al., 2009). In those that have, findings regarding the impact of cognitive function on PA programme adherence have been mixed (Cox et al., 2013; Di Lorito et al., 2020; van Uffelen et al., 2009; van Uffelen et al., 2008). Physical function (Uemura et al., 2013) and being male (Cox et al., 2013), living with a partner for males only (van Uffelen et al., 2008), and a higher level of education (Cox et al., 2013) have been positively associated with PA programme adherence. Depression and baseline PA (for males only) were found to be negatively associated (van Uffelen et al., 2008). Thus, there are limited and inconsistent data on the impact of cognitive, physical, demographic, and psychosocial variables on PA programme adherence in individuals with MCI. Further, there is a lack of evidence regarding the possible mediating effects arising from interactions with conditions common in individuals with MCI such as frailty and chronic illness (Delbaere et al., 2012; Lopez et al., 2003; McKinnon et al., 2019). Further, the findings of Chapter 3 identified a lack of PA programme adherence data or evidence of the determinants of programme adherence in an Irish context.

To achieve greater adherence to PA programmes targeting cognitive decline in individuals with MCI and potentially improved cognitive outcomes, clarification regarding the impact of programme related factors and correlates of programme adherence are needed to inform and refine intervention design in terms of supporting adherence. Thus, the objective of this study was to address objective 2, sub – objective 2.1 of this thesis. This was to quantitatively assess the impact of a range of cognitive, demographic, physical, psychological and programme related variables on adherence as part of a mixed methods analysis of the determinants of PA programme adherence in Irish adults with MCI.

It was hypothesised that PA programme adherence would differ between implementation condition (class or home - based), PA type (aerobic or strength & tone), and duration (between 6 months and 12 months). Further, it was hypothesised that the degree of cognitive impairment would be associated with PA programme adherence when the effect of age, education, baseline PA, chronic illness, frailty, quality of life and level of depressive symptoms were controlled for.

7.1.1 Objectives

The objectives of this study were to:

1. Describe and explore PA programme adherence according to 3 programme related factors; intervention conditions (aerobic/ stretch and tone), session type (class/ home – based) and time – point (6 months/ 12 months) by comparing means.
2. Investigate the association between cognitive (MoCA), demographic (age, years of education), physical (handgrip strength, number of medications, baseline PA) and psychosocial (CES – D, DemQoL) measures and PA programme adherence by conducting multivariate analysis.

7.2 Methods

7.2.1 Design

This was a descriptive multivariate analysis exploring the link between cognitive function, other covariates, and PA programme adherence using secondary data from the Neuro Exercise study (see Chapter 2, section 2.1.2). The independent variable was cognitive function. Covariates were age, years of education, frailty, chronic illness, depression, quality of life and baseline PA. The intervention variable was exercise condition (aerobic or stretch & tone). The dependent variables were total PA programme adherence, class – based and home – based adherence.

7.2.2 Participant Characteristics

Participants were 41 individuals aged 50 years + with MCI (56 % male, n = 23, mean age 71 (*SD* = 6.0)) that consented to participate in the NeuroExercise study. Inclusion criteria was determined by NeuroExercise protocol. As the outcome of interest was adherence to the PA programme, only the two active conditions were included in analysis.

7.2.3 Sampling, Sample Size & Precision

This secondary analysis purposively sampled all participants from the aerobic and stretch and tone NeuroExercise intervention conditions. The aerobic group (n = 19) and the stretch & tone group (n = 22) were included in analyses (N = 41). A priori power calculations using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) suggest that the sample size needed for adequately powered multiple regression analysis using 8 predictor variables and testing 3 outcome variables, employing an alpha of .05, and an estimated effect size of .3 (based on previous studies in this field (van Uffelen et al., 2009)) was 62 participants. The sample size of n = 41 used here suggest this analysis was underpowered.

7.2.4 Recruitment & Randomisation

Recruitment and randomisation of study participants was a function of the NeuroExercise study protocol which is described in further detail in Chapter 2 (section 2.2.2 – 2.2.4).

7.2.5 Measures

7.2.5.1 Dependent Variables

7.2.5.1.2 Adherence. Adherence to class sessions was recorded by the instructor. Adherence to home - based sessions was self- reported via exercise diaries returned during class sessions. Adherence to the programme was calculated as both a count variable (number of sessions completed) and a percentage (number of sessions completed over the total number of sessions prescribed) for use in regression and for comparisons of means, respectively. For instance, if a participant successfully completed 72 sessions of the total 144 prescribed sessions, they would have achieved an adherence percentage of 50%. Adherence was subdivided into three study outcomes; adherence to class – based sessions, adherence to home – based sessions, and total PA programme adherence (class – based plus home – based session adherence).

7.2.5.2 Independent Variable

7.2.5.2.1 Cognitive Function. Cognitive function was measured using the Montreal Cognitive Assessment (MoCA) (Nasreddine et al. 2005), a 30 – item researcher-administered scale assessing visuospatial and executive function, naming, verbal memory registration and learning, attention, abstraction, delayed verbal memory, and orientation (see Chapter 4, 4.3.3 for more detail). The full MoCA questionnaire is provided in Appendix I.

7.2.5.2.2 Demographics. Demographic information for age and years of education was collected at baseline and were included as covariates in regression analysis.

7.2.5.2.3 Baseline PA. PA was measured using the Actigraph GT3X (Actigraph, Pensacola, Fl, USA) accelerometry device which participants wore on the hip for seven days. The Actigraph is described further in Chapter 4. It is a valid (Barrett et al., 2017; Ozemek et al., 2014) and reliable tool for measuring PA engagement in non – impaired adults (Aadland & Ylvisaker, 2015). Data was extracted and analysed using ACTi life software Version 6.13.1.

7.2.5.3 Psychological Measures

7.2.5.3.1 Quality of Life. Health related quality of life was measured using the Quality of life for Dementia questionnaire (DemQoL (Smith et al., 2005)), which is described in more detail in Chapter 4 and the full questionnaire is provided in Appendix J. The Cronbach coefficient was .87 for this sample.

7.2.5.3.2 Depressive Symptomatology. Depressive symptomatology was measured using the Centre for Epidemiologic Studies Depression scale (CES- D 20) (Radloff, 1977). See Chapter 4 for a full description. Cronbach's alpha of .78 showed a high level of internal reliability in this sample. The full questionnaire is presented in Appendix K.

7.2.5.3.3 Medication Load. Medication load was used as a proxy measure of chronic illness (Rovner et al., 2016). All regular medications were recorded by the research team and a medication count performed, excluding vitamin supplements, over the counter eye/ nasal drops and herbal treatments, in line with previous studies (Agostini et al., 2004).

7.2.5.3.4 Physical Frailty. Upper limb strength was used here to indicate frailty status using a Jamar Digital Dynamometer measure of hand- grip strength (see Chapter 4 for more detail). Participants were asked to squeeze the dynamometer for 5 seconds with their arm placed at a right angle by their side, three times per hand. Data relating to dominant handedness was used in this analysis.

7.2.6 Missing Data

Table 19 presents the missing values for all study variables. A missing values analysis indicated that Littles (1998) test of MCAR (missing completely at random) was not significant (x^2 = .000, DF = 93, p = 1.0). A p value of > .05 assumes that data is missing completely at random. Missing cases were excluded using pairwise deletion methods to maximise all data available.

Table 19.

Overview of Missing Data

Variable	N	Missing count (%)
Age Screening	41	0
Years Education	41	0
Actigraph	39	2 (4.9%)
Baseline MoCA	41	0
Ces- D	38	3 (7.3%)
DemQoL	41	0
Handgrip Right	39	2 (4.9 %)
Number of Medications	40	1 (2.4%)

Adherence		
Class session Adherence	41	0
Home Session Adherence	41	0
Total Programme Adherence	41	0

7.2.7 Statistical Analysis

Analysis was carried out using SPSS V.25. Linearity was inspected using scatterplots for the independent variable of cognitive function (MoCA), the covariates of age, years of education, baseline PA (Actigraph), chronic illness (number of medications), frailty (handgrip strength), depression (CES -D), quality of life (DemQol) and the dependent variables of total programme, class – based and home – based adherence (Appendix Z, Figure A11). Kolmogorov - Smirnov values were used to assess distribution of variables (Table 20). Number of medications, MoCA, baseline PA, and class – based adherence data were not normally distributed. Boxplots were inspected for the presence of outliers. Depression (CES - D) and quality of life (DemQoL) each had one outlier, which were not removed from the dataset on inspection of trimmed means. Boxplots of outliers for the CES -D and DemQoL are presented in Appendix AA (Figures A12 & A13 respectively). Multicollinearity and homoscedasticity were diagnosed using the linear regression function in SPSS. Variables were not highly correlated to one another; however, residuals were slightly clustered in analysis of scatterplots (multicollinearity tables and scatterplots for adherence outcomes are presented in Appendix BB (Table A15 and Figure A14 for total programme adherence), Appendix CC (Table A16 and Figure A15 for class adherence) and Appendix DD (Table A17 and Figure A16 for home adherence). Adherence outcome variables (total adherence, home – based and class – based adherence) were converted to percentages using the compute variable function in SPSS for comparisons of means and used as a count variable for regression analysis.

Alpha was set at $p < 0.005$ (i.e., 0.05/ 10 tests) to account for multiple comparisons using the Bonferroni method. Non – parametric tests were used to account for the non – normal distribution of data. A Wilcoxon Signed Rank test was used to assess differences in % adherence between class-based and home – based sessions. 3 Mann -Whitney U tests were used to test for differences in adherence outcomes (total adherence, home – based and class adherence) by intervention condition (aerobic /stretch & tone). Three Wilcoxon Signed Rank tests were used to test for differences in adherence outcomes (total adherence, home – based and class adherence) at 6 and 12 months. Three Negative Binomial regressions were used to explore the association between demographic, cognitive, physical, and psychosocial variables, and adherence outcome variables.

Table 20.

Assessment of Normality

Variable	Kolmogorov – Smirnov	P values
Age	.09	.20
Education	.10	.20
Number of meds	.16*	.01
MoCA	.17*	.04
Handgrip	.12	.19
DemQol	.12	.19
CES – D	.09	.20
Baseline PA	.19*	.00
Total PA programme adherence	.09	.20
Total class adherence	.15*	.02
Total home – based adherence	.11	.20

*$p < .05$ indicates violation of the assumption of normality.

7.3 Results

7.3.1 Descriptive Statistics

The Median MoCA score was 23 (*IQR*: 20, 24) and mean years of education was 13.4 (*SD* = 3.6). Participants had a mean CES -D score of 10.8 (*SD* = 6.1) and mean DemQoL was 91.4 (*SD* = 10.7). Participants regularly were taking a mean of 3.6 (*SD* = 2.3) medications. Mean adherence to the programme was 55% (*SD* 48.4). Mean adherence was higher for class (*M* = 63.4, *SD* = 31.9) than for home - based sessions (*M* = 49.3, *SD* = 37.0). Means, Medians and Interquartile Ranges (*IQR*) for all study variables are reported in Table 21 with normative values for comparison where available.

Table 21.

Means, Medians, Standard Deviations & Interquartile Ranges for all Study Variables.

Current study					Normative values	
Variable	*Md* (*IQR*)	*M* (*SD*)	Range			*M* (*SD*)
			Min	Max		
Age in years	72. (67.0, 76.0)	71.4 (6.0)	56	84		
Years of education	13.0 (10.5, 16.0)	13.4 (3.6)	7	22		
Baseline MoCA	23.0 (20.0, 24.0)	22.1 (2.5)	18	26		24.6 (3.2)****
Baseline PA in minutes per week	64.0 (10.0, 181.0)	114.5 (123.4)	0	377		
Handgrip males (in Kg)	32.5 (28.5, 42.5)	35.0 (8.7)	20	48	Males <173cm	31.8 (6.7)****
					Males > 173cm	36.1 (7.1)****
Handgrip females (in kg)	19.2 (16.0, 22.9)	20.0 (5.4)	13	32	Females < 160cm	19.1 (3.9)****
					Females > 160cm	21.6 (4.4)****
Number of medications	3.0 (2.0, 5.0)	3.6 (2.3)	0	9		2.4 (2.6)***
CES- D Scores	11.0 (6.8, 14.0)	10.8 (6.1)	0	26		9.4 (9.1)*****
Dementia Related Quality of Life (DemQol)	93.0 (85.0, 99.0)	91.4 (10.7)	65	109		
Total PA programme adherence %	60.4 (27.4, 82.6)	54.8 (33.6)	0	115		

Class - based adherence %	75.0 (42.0, 88.4)	63.34 (31.9)	0	104
Home – based adherence %	45.5 (15.3, 78.4)	49.3 (37.0)	0	126

Note. *Population norms for educational attainment of Irish adults derived from TILDA data (Kearney et al., 2011). *** Data cited by Peklar et al. (2017) for Irish adults aged 50 years + obtained from TILDA. **** Normative muscle strength and MoCA values for adults 70 years + derived from TILDA data stratified by height (Kenny et al., 2013). ***** Population norms for Australian adults aged 25 – 90 years (Crawford et al., 2011).

7.3.2 Inferential Statistics

7.3.2.1 Objective 1: PA Programme Adherence

A Wilcoxon Signed Rank test indicated that the difference in % rates of adherence between class and home - based sessions was statistically significant, $z = -3.85$, $p = < .001$, with a large effect size ($r = .6$). The median rank scores were 22.2 and 12.7, respectively.

A Mann Whitney U test showed that mean adherence did not differ significantly by intervention condition for the aerobic ($M = 22.9$) or stretch and tone ($M = 19.3$) groups for total PA programme adherence ($U = 172.5$, $p = .347$). Mean adherence did not differ by intervention condition for the aerobic ($M = 21.2$) or stretch and tone ($M = 20.8$) groups for class adherence ($U = 205.5$, $p = .933$). Mean adherence did not differ by intervention condition for the aerobic ($M = 23.8$) or stretch and tone ($M = 18.61$) groups for home - based adherence ($U = 156.5$, $p = .173$).

A series of Wilcoxon signed rank tests revealed that there was no significant difference in total PA programme adherence between 6 months ($Md = 58.4$, $IQR = 20.8, 80.5$) and 12 - month adherence measures ($Md = 55.9$, $IQR = 15.6, 76.6$). There were no differences in median adherence at 6 months ($Md = 47.5$, $IQR = 1.3$ 86.3) and 12 months ($Md = 52.1$, $IQR = 0, 82.3$) for home - based adherence (z = -1.128, $p = .259$), or between 6 months ($Md = 81.3$, $IQR = 42.2, 87.5$) and 12 months ($Md = 70.8$, $IQR = 25, 89.6$) for class adherence ($z = -1.389$, $p = .165$).

7.3.2.2 Objective 2: Testing for Relationships

A negative binomial regression analysed the relationship between the independent variable of cognitive function (MoCA), the covariates of age, education, baseline PA (Actigraph), handgrip strength, quality of life (DemQoL) and depression (CES – D) and the outcome of total PA programme adherence. The model was not significant ($p = .536$). Higher MoCA score was associated with increased total PA programme adherence (OR = 1.23, 95% CI [1.01, 1.51], p = .

043) but this effect was not significant following adjustment for multiple comparisons. No independent variables were significantly associated with total PA programme adherence, but regression coefficients show that total PA programme adherence increased by one session for every additional minute of baseline PA (OR = 1.00, 95% CI [1.00, 1.01], *p* = .17).

A second negative binomial regression was conducted to analyse the effect of the same independent variable and covariates on class adherence. This model was non – significant (*p* = .817). Cognitive function (MoCA) was not significantly associated with class – based adherence (OR = 1.16, 95% CI [.96, 1.41], *p* = .132). No other variables were significantly associated with class – based adherence, but for every additional minute of baseline PA the odds of class – based adherence was 1 time greater (OR = 1.00, 95% CI [1.00, 1.00], *p* = .42).

Finally, a negative binomial regression with home - based adherence as the outcome measure showed that for every additional MoCA score, home – based adherence increased by 1.32 sessions (OR = 1.32, 95% CI [1.06, 1.64], *p* = .013,). However, this effect was not significant following corrections to alpha for multiple comparisons. No other variables were statistically significant. The model overall was not significant (*p* = .254). Exponentiated coefficients (Odds Ratios), confidence intervals and *p* values are presented in Table 22.

Table 22.

Negative Binomial Regression Models for Total, Class and Home - Based Adherence Variables.

	Total Adherence				Class Adherence				Home - Based Adherence			
		95 % CI				95 % CI				95 % CI		
	OR	Lower	Upper	*p*	OR	Lower	Upper	*p*	OR	Lower	Upper	*p*
MoCA	1.23*	1.01	1.51	.04*	1.16	.96	1.41	.13	1.32**	1.06	1.64	.01*
Age	1.03	.97	1.10	.36	1.02	.96	1.09	.56	1.04	.98	1.12	.22
Years of education	.94	.83	1.06	.30	.95	.84	1.07	.42	.92	.81	1.04	.20
Baseline PA	1.00	1.00	1.01	.17	1.00	1.00	1.00	.42	1.00	1.00	1.01	.06
Number of medications	1.04	.88	1.24	.65	1.02	.86	1.21	.83	1.07	.90	1.27	.46
Handgrip	1.01	.97	1.06	.49	1.01	.98	1.06	.49	1.02	.97	1.06	.49
Quality of life	1.00	.95	1.05	.96	1.00	.95	1.05	.97	1.00	.95	1.05	.99
Depression	1.02	.95	1.10	.60	1.02	.95	1.10	.55	1.02	.94	1.10	.62

Note. *p = < .05, **p = <.005.

7.4 Discussion

The objective of this study was to report adherence to a 12-month PA programme for individuals with MCI, and to quantitatively assess the relative contribution of cognitive, demographic, physical, psychological and programme related variables on PA programme adherence. Overall, PA programme adherence was low (55%). Adherence was higher for class - based than for home - based sessions. Cognitive function was correlated with total adherence and home – based adherence but this effect was not statistically significant after adjustment for multiple comparisons. Demographic, physical, and psychological variables were not related to PA programme adherence.

Adherence was low overall (55%), particularly for home – based sessions (49%), consistent with some study reports of 49 – 63% for programmes of similar duration (Tak et al., 2012; van Uffelen et al., 2008). However, this differs from the mean 70.5% adherence rate for PA and PA plus multimodal programmes reported by Di Lorito et al. (2020), though the majority of studies included in that review were group – based rather than home - based interventions, with group – based PA formats more likely to result in greater programme adherence. A strength of this current study was that the implementation of the programme in more than one format allowed for a comparison of adherence by setting, showing that the implementation condition (class versus home – based), was significantly related to PA programme adherence. The findings of this study add to those of Di Lorito et al. (2020) and suggest that supervised class conditions may result in superior PA programme adherence in this cohort as compared with individual or home – based PA. This is consistent with the literature in non – cognitively impaired groups demonstrating that supervised session adherence is better than for unsupervised conditions (Arikawa et al., 2011; Courneya et al., 2012; Cox et al., 2003; El-Kotob & Giangregorio, 2018)

It is unclear from these findings why, or what the components of a class – based or "supervised" programme are that drive adherence. It may be that the additional support provided in a supervised context is important for individuals with MCI; however little quantitative evidence can be found to explain the difference in adherence between these implementation conditions. There is some tentative qualitative support for the role of the instructor in PA programme adherence. For instance, post – programme maintenance has been found to be influenced by instructor characteristics and quality (Tak et al., 2012) suggesting that facets of the instructor themselves may impact PA programme adherence. This is consistent with findings in cognitively healthy older adults that the quality of the instructor were important in maintaining participation in PA programmes (El-Kotob & Giangregorio, 2018; Stiggelbout et al., 2006). Other factors may also have impacted the difference in class adherence over home session adherence. For example, techniques to support memory, and providing practical and emotional support to participants were facilitators to PA programme adherence in one recent qualitative study (Hancox et al., 2019) and in this current analysis, there may have been ancillary benefits arising from the structure of the class sessions. Based on these findings, further examination of the underlying factors that enhance adherence in relation to a supervised or class setting would be useful to inform future intervention design.

Though there was a trend toward lower adherence at 12 months (49%) than at 6 months (54%), PA programme adherence did not differ significantly between time – points, contrary to our hypothesis. This finding is similar to that of Di Lorito et al. (2020) who found no statistically significant difference in adherence over time, but in contrast with one study that reported that PA programme adherence significantly decreased over time (Cox et al., 2013). In addition, there were no significant differences in adherence between the aerobic or stretch and tone conditions, suggesting that programme supervision may be more important for adherence than the type of PA or duration of programme. This finding is in line with findings from one study which also found no difference in mean adherence between a low intensity activity programme and a moderate intensity walking programme in Dutch individuals with MCI (Tak et al., 2012). The reason for the contrasting results in the literature may be that Cox et al. (2013) compared an aerobic group with a control condition, who were required to continue with their usual level of PA. This may have been biased by differential attrition, whereas in this study and in that reported by Tak et al. (2012) participants in both exercise conditions were prescribed PA.

Cognitive function was not significantly associated with total PA programme adherence, home – based or class – based adherence overall. However, there was a moderate positive association between cognitive function and total adherence before the alpha level was adjusted to account for multiple comparisons. Each one - point increase in MoCA scores corresponded with a 1.23% increase in PA programme adherence, with confidence intervals suggesting a moderate positive association. Similarly, unadjusted analysis found that cognitive function was associated with adherence to home - based sessions, with an increase of 1.32% in adherence for every increase in MoCA score. However, following corrections to the alpha we failed to reject the null hypothesis that cognitive function is associated with PA programme adherence. This finding is in line with findings from two studies reporting no differences in PA programme adherence between individuals with MCI and cognitively healthy participants (Cox et al., 2013; van Uffelen et al., 2008) but in contrast with another which reported a weak but positive association between cognitive function and adherence for two active intervention conditions of an RCT (van Uffelen et al., 2009). Based on the effect sizes and confidence intervals of regression analysis in this study, it is likely that the negative findings of this current study were due to an increased risk of type II error and therefore should be interpreted with caution.

Finally, it is worth considering the reliability of self report PA diaries in this population. In this study, class session adherence was recorded by the research team, but home – session adherence was self – reported weekly using PA diaries. Self – report methods of PA reporting are prone to underestimation and have low – moderate correlation with direct observation of general PA engagement in adults (Prince et al., 2008; Siebeling et al., 2012).Systematic review evidence suggests that self – report measures of adherence to unsupervised PA interventions are generally unreliable, and lack validity (Bollen et al., 2014). In addition, cognitive impairment may have further negatively impacted their reliability (Cumming & Klineberg, 1994; Helmerhorst et al., 2012). Indeed, study 1, sub – study 1.3 (Chapter 6) of this thesis found that self – reported PA was inaccurate in this sample and may have been impacted by memory issues and a lack of clarity regarding defined PA. Thus, the differences in programme adherence between class and home sessions may have partially resulted from imperfect recording of adherence of home sessions.

7.5 Limitations

This study has a number of limitations. Firstly, the small sample size and lack of power may have increased the risk type II error. Secondly, this study was unable to determine the key components of class – based sessions that supported greater adherence due to the way in which the programme was implemented. In other words, it was not possible to determine whether supervision by a trained professional, a group – based approach or other factors resulted in the difference in adherence between class and home – based sessions. Thus, the role of programme related factors requires further investigation to better understand the determinants of PA programme adherence in this population. Finally, though class session adherence was recorded by an instructor, home – session adherence was self – reported by participants in PA diaries and study 1 has suggested that memory issues may negatively impact the accuracy of self – report PA data in this cohort.

7.6 Conclusions

Adherence to a 12 - month PA intervention for individuals with MCI was low. Cognitive, demographic, physical, and psychological variables were not statistically associated with PA programme adherence, but results should be interpreted with caution as a lack of power may have masked an effect of cognitive function on home – session adherence which requires further investigation in larger samples. Adherence was greater for class compared with home – based programme setting, indicating that a providing a group setting or level of supervision may be an effective way of optimising PA programme adherence in MCI. However further research is needed to ascertain the “active ingredients” of supervised or class – based sessions, and/ or the barriers to home - session adherence to identify best practice for PA programme design for this population. Qualitative research may be useful in teasing apart these issues.

7.7 Chapter Summary

This chapter presented sub – study 2.1, a multivariate analysis of adherence to a 12 – month PA programme as part of a mixed methods analysis of the determinants of PA programme adherence in Irish individuals with MCI. Programme adherence was low. No associations were found between programme adherence and the cognitive, physical, demographic, or psychological variables tested. Class -session adherence was significantly higher than home – session adherence, but programme duration and intervention condition were not related to adherence.

Chapter 8: An Exploration of the Barriers and Facilitators of Physical Activity Programme Adherence in Individuals with MCI

8.1 Introduction

In addition to a lack of clarity regarding PA programme adherence in the quantitative literature, there is a lack of insight into the factors that impact PA programme adherence from the perspective of individuals with MCI. For instance, commonly cited reasons for non – adherence to PA interventions as reported by participants are health related problems such as illness, injury, and mobility (Cox et al., 2013; Tak et al., 2012; van Uffelen et al., 2009) but there is a lack of detail in the literature expanding on this and thus a lack of understanding of type of illness, injury or mobility issues that impact PA programme adherence in individuals with MCI, or how this might occur. Although these findings provide a basis for determining possible issues relating to PA programme adherence in this cohort, further research is needed to identify and explain the barriers and facilitators to adherence from the perspective of individuals with MCI to understand the variability in PA programme adherence and optimise cognitive outcomes.

One study has provided explanatory detail of the barriers and facilitators to adherence to a home- based PA programme for individuals with MCI and mild dementia (Hancox et al., 2019). That study reported that the six themes of routine, practical, and emotional support, memory support, purpose, past - experience, and belief in the benefits of PA were associated with adherence. In that study, routine referred to how consolidating programme adherence as a habit helped to enhance programme adherence. The theme of practical and emotional support illustrated how carers socially influenced adherence through helping participants complete programme exercises and providing encouragement. Memory support in that study was provided by carers and clinicians in the form of prompts for exercise. Developing a routine made adherence habitual and less likely to be forgotten. Having a strong past history of sport or exercise and an identity as being active was an important theme for programme adherence. Additionally, having a clear purpose for adherence such as maintaining physical or psychological health was a key determinant of adherence. This was further impacted by having a belief that PA was a beneficial activity. However, these findings are derived from just one study, and that study used a combined MCI and dementia sample. Since it is not known if the barriers and facilitators of programme adherence in MCI differ from those in adults with dementia, further exploration of the factors specific to individuals with MCI is needed. In addition, the literature in this area overall has focused on either supervised or centre - based PA programmes, with little data regarding adherence to individual or home – based programmes. Thus, it is unclear, especially within the qualitative literature, whether programme setting, or format is a determinant of PA programme adherence from the perspective of the participant.

The factors that impact on PA programme adherence in MCI cohorts are not well documented and require further exploration and contextualisation to be useful in understanding the determinants of adherence in this group. Understanding these determinants in this population is an important area of focus to understand inconsistent experimental evidence and variability in reported adherence, and to inform intervention design and optimise cognitive outcomes. This study aimed to explore the barriers and facilitators of adherence to a 12 – month class and home – based PA programme in a sample of Irish adults aged 50 + with MCI to address the gaps in the extant literature as part of Study 2, sub – objective 2.2 of this thesis.

8.2 Methods

8.2.1 Design and Rationale

This inductive qualitative sub – study (2.2) used thematic analysis (Braun & Clarke, 2006) to explore and analyse the barriers and facilitators of PA programme adherence in this cohort to address a gap in the literature and further our understanding. Further detail regarding the rationale for and use of thematic analysis has been provided in Chapter 5 (section 5.2.1). This approach allowed for the gathering of rich information regarding the phenomenon of adherence to a PA programme from the participants perspective, within the context of experiencing cognitive impairment. It also allowed for the integration of correlational quantitative data and experiential qualitative data to contribute to the mixed methods analysis of the determinants of PA programme adherence in individuals with MCI (Study 2).

8.2.2 Participants and Sampling

Participants were 12 adults (mean age = 73, *SD* = 5.81, 58% male) with MCI recruited from the NeuroExercise study (Chapter 2, section 2.2.1). Participants were eligible for inclusion if they had completed either the NeuroExercise aerobic or stretch and tone programmes and had exited the study between June 2017 and July 2018. Participants were excluded from the study if they had been randomised to the passive control condition.

Participants were sampled using a combined purposive – convenience sampling approach. Purposive sampling is commonly used in qualitative research to ensure data is collected from those best placed to offer insight into the phenomenon under investigation (Creswell, 2015). In this instance, this was based on participants' inclusion in the active intervention conditions i.e., the aerobic or stretch and tone groups. Convenience sampling typically involves drawing on participants that are easily accessible (Teddlie, 2009; Teddlie & Yu, 2007). As participants were targeted for inclusion as they approached the completion of the 12 – month programme, this also constitutes a convenience sample.

8.2.3 Recruitment

Participants were recruited from the NeuroExercise study between June 2017 and July 2018. On completion of NeuroExercise assessments, participants were approached by a researcher (LC) and briefed on the study. They were invited to take part in a single interview in addition to their participation in NeuroExercise. Participants were provided with a Patient Information

Leaflet (PIL, Appendix U) outlining the study aims and detailing the role of the participant and researcher. Participants were then contacted by the researcher (LC) to arrange an interview. All participants who were approached for interview agreed to take part in this study.

8.2.4 Intervention

The NeuroExercise intervention consisted of 12 – months of aerobic or stretch and tone sessions, or a passive control condition. The aerobic programme consisted of 60 minutes of aerobic PA (elliptical training, outdoor walking ,treadmill walking) 3 times per week. The stretch and tone programme consisted of 60 minutes of coordination, balance, light resistance and stretching exercises 3 times per week. The programme involved 56 physiotherapist led class sessions and 88 unsupervised, unstructured home - based sessions, totalling 144 sessions. The programme was implemented as follows; two hospital - based class sessions and 1 unstructured home -based session per week for the first 8 weeks of the intervention, followed by 1 hospital - based class session and 2 home – based sessions for the remaining 10 months. Class adherence was recorded by the physiotherapist who was a study researcher. Home adherence was self-reported in PA diaries by participants and submitted to the research team weekly. Rates of adherence to the NeuroExercise programme are detailed in Chapter 7 (section 7.3.2) of this thesis.

8.2.5 Data Collection and Analysis

Semi- structured interviews were conducted by one researcher (LC) in the Clinical Research Facility in St. James`s Hospital, Dublin. Participants were familiar with the location and the researcher in advance. Prior to commencement of the interview participants provided informed written consent.

8.2.5.1 Topic Guide and Piloting

A topic guide was developed for use during interviews to promote discussion based on a gap in the current literature regarding the barriers and facilitators of PA programme adherence in an MCI specific sample. The topic guide was not derived from a full literature review in line with the grounded theory method (see Chapter 2, section 2.2.7 for details). Instead, the topic guide was designed to elicit participants opinions regarding PA and adherence to this PA programme. The topic guide was piloted prior to data collection and amended based on feedback from one lay person and two research colleagues. The topics included participants feelings and opinions about PA, their experience of living with MCI, and their experience of participating in the PA programme. The full topic guide is provided in Appendix EE.

8.2.5.2 Interview Process

Interviews took place between June 2017 and August 2018, with participants giving interviews shortly following (typically within a week) their final PA session. Participants were advised that interviews may last up to 1 hour. The mean interview time was 30 minutes (between 21 and 45 minutes). All interviews were conducted, audio recorded and later transcribed verbatim by one researcher (LC). Only the interviewer and participant were present for the interview process. Participants were interviewed once.

8.2.5.3 Analysis Strategy

Analysis followed the six- step iterative approach to thematic analysis (Braun & Clarke, 2006) outlined previously in Chapter 5 (section 5.2.4.3) of this thesis. Analysis was performed using the qualitative data analysis software package NVivo version 12.

The transcription of interviews facilitated familiarisation with the data. Coding was conducted by one researcher (LC) and reviewed by a second researcher (AW) to ensure themes and codes were an accurate representation of the data. Initial coding was conducted using line- by – line coding of the full dataset to generate initial codes. Data was labelled and sorted according to similarity of content to search for themes. In vivo code labels were derived from the data and used as code descriptors. Examples of early line by line coding are presented in Table A17, Appendix FF. Data was analysed at the semantic level.

Early themes were used to develop a coding matrix to compare patterns within and across cases to develop potential themes. Cases were examined for patterns and associations between phenomena within cases using case summaries. An example of early theme development is provided in Table A18, Appendix GG. Analysis of patterns between groups of cases was conducted using case classifications. Cases were grouped on the basis of age, gender, level of MCI, level of adherence, and level of motivation (i.e., reviewing themes). A thematic framework was developed and tested against all transcripts and coding indices to ensure that themes and codes were well developed and representative of the data (i.e., defining and naming themes). An example of later theme development is provided in Table A19, Appendix HH. A detailed account of each theme was written to ensure that each theme fitted with the narrative of the data and were understandable and robust (i.e., writing the report). The thematic analysis process was guided by Braun and Clarkes 15 – point checklist of criteria (Braun & Clarke, 2006) (Appendix Y). Data saturation was determined when informational redundancy had been achieved (Sandelowski, 1995). This occurred following 10 interviews, however a further 2 interviews were subsequently conducted to ensure saturation.

8.3 Findings

Three key themes were identified in this analysis. These were “motivation”, “support”, and. “ individual experience”. To enable comparison between participants based on level of programme adherence, participants were stratified based on previous estimates of PA programme adherence in MCI cohorts which range from 49 – 70% (Di Lorito et al., 2020; Tak et al., 2012; van Uffelen et al., 2008). The classifications of programme adherence were low (0 – 49% of prescribed sessions completed), moderate (50 – 74 %) and high adherence (< 75%). For class session adherence, 1 participant was grouped as having low adherence, 1 had moderate adherence and 10 were grouped as having high adherence. In terms of home sessions, 3 were grouped to low adherence, 1 to moderate and 8 as having high adherence. Table 23 presents the key themes, sub – themes and codes.

Table 23.

Table of Themes, Sub – themes and Codes

Theme	Sub – theme	Code
Motivation	Internal motivation	Belief in/seeing the benefits of PA
		Attitudes to cognitive/ physical decline
		Awareness of the cognitive benefits
	External motivation	Guidance & supervision
		Routine
		Feeling accountable
Support	Practical support	Guidance & supervision
		Routine & structure
	Group support	Fitting in
		Making friends
		Enjoyment
Individual experience	Memory complaints	Mild, moderate, severe memory complaints
	Physical health	Co – morbidity, injury

8.3.1 Theme 1: Motivation

Motivation was a key theme present across the dataset and includes the sub – themes of internal and external levels of motivation as being related to PA programme adherence. The theme of motivation was developed through identification of patterns relating to the participant characteristic of having high or low motivation for PA and PA programme adherence, and the value placed on externally derived motivation for adherence. Participants were characterised as having high or low internal motivation based on within case analyses and summarising the tone of participants attitude toward engaging in and adhering to the PA programme.

8.3.1.1 Internal Motivation

Internal motivation was an important determinant of home session adherence. Internal motivation refers to participants` individual level of "readiness" for PA. Internal motivation was influenced by attitudes to physical and cognitive decline and awareness of how to impact decline, having a belief in the importance of and seeing a benefit from PA and general enjoyment of PA. Seeing a benefit for example might be physical or cognitive, and lead to enhanced motivation to adhere to the programme to maintain the benefits.

"I could feel the physical side was doing me some good, I was actually able to move better. My balance still wasn't great, but I was still able to... I could react quicker to stumbling or something like that because I didn't fall half as much afterwards. Because I was able to, you know if you trip over something and you can react to it, I was just falling, whereas you would stumble and keep going. But I was falling. So, I found after a couple of weeks of that I was actually able to readjust my balance while I was falling or moving or whatever. It definitely did make a difference. I felt more confident after that, and I actually went back out taking photographs in places that I was afraid to go before that." 033.

Motivation was particularly important regarding home session adherence. Some participants were highly motivated to be physically active through enjoyment of PA and reported being habitually active. There was a pattern among these participants to feel that they could positively impact their general health through PA which provided motivation to be regularly physically active.

"It would because I really felt exercise is very important and I do believe myself that exercise influences memory." 027.

Feeling that one could impact ones` health was a key reason for being physically active and helped to enhance internal motivation for adherence. Perceived control over health helped to establish PA as a way to exert this control and delay physical and cognitive decline. For these participants, being routinely physically active was important and being a habitual exerciser positively impacted home session adherence:

" Walking is my only exercise, is as vital as having my meals or any other aspects of my life."027.

In contrast, those with lower motivation for being physically active had greater difficulty adhering to home sessions. Many participants with lower motivation reported finding PA unenjoyable and boring. For these participants, adherence to the prescribed home sessions was more challenging. Participants spoke about needing someone to "push" them and the difficulty of exercising alone which impacted on motivation. This sometimes caused the frequency of home sessions completed to taper off as participants struggled to maintain motivation.

"Initially alright, but then I cut it down to two and then.. it was down to one (laughs). Just laziness on my part, and you`re doing it… you don't have the incentive… with a group, the craic was good when he had the group of six or eight of us… see I`m not a talker, I just sit and listen, but God they were great." 057.

This illustrates the distinction between those with high internal and low internal motivation for PA in general which impacted on motivation for programme adherence also. Participants who were less internally motivated to be physically active in general and to adhere to home sessions tended to perceive that they had less of an ability to impact their cognitive and physical health and viewed decline in these areas as typical and expected parts of the aging process.

Some participants who expressed high motivation for being physically active reported fewer barriers to home session adherence. Indeed, for some, the required home sessions merged with existing routines and were consolidated in that way so that home session adherence was an automatic process.

"I was just living normally." 043.

One participant described that they were "just living normally" referring to how they approached adherence to home sessions. As this participant was already a habitual exerciser, the prescribed home sessions simply became part of their routine. A few participants who were more highly motivated for PA actively addressed lapses in motivation when they occurred. This was achieved through strategies such as recruiting partners to alleviate boredom, scheduling exercise sessions, tracking exercise or setting reminders.

"You see I am retired, and I am quite busy in fact but because it was kind of an organised thing from week to week it wasn't loose ended, you did your two things, I didn't have a problem. It was tightly organised I would say for myself." 027.

These strategies were more common to those who had higher internal motivation for programme adherence, as they endeavoured to overcome barriers, in contrast with those with lower internal motivation who did not attempt to overcome barriers to adherence. However, those with low internal motivation were supported in adherence through sources of external motivation, such as the group support provided by the programme.

8.3.1.1.1 Attitudes to Cognitive and Physical Decline. This code refers to participants attitudes toward cognitive impairment within the context of normal ageing and is a component of internal motivation. Some participants expressed a belief that decline, both physical and cognitive, are normal parts of ageing and cannot be impacted by behaviour.

"I suppose it is only in the last couple of years that I started to realise I can't remember names and things like that and you just slag each other, old age or whatever. But not thinking you can do something to stop that." 056.

Among these participants, there was a sense that one was expected to slow down and be less active with increased age. This was a common belief in participants who had low internal motivation for home session adherence. It was also common in participants who had high support needs for home session adherence.

"I don't want to bother. I am okay, 72 years old, why would I go through all that. Just do a bit less and you will be all right….But it is all part of getting old I think really, isn't that it?. 033.

"I think I`ve gone too far… I`m on the way out (laughs). Well, I haven't got many years left (laughs), so you`re putting the pressure on me!." 057.

In these instances, interviewees expressed the opinion that they have little control over the progression of decline, both physical and cognitive. In contrast, those with a greater feeling of control over their age - related health demonstrated more internal motivation toward being physically active. Thus, believing one can positively impact their decline, usually physical decline, enhanced internal motivation for PA programme adherence.

8.3.1.1.2 Awareness of the Cognitive Benefits. Most interviewees were unaware that PA can be a beneficial intervention for MCI. Most participants reported a belief that cognitive tasks are the most beneficial for MCI, but some also stated a belief that PA is important for cognition, albeit mainly in a psychological sense, i.e., stress relief and generally feeling good post exercise, rather than directly affecting cognitive function.

"Well, you see it clears your head. When you come in off a good walk or whatever it is your head is clear and you`re more focused. I think that's about it really." 035.

"Psychologically, big time… eh… as they always say, the endorphins I guess." 021.

There was a lack of knowledge regarding the more direct cognitive benefits of PA, and it was commonly thought that PA incurs physical benefits only.

"No, I thought exercise was for the body." 032.

To this end, cognitive pursuits were most generally used to sharpen cognitive function as these were perceived as having a direct impact on the cognitive function. Whereas PA was thought to impact memory through more general pathways. For example, although participant 027 was highly motivated to adhere to both class and home sessions, their motivation for adherence was based on a general understanding that PA is beneficial for psychological health rather than a knowledge that PA can directly impact cognitive function. For that, pursuits which are traditionally associated with using ones` brain were employed.

"It made me aware of where the weaknesses are in my memory, so I play Scrabble and I play memory games. Probably what has changed for me in relation to memory is I would have to encourage myself to do more reading, I was great at reading novels and reading stuff so my reading would have lessened in the last few years." 027.

The extract below illustrates how when questioned about using PA to aid cognitive function, the participant equates exercise for helping cognitive function with cognitive activities.

"Not really. Well, they did, they said that any kind of exercise helps, and I said I do the crossword every day and he said (GP) that is very good for your memory, to help your brain to keep active. And that is what I try to do." 036.

In this way, participants awareness of the cognitive benefits of PA influenced the ways in which participants chose to respond to their cognitive decline, and thus their motivation for adherence to the PA programme. In addition, perceiving a cognitive benefit from participation in the PA programme helped to increase awareness that PA is beneficial for maintaining cognitive function and enhanced motivation for programme adherence in this way.

"If it happened earlier, at the start of the course, you might feel that you have a reason for coming and if you do hint it is working you might even try harder to get there. That is the only thing I can think of for that reason. I never thought it was brain exercise, it just didn't register with me at all." 033.

"Well, it (knowing about the cognitive benefits of PA) would make it more of a priority." 057.

8.3.1.4 External Motivation

External motivation refers to the additional supports outside of the participants individual internal motivations for adherence that impacted or enhanced motivation for programme adherence. These factors were programme level factors such as the supervision and guidance provided through the class – based sessions or providing routine and structure. Being motivated by external factors helped compensate for having low internal motivation, and further enhanced motivation for adherence in those with high internal motivation.

For example, class sessions aided in addressing lack of motivation for PA and enhanced motivation for home adherence. There was also a sense of feeling accountable to class instructors and other group members which externally enhanced adherence both to home and class sessions.

"I think demanding the two (home sessions) at home was a good training as well…. Yeah because it… you had to come in and tell (Instructor) if you`d done your two or not, you know. She wasn't demanding answers, but…Yeah, to some extent, yeah. That's why I`m going to have to sort of make myself accountable." 035.

Though participants who had high motivation for PA experienced less difficulty in adhering to home sessions, some still reported that the added support and routine of the class sessions motivated them to "push" themselves in the class setting, and furthered motivation to complete home sessions.

"They (class sessions) were very good but what had helped, coming in one day a week motivated me for the rest of the week. When I had that hour, I found I was more motivated to continue with the exercise than I would normally be." 027.

This demonstrates that external support was valued in some form by all participants and was a source of external motivation even in those with high internal motivation. It suggests that motivation can be enhanced externally through programme design.

8.3.2 Theme 2: Support

The theme of support encompasses two sub themes: practical (including guidance, and routine and structure) and group support (including fitting in, making friends and enjoyment). This theme describes participants' accounts of the concepts of practical and group support and how they impacted on programme adherence positively when provided, and negatively where they were lacking.

8.3.2.1 Practical Support

8.3.2.1.1 Guidance. Many participants spoke about lacking confidence for being physically active and the impact of this on adherence to home sessions. In addition, many were uncertain of how to exercise and expressed a fear of injury or "overdoing it". This translated to a need for support in the form of supervision or guidance which was patterned across the data.

"The whole stream of that… I`d tried gyms twice and I couldn't ever get anybody to help me once I`d joined, and I`d leave it, do you know what I mean? And I was always more afraid of like that… tears and torn ankles, I do different things, and I wanted supervision so the idea of a supervised (class)." 035.

Participants felt more comfortable exercising with supervision as this addressed a lack of confidence and a lack of knowledge regarding how to exercise safely. Class sessions filled this need and provided knowledge and guidance which was lacking with home sessions. In addition, participants reported that the support and guidance provided by the class sessions helped to increase motivation for PA programme adherence and for general PA going forward:

"Again, that was at the beginning, and we had been coming for the two, so you had become more fit and when you are fit it is easier to continue with the exercise. And then you were coming back next week again, so the regularity of it was very good…. Not so much confidence as motivation and the more exercise you did the more fit you became and therefore the more you felt good about it and therefore you were motivated to do it again." 027

This suggests that by addressing a lack of knowledge and lack of confidence in being physically active and adhering to the PA programme, motivation to continue to be physically active and adhere to the sessions prescribed can be positively impacted.

8.3.1.2.2 Routine and Structure. Many participants spoke about needing to have structure and routine to adhere to this PA programme. This was especially important for the initiation of a PA routine and home session adherence and was common in participants who had low home session adherence. Routine was also spoken about by participants who had high motivation to be physically active in terms of helping maintain their habitual exercise.

"Just the fact that it was a bit of structure, and I could feel the physical side was doing me some good. If it did nothing else it added another bit of structure to my life, I don't know if it is the depression, but I need structure, I need to keep myself going and it is great when I have something to do planned rather than having to think of something." 033.

The above participant spoke about how class sessions offered a focus in their life that helped motivate them, providing them with "direction" or a "focal point" to motivate them, which is echoed by other participants.

"I used to come in here on a Tuesday morning, so I started doing that on a Tuesday morning, get up and go out and do the walk then instead of coming in here, I found that as a focal point…. You are better off to schedule it."056.

"It also gave me something, it changed the direction. I was a little bit directionless. It was like a door opened, that is how I felt about it." 030.

In contrast, home session adherence was negatively impacted by a lack of structure because participants found it difficult to manage time constraints such as family commitments. There was a common pattern for those with low internal motivation to also have low home – session adherence. This was most evident in participants who were not habitually active in general. Scheduled class sessions were thought to be easier to adhere to, whereas home session adherence was prone to interruption and tapering off in the long term. Being busy and other life and home commitments competed for time with the home sessions and some participants reported difficulty in finding time to complete them.

"Some weeks it was easy as pie, other weeks… like, I`m inclined to do it in the evenings when I come home and sometimes I`d do it in front of them actually, but someone always rings you and you lose your thread and you`ve just done your workout and you`ve to start again, and that was the only thing. It was trying to get that blocked off. That was the only thing." 035.

A number of participants identified "getting started" or initiating a PA routine as a key difficulty. However, some participants found that employing certain strategies helped to maintain home session adherence, especially where cognitive deficits impacted on memory. These included scheduling and making time for their home sessions, setting reminders, or using tracking apps to impose structure:

“Then again I have started this thing Map My Walk (mobile app) and I found that focused me better on the walking.” 056.

These finding show that the provision of support for adherence in the form of set class schedules aided in the establishment of further routine PA and enhanced motivation for adherence in this way.

8.3.2.2 Group Support

There was a clear preference throughout cases for exercising in a group setting. This was especially true in the case of home session adherence and dislike of exercising alone was often cited as a reason for low motivation for adherence. In particular, participants reported enjoying the social aspect of class sessions more than individual home sessions.

“I could join a gym, but you do it on your own and I just found coming in here and doing it with people, it gave you something to work towards and that. It keeps you in touch with other people as well who have been doing it. Yes it was grand, especially the cup of coffee, we used to go down and have a cup of coffee afterwards and to chat, that was very good.”056.

This extract illustrates that group support extended beyond support for class adherence and became a social experience that enhanced motivation for adherence. Class sessions fostered a sense of group cohesion and “fitting in”. Some participants highlighted feeling at ease within in the group regarding their own cognitive decline as it was felt that the group, including instructors, “understood” their cognitive deficits and were a source of information and learning.

"We had a lovely group here, really nice group. As (other participant) was saying, 'it has gone so damn quiet since you left,' he said, nobody cracking jokes or anything. But again, we just fitted nicely, that was it." 033.

A common pattern regarding class sessions concerned participants "making good friends" which enhanced enjoyment of the class. This referred to the atmosphere within the class setting and also extended to socialising after class. Providing coffee vouchers for participants to use after class common practice and was well received. This was spoken about by many as a key factor in the enjoyment of the programme:

"I loved the aerobics because we are all friends and that is a big advantage." 036

"Also, the people who were also on the programme, there was a great camaraderie among us, and we were kind of saying what we were doing or not doing." 027.

The value of group support was not diminished in participants who expressed higher motivation for adherence. Although participants with greater motivation for adherence did not report a preference for exercising with others and reported enjoying exercising alone, group support was still valued and enhanced enjoyment of the class sessions. This suggests that even where internal motivation for adherence is high, providing a group setting for PA met a more general need for group, or social, support that extended beyond the need for practical support for PA programme adherence:

"For the walking I could walk by myself, I probably don't need somebody, but I do enjoy , you know, going with the groups." 021.

Class sessions enhanced group support for adherence by enhancing enjoyment and providing social opportunity, thus impacting motivation for adherence. In contrast, home sessions lacked these components and were referred to as key factors associated with home – session non – adherence.

8.3.3 Theme 3: Individual Experience

The theme of individual experience describes participants individual level factors which impacted on PA programme adherence including subjectively described memory complaints and physical health.

8.3.3.1 Classification of Participant Accounts of Cognitive Symptoms

Participant experiences varied among participant reports, but there was a pattern for participants accounts of their individual experiences of MCI to be associated with programme adherence. Participants experiences of MCI were more accurately characterised by their personal accounts of their level of cognitive impairment and how problematic they perceived these to be, termed memory complaints here, than by objectively classified stages of cognitive impairment. Participants were classed as having mild, moderate or severe memory complaints as measured subjectively based on analysis of case summaries containing participants accounts of how problematic their cognitive symptoms were. A description of these groups are provided in Table 24.

Table 24.

Description of Levels of Subjectively Reported Memory Complaints

Classification of Memory Complaints	Description
Mild	Forgetting names, incidental and short - term memory loss
Moderate	Clouded or hazy thinking, more noticeable forgetfulness, and trouble completing familiar tasks.
Severe	Experiencing more extreme memory loss, trouble keeping track i.e., of prescriptions, trouble keeping track of time, forgetting how to perform familiar tasks

Analysis of cases using an objective measure of cognitive function (MoCA) as a comparator showed a discrepancy between how participants describe their symptoms and their objectively measured level of cognitive impairment. To further explore this discrepancy between objective level of cognitive function and participants subjectively reported level of impairment, participants were further categorised according to stage of MCI according to the MoCA and data was cross compared with the theme of subjective memory complaints. Participants were stratified into three groups representing stages of MCI according to their MoCA scores as follows: > 25 representing subjective cognitive impairment (SCI), 22 – 25 representing early MCI (EMCI), and scores of 19 – 21 representing late MCI (LMCI). This approach has previously been used in PA research in MCI populations (Stuckenschneider et al., 2018).

Analysis showed that participants` subjective accounts of memory complaints were not consistently related to their objective stage of MCI. For example, participant 036 with a low MoCA score of 19 and classed as being LMCI reported experiencing mild memory complaints, whereas participant 033 had a MoCA score of 26 (SCI) but reported experiencing moderate

/severe level of subjective memory complaints. In addition, participants descriptions of their subjective memory complaints were more closely related to PA programme adherence, particularly home session adherence, than was stage of MCI. Four participants had LMCI. It was surmised that participants with LMCI would report more severe or moderate subjective memory complaints. However, 2 of 4 participants reported mild memory complaints and 2 reported moderate memory complaints. Five participants had EMCI. It was surmised that participants with EMCI would report mostly mild subjective memory complaints. It was found that 3 reported mild symptoms, 1 reported moderate memory complaints and 1 reported severe memory complaints. In the case of the participant who reported moderate memory complaints, and especially in the case of the participant who reported severe memory complaints, the classification of EMCI seems counter - intuitive. The greatest discrepancy between objective and subjective MCI classifications in this sample was found in participants objectively classified as LMCI. Here, participants reported mild and moderate symptoms. As the stage that should represent a more advanced level of cognitive impairment, it would be intuitive that the participant who reported severe subjective memory complaints would also be classed as having LMCI, but they were objectively classed as having EMCI. Therefore, subjective memory complaints were associated with programme adherence in this sample, but objectively measured stage of MCI was not.

8.3.3.2 Memory Complaints

Many participants reported feeling fear, anxiety, frustration and worry in relation to having MCI regardless of the severity of their cognitive impairment as measured using the MoCA. Subjective accounts of memory complaints showed that most participants were experiencing mild memory complaints such as forgetting names or dates, but one participant reported more severe procedural impairments such as forgetting how to use familiar objects such as a camera or computer.

"I felt… during the process I felt that I was very worried." 021.

"It gets frustrating at times, you know. I do a bit of photography and the technical side of that gets very frustrating when you can't remember. You go out to take shots and you can't remember camera settings and things at the right time for the right place and things like that. That is where I do miss it the most, it is totally frustrating but other than that it is not really a problem. I forget important dates and things like that." 033.

Memory complaints, and whether participants experienced mild, moderate, or severe complaints, negatively impacted on home – based session adherence, but not class – based adherence. For example, participants classed as having severe or moderate memory complaints also had the lowest rates of home session adherence. Memory complaints were associated with practical support needs in that where participants reported greater levels of memory complaints there was also greater need for practical support to adhere to home – based PA programme sessions. This was evident in those who were experiencing moderate memory complaints. For example, four participants in particular reported experiencing confusion and "hazy thinking" in addition to the mild forgetfulness reported by participants classes as having mild memory complaints. In these cases, participants had trouble implementing and adhering to a PA routine alone and expressed an increased need for support for adherence to the programme, especially in terms of home session adherence. For example, participants 033, 043, 047 and 030 all spoke about needing routine and structure to ensure adherence to the programme. This suggests an association between participants subjective reporting of memory complaints and the need for practical support for programme adherence, especially home - based adherence. Some participants with severe or moderate subjective memory complaints displayed confusion regarding the expected home session commitment.

"I didn't have that (home – based sessions). I don't remember it." 033.

"Well, I haven't done much (laughs). I just filled in that exercise thing…". 043

In the above excerpt, participant 043 was explaining that they had not completed the home – based sessions as they understood that they were only to fill out the diary, when in fact they had completed the diary after completing 75% of the prescribed home – based sessions. Both quotations are from participants who were experiencing greater subjective memory complaints, highlighting the fact that this may negatively impact home – based PA programme adherence.

8.3.3.3 Physical Health

In this sample, MCI was accompanied by ailments such as hearing loss, heart and lung problems, and mobility problems for many participants which negatively impacted on being active in general and PA programme adherence.

"The only thing about that is the heart has deteriorated a bit which has set me back another wee bit, but again that is part of life, isn't it?". 033.

"I was wary of it (the PA programme) because I have done my back in a few times, and it makes me very wary of the whole thing. I had one very bad session with my back one time". 056.

These findings show that barriers posed by me health issues can make PA programme adherence more difficult in a practical sense. Thus, some of the practical supports identified in the data, such as the need for guidance or routine and structure, may be a function of the practical limitations related to MCI.

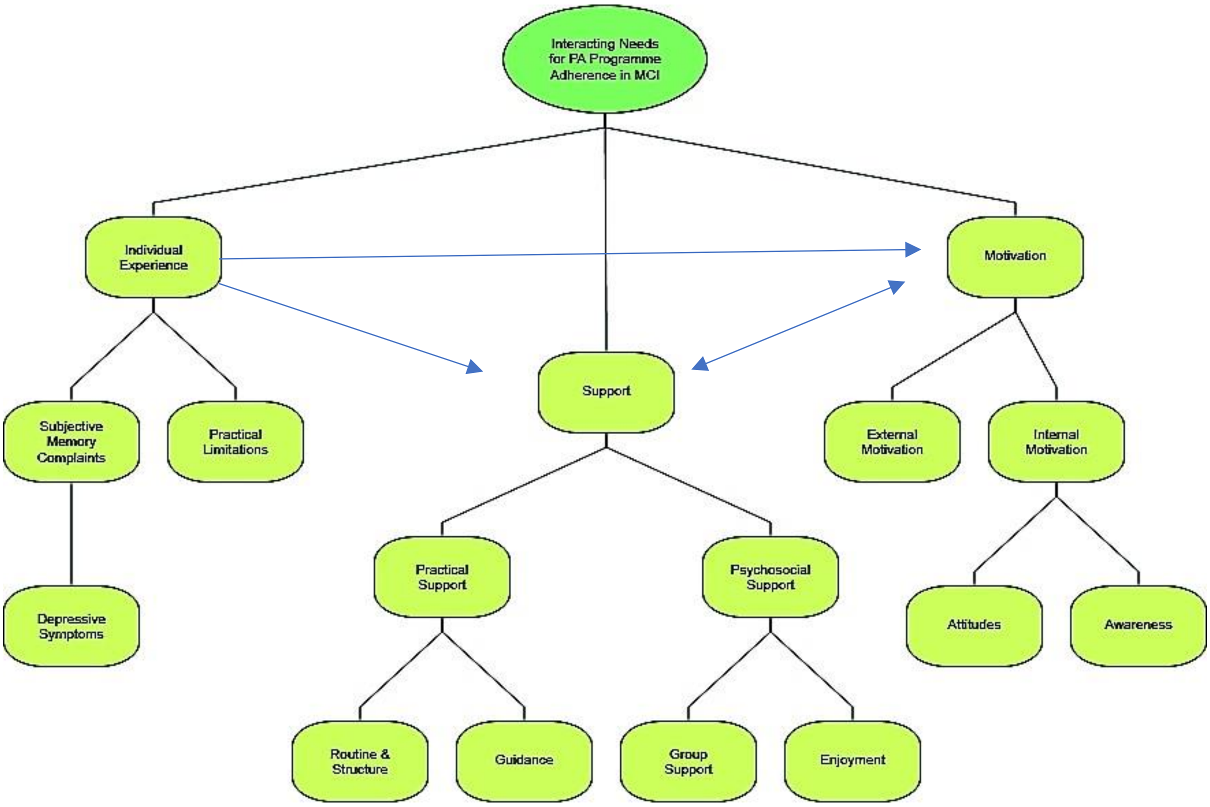
8.3.4 Interactions Between Themes: Interacting Needs

This section describes the relationship between the themes of support and motivation and the “needs” for these supports arising from the participants individual experience of MCI, and how this impacted on PA programme adherence. The theme of individual experience impacted the need for practical support through participants subjective memory complaints and physical health. In addition, participants individual experience and support needs influenced their motivation for programme adherence. Participants with low internal motivation to adhere expressed a need for routine and structure to adhere to the programme, but also stated that routine and structure in turn enhanced motivation for adherence to home sessions and PA in general demonstrating a reciprocal relationship between themes. Similarly, participants who had high motivation to complete home session adherence reported valuing the additional routine and structure to help reinforce motivation for existing PA routines and for “pushing” themselves within the class setting. The same reciprocal relationship is evident in participant accounts of how a need for guidance or supervision, once met, enhanced confidence and motivation for physical activity in general. In this way, having low internal motivation can increase the need for support in individuals with MCI, but meeting these needs can in turn positively impact on adherence.

Another route through which motivation and support needs interact is through the need for group support and enjoyment. Many participants cited a lack of enjoyment of PA and being physically active alone as reasons for lacking motivation to adhere to home sessions. Class sessions directly addressed these needs by virtue of being group – based. Meeting these needs positively impacted on participants external motivation to adhere to class sessions, and indirectly motivated adherence to home sessions through feeling accountable to instructors and other group members and feeling enjoyment being physically active. Figure 6 illustrates the thematic framework of PA programme adherence in individuals with MCI interactions between themes.

Figure 6.

Diagram of Thematic Framework of PA Programme Adherence in MCI and Interactions Between Themes



8.4 Discussion

This study aimed to explore the barriers and facilitators of adherence to a 12 – month class and home – based PA programme to address the current lack of understanding of the phenomenon of PA programme adherence in individuals with MCI. The main themes were motivation, support and individual experience of MCI. The findings showed that people with MCI benefit from the support of routine and structure to help compensate for memory issues and to enhance motivation to adhere. Having, or lacking, motivation impacted on participants willingness and ability to adhere to the programme, particularly in terms of home sessions.

Participants attitudes to physical and cognitive decline (i.e., believing that physical and cognitive decline were expected with ageing and could not be impacted positively, or that slowing down is necessary with ageing) and a lack of awareness of the cognitive benefits of PA was associated with participants level of motivation for adherence. Participants identified various practical and group support needs that influenced programme adherence, and support for these was most evident with class session adherence.

These findings are in support of previous research (Hancox et al., 2019) which determined that the themes of routine, practical and emotional support, memory support, purpose for PA, past experience, and belief in the benefits of PA impacted adherence to a home -based PA programme. The findings of the latter study and this current study converge in finding that individuals with MCI need both practical support to enable programme adherence and emotional support to encourage and motivate. In addition, Hancoxs` (Hancox et al., 2019) concept of "belief in the benefits of PA", and "purpose" are analogous with elements of the sub - themes of attitudes and awareness identified in this current study, which impacted adherence through internal motivation to adhere. Within this sample of participants there was a low level of awareness of the cognitive benefits of PA. Relating the benefits of PA to individuals in terms of cognitive health may help to increase internal motivation to adhere, as there was a tendency for participants to undervalue the cognitive benefits. Addressing this deficit in knowledge may help to increase internal motivation in this cohort.

A key difference between this current study and that of Hancox et al. is that this current study compared programme adherence according to programme formatting, i.e., home - session or class - session adherence. The findings demonstrated differences in PA programme adherence relating to programme implementation that had not before been explored. For example, class – session adherence was positively impacted by the provision of external motivation, practical and group support which were lacking in the home setting. Further, participants with more problematic memory complaints more often reported needing practical and group support, as well as external motivation for adherence and found home session adherence more challenging than those with less problematic memory complaints. This suggests that the support needs of individuals with MCI for PA programme adherence may vary based on the severity of memory complaints experienced. In addition, it suggests that class – based formats may enhance programme adherence for those with more problematic memory and physical complaints.

The findings of this study are consistent with findings from two previous PA programme adherence studies. In one study (Cox et al., 2013) the authors reported that enjoyment of a PA programme was related to the factors of "feeling active", "improved quality of life" and "life satisfaction", "seeing physical benefits", "provided motivation/ sense of purpose", and "fitted routine". The themes of "seeing a physical benefit" and "provided motivation/ sense of purpose" are reflective of components of "motivation" in this study. Similarly, the theme of "fitted routine" echoes elements of routine and structure identified in this current study. Findings from another study on post – intervention maintenance of a PA programme in individuals with MCI suggest that maintaining PA long term was impacted by the "quality of the programme/ instructor", "programme intensity" and "seeing less progress" in ones` health or fitness (Tak et al., 2012). The latter may be a facet of "belief in PA benefits" as identified by Hancox et al. (2019), "seeing physical benefits" cited by Cox et al., and "attitudes to cognitive and physical decline" and "awareness of the cognitive benefits" as conceptualised as components of motivation in this current analysis. The theme of "quality of programme/ instructors" may be similar to the theme of practical support in this current study, however the content of those themes is unclear from the published texts. Therefore, these current findings have provided further explanation regarding these concepts.

These findings support the findings and thematic framework of PA programme adherence in individuals with MCI reported by Hancox et al. (2019) and suggest that the need for motivation and support vary according to individual experiences of MCI, and individuals experiencing more problematic cognitive symptoms benefit from additional support in the form of routine and structure to enable PA programme adherence.

8.5 Conclusions

This study addressed a scarcity of qualitative research regarding the barriers to PA engagement in Irish adults with MCI, and a lack of exploration of previously cited reasons for non – adherence to provide a greater depth of understanding. In addition, it addressed a lack of current findings exploring differences in adherence between two types of PA programme formatting, class – based and home – based. The findings of this study show that individuals with MCI require differing levels of support based on their individual experience with MCI and their level of motivation. More problematic subjectively reported memory complaints and poorer physical health were key barriers to PA programme adherence. These barriers impacted on participants needs for practical and group support, and with greater need for support a lack of guidance and a lack of routine and structure also became barriers to adherence. Motivation for adherence was impacted by participants attitudes and awareness regarding the benefits of PA for cognitive health, and motivation in turn influenced participants support needs. There was a general lack of awareness of the cognitive benefits of PA however, which should be addressed to enhance motivation.

These findings suggest that PA programmes for individuals with MCI should account for the specific support needs arising from how problematic individuals cognitive and physical limitations are from their perspective. These findings also suggest that supervised class – based formats may help to support the needs of individuals with MCI to optimise adherence. Practical ways that adherence support systems can be implemented to enhance PA programme adherence may include providing instruction and guidance in the form of supervision as a form of practical support and using a class or group - based setting design to create group support. In addition, these supports would also provide routine and structure which has been highlighted as a key facilitator to programme adherence. Although a group setting resulted in greater programme adherence, home - based programmes are feasible with an increased level of support, such as encouraging individuals with MCI to establish a routine and recruit partners to make PA programme adherence more enjoyable.

8.6 Chapter Summary

This Chapter presented the findings of a thematic analysis of barriers and facilitators of PA programme adherence in a sample of Irish adults with MCI. Three key themes were identified which interacted to impact adherence, these were motivation, support, and individual experience. Barriers to adherence were memory and physical complaints. The extent of these impacted on need for support such as guidance and routine/ structure, which if not met in turn became barriers to adherence. Thus, providing support in terms of practical and group support facilitated PA programme adherence.

Chapter 9: A Mixed Methods Analysis of Factors Impacting Physical Activity Programme Adherence in Individuals with MCI

9.1 Introduction

PA programme adherence has been shown to be variable in individuals with MCI (de Oliveira Silva et al., 2019; Tak et al., 2012) and this may partly explain inconsistent RCT evidence regarding the effects of PA on cognitive function. However, there is a scarcity of mono - methods studies examining the determinants of PA programme adherence in this group. In addition, there is a lack of mixed methods studies combining research methodologies to expand on this under – researched area. Further understanding the determinants of PA programme adherence in this group is necessary to understand the variability in PA programme adherence and inform intervention design to optimise cognitive outcomes and potentially reduce dementia risk. This study aimed to integrate quantitative and qualitative findings regarding the correlates and barriers and facilitators of PA programme adherence to expand depth of understanding and generate insight, and to form evidence-based recommendations to support PA programme adherence (sub – objective 2.3). This was the final phase of a mixed methods analysis of the determinants of PA programme adherence (Study 2, sub – study 2.3) consisting of a quantitative analysis of the correlates of adherence (sub – study 2.1, Chapter 7) and a qualitative exploration of the barriers and facilitators (sub – study 2.2, Chapter 8).

9.1.1 Mixed Methods Research Questions

- Does the qualitative data converge with the non – significant finding regarding the impact of cognitive and physical function on programme adherence?
- Does the qualitative data explain why overall adherence was low?

- Does the qualitative data explain why home session adherence was lower than class session adherence?
- Does the qualitative data explain what aspect of the class session format resulted in higher class adherence?
- Does the qualitative data support the quantitative finding that the mode of PA (aerobic/ stretch and tone) was not related to programme adherence?
- What results emerge from comparing qualitative and quantitative findings regarding the correlates and barriers and facilitators of PA programme adherence in individuals with MCI?

9.2 Methods

9.2.1 Design

This was a convergent parallel mixed methods design (Creswell, 2015; Creswell, 2007; Teddlie, 2009) which adhered to the same methods of integration detailed in Chapter 6 (section 6.2) of this thesis. In summary, methodological strands of data were synthesised separately and then integrated in a third synthesis in the interpretation phase of analysis by juxtaposing the data (Bazeley, 2018; Hong et al., 2017; Thomas et al., 2004) using the COM – B framework domains (Michie et al., 2011) as a priori themes to create a joint – display (Thomas et al., 2004). Integrated findings were then applied to the BCW to identify relevant intervention functions and cross referenced with the Behaviour Change Technique (BCT) taxonomy v1 (Michie et al., 2013) to form recommendations. Further detail on the COM – B framework, BCW and BCT taxonomy v1 is provided in Chapter 2 (2.2.9) of this thesis and a rationale for the use of this framework can be found there.

9.2.2 Analysis

Analysis followed an 8 step process outlined by Michie (2014), which is detailed further in Chapter 2 (2.2.9) of this thesis. Steps 1 – 3 of this process were concerned with identifying the target behaviours for behaviour change (Chapters 7 and 8). Thus, this integration study commenced from step 4, using the COM – B framework to identify the specific areas that impact that behaviour (PA programme adherence) to influence change. To avoid repetition, further detail regarding the methodological approach to the remaining steps (5- 8) is provided in Chapter 6 of this thesis.

9.3 Integrated Findings

The following section outlines the integrated findings in a narrative synthesis according to the COM-B framework domains of capability, opportunity, and motivation as a priori themes followed by a discussion of the implication of these integrated findings. Table 25 presents the joint display for the synthesis of qualitative and quantitative findings.

Table 25.

Joint Display for Synthesis of Qualitative and Quantitative findings

COM - B Domain		Qualitative Themes	Quantitative Findings
Capability			
Psychological capability	Psychological strength/ stamina and knowledge & skills	• Internal Motivation - Awareness of cognitive benefits	• Depressive symptoms (CES – D) - not significant • Years of education - not significant • Programme characteristics - programme condition (aerobic v stretch & tone) not significant - programme duration (6 v 12 months) not statistically significant - class setting positively related
Physical capability	Physical strength, skills, or stamina.	• Individual experience - memory complaints - physical health • Internal Motivation - attitudes to cognitive/ physical decline	• Cognitive function - not significant • Age - not significant • Frailty (handgrip strength) - not significant • Health related quality of life (DemQol) - not significant • Chronic illness (number of medications) - not significant
Opportunity			
Physical opportunity	Environment, time, location, resources	• Practical Support - routine & structure - guidance and supervision	• Programme setting - class setting positively related to adherence
Social opportunity	Social factors such as	• Group support - fitting in	• Programme setting - class setting was positively related to adherence

	cultural norms and social cues	- making friends - enjoyment	
Motivation			
Reflective motivation	making plans, beliefs, evaluations of past events	• Internal motivation - belief in/ seeing a benefit • External sources of motivation - routine - guidance/ supervision - feeling accountable	• Programme setting (class v home) - significant
Automatic motivation	Desires, impulses, and inhibitions	• Group support - fitting in - making friends - enjoyment of PA	• Baseline PA - baseline PA be a possible indicator of motivation for adherence

9.3.1 Capability

9.3.1.1 Psychological Capability

Psychological capability refers to the components of psychological strength and stamina, knowledge, and skills necessary to perform a behaviour. Statistical analysis of the relationship between programme adherence and the presence of depressive symptoms and health related quality of life were not significant. The programme characteristics of mode of PA employed and duration of the programme did not impact programme adherence. However, programme setting was a significant factor in programme adherence, with class session adherence being significantly higher than home session adherence. Qualitative analysis showed that participants lacked confidence for PA and wanted guidance in performing activities to enhance their own knowledge and skills regarding being physically active.

Qualitative findings showed that participants were lacking knowledge regarding the cognitive benefits of regular PA and were more likely to employ cognitive strategies to try to improve their brain health. There was a suggestion in the qualitative data that improving knowledge in this area might serve to enhance motivation for programme adherence. In addition, participants attitudes toward cognitive and physical decline and having or lacking a belief in the benefits of PA impacted adherence, most notably home session adherence.

9.3.1.2 Physical Capability

Quantitative analysis of the association between cognitive function and PA programme adherence was not significant. Qualitative findings found that home session adherence was related to participants individual experience, i.e., memory complaints and physical health were barriers to adherence, but these were not reflective of objectively measured cognitive function or physical health. These cognitive and physical barriers pertained to home session but not class session adherence. Qualitative evidence goes further to show that home session adherence was negatively impacted by the lack of guidance and routine/ structure that was available within the class setting that helped to overcome barriers posed by subjective memory complaints. This provides a possible explanation for the differences observed in adherence in the home setting compared with the class setting.

Other measures of physical capability such as frailty, chronic illness and health related quality of life were not statistically related to programme adherence. However, qualitative findings showed that participants reported experiencing co – morbidities that negatively impacted their adherence. Participants reported issues with pain, mobility, cardiac and respiratory health that were not reflected in the statistical analysis. Although age was a non – significant variable in quantitative analysis, many participants reported feeling that older age necessitated slowing down and being less active and expressed a belief that decline was to be expected and was outside of their control. These attitudes may reflect societal norms regarding the process of ageing in combination with a lack of awareness of the extent to which the decline which accompanies ageing can be impacted on through PA. This suggests that perceived age and physical health as subjectively recounted by individuals may be a more important determinant of programme adherence than objective age and physical health.

9.3.2 Opportunity

9.3.2.1 Physical Opportunity

Physical opportunity refers to factors such as the environment, time, location, and resources that impact on a behaviour. Participants qualitative accounts showed that a lack of routine and structure limited home session adherence, and time constraints (family and home commitments) and the increased possibility of interruption in the home setting were barriers to adherence. Participants spoke of the lack of/ presence of routine & structure, and guidance from instructors as key differences between the two modes of programme delivery resulting in more favourable adherence in this class setting. This provides explanatory data to the quantitative findings regarding the significant difference in adherence between setting, showing that the practical support (routine/ structure, guidance/ supervision) provided in the class sessions positively impacted physical opportunity for programme adherence. Therefore, the qualitative findings further the quantitative results here and support the finding that programme setting is a key determinant of PA programme adherence in this cohort.

9.3.2.2 Social Opportunity

Social factors such as cultural norms and social cues are the components of behaviour that comprise the concept of social opportunity. Group support provided by the class setting enhanced enjoyment of the programme as participants reported making friends and feeling as though they fitted in. This is in contrast with accounts of home session adherence where this support was lacking, and adherence was negatively impacted as a result. Again, this qualitative finding expands on the statistical difference between home and class session adherence, suggesting that PA programmes containing a social element may be superior in terms of programme adherence.

9.3.3 Motivation

9.3.3.1 Reflective Motivation

Reflective motivation refers to individuals` beliefs, evaluations of past events and plans they may make. Components of the qualitative theme of external motivation derived from the qualitative analysis were related to programme adherence. Participants reported having trouble initiating PA and having time constraints as barriers to home session adherence, which were addressed within the class setting by the provision of routine. In addition, participants spoke favourably regarding the quality of the programme instructors and having guidance and supervision. The supervision of the class sessions also fostered a sense of accountability which was a motivator for programme adherence.

Having a belief in the benefits of PA was a component of internal motivation in the qualitative findings impacting programme adherence, and here it represents reflective motivation for adherence. Seeing a benefit resulting from programme adherence enhanced motivation for adherence for class sessions which carried over to enhancing motivation for home session adherence also.

The quantitative data was not informative regarding the themes of reflective and automatic motivation, as no variable relating to either concept was analysed within the quantitative study; but these qualitative findings further expand on the research question arising from the quantitative data regarding the difference in rates of adherence with class compared with home sessions.

9.3.3.2 Automatic Motivation

Automatic motivation is influenced by individuals` desires, impulses, and inhibitions. The theme of group support identified in the qualitative findings fitted with the COM – B theme of automatic motivation here. For example, participants who displayed a greater level of enjoyment of PA reported less need for routine and structure to consolidate programme adherence and less of a dependence on group support to maintain adherence. In addition, disliking being physical active without company was a common barrier to home session adherence. Qualitative findings showed that having a dislike of being physically active alone was addressed by conducting programmes in a group setting, which positively impacted automatic motivation. Quantitative data, though silent regarding the statistical effect of motivation on adherence to the programme, may offer a possible practical indicator of automatic motivation for PA programme adherence in individuals with MCI. For example, the relationship between programme adherence and baseline levels of PA was not significant, but the effect size and confidence intervals suggest that there may be an interaction between baseline PA and both class and home session adherence that may have been masked by the small sample size that was quantitatively analysed. Further inspection in larger samples may clarify this effect. However, in conjunction with the qualitative data, the integrated findings suggest that baseline PA may be an indicator of internal, or automatic, motivation for programme adherence. For example, internal motivation was positively impacted by general enjoyment of being physically active which intuitively would be expected to result in a higher baseline level of PA engagement. Indeed, in the qualitative sample, some participants were highly motivated to be physically active through enjoyment of PA and reported being habitually active. These participants felt they could positively impact their general health through PA which provided motivation to be regularly physically active.

These integrated findings suggest that enjoyment of PA may be a key factor in general PA engagement and PA programme adherence in individuals with MCI and measuring baseline activity may help identify participants who need additional support for PA programme adherence. This is supported by the fact that participants in the qualitative study with higher internal motivation had greater baseline levels of PA and greater levels of home session adherence. In contrast, where participants reported less enjoyment of PA in general and a dislike for being physically active alone, baseline levels of PA and home session adherence were lower and the need for group support for adherence was greater.

9.3.4 Triangulation of Findings

A triangulation assessment showed that the sets of findings were dissonant regarding capability for programme adherence and the impact of cognitive function on adherence. The qualitative findings showed that memory issues and physical health negatively impacted adherence, but these were not significant in the quantitative analysis. These findings suggest a discrepancy between these constructs as they are objectively measured and how they are perceived from the perspective of the person with MCI.

The quantitative findings were silent regarding opportunity in terms of programme adherence, but the qualitative findings here suggest that practical support is a facilitator of adherence and thus supplements the quantitative finding regarding higher class session adherence suggesting that routine/ structure and guidance/ supervision are facilitators of PA programme adherence.

Similarly, the quantitative data was silent regarding the concept of motivation for adherence as these constructs were not statistically examined. However, the qualitative findings show that group support and practical support were key motivators for programme adherence. This finding again provides further explanation for the higher adherence for a class setting. A summary of convergence, dissonance and silence between findings is presented in Table 26.

Table 26.

Assessment of Convergence, Dissonance and Silence in Integrated Findings

Com – B Domain	Convergence	Dissonance	Silence
Psychological capability			• Qual is silent regarding education, programme condition/ duration, depression. • Quant is silent regarding awareness of cognitive benefits
Physical capability		• Cognitive function (memory issues versus non-significant cognitive function) • Age versus attitudes (to cognitive decline) • Physical health and function versus attitudes (physical health/ decline)	
Physical Opportunity	• Qual supplements quant regarding significant difference in adherence for class versus home sessions (routine/ structure & guidance/ supervision)		
Social Opportunity	• Qual supplements quant regarding low home session adherence (group support)		
Reflective Motivation	• Qual supplements quant regarding low home session adherence (internal & external motivation)		
Automatic Motivation	• Qual supplements quant regarding class versus home sessions (group support) • Baseline PA as a possible predictor of motivation for adherence		

9.4 Discussion

The purpose of this integrated analysis was to combine qualitative and quantitative findings to expand the depth of understanding of the determinants of PA programme adherence in individuals with MCI. There was dissonance within the integrated findings regarding the role of cognitive function in PA programme adherence. From the participants perspective, memory issues negatively impacted PA programme adherence through forgetting and confusion which was problematic especially in terms of implementing home session adherence. This was not reflected in the quantitative findings of this current study. The role of memory issues as described here are in support of the current qualitative literature (Hancox et al., 2019), although quantitative evidence regarding the effect of cognitive function on PA programme adherence has been mixed (Lam et al., 2015; Uemura et al., 2013; van Uffelen et al., 2009). Sufficient power has already been posited as a possible reason for this lack of statistical effect (Chapter 7, section 7.5). Alternatively, it may be the case that the MoCA was not sensitive enough of a measurement tool to capture the real-world impact of cognitive impairment on adherence as experienced by the individual. Indeed, an interesting finding of the qualitative study (Chapter 8, section 8.3.3) was that subjectively reported memory impairment was more important a determinant of programme adherence than objectively measured cognitive function in that sample. This may explain the lack of a statistically significant relationship between cognitive function and programme adherence in the quantitative analysis of PA programme adherence. The discrepant findings between strands of data where memory issues are concerned, and the existence of a similar discrepancy between findings in the current literature points toward the importance of understanding the impact of cognitive decline on the individual and suggests that individualised assessment using self – reported measures of cognitive impairment may be necessary going forward.

There was also dissonance between findings regarding the role of physical health (frailty and chronic illness) in PA programme adherence. Quantitative analysis found no relationships between measures of frailty and chronic illness and adherence, contrary to a previous study which reported that physical function was associated with PA programme adherence in individuals with

MCI (Uemura et al., 2013). However, the qualitative analysis identified co – morbidities reported by participants as barriers to programme adherence, again suggesting there may be a gap between clinically recorded and subjectively experienced limitations to programme adherence resulting from chronic illness. This dissonance between findings may be the results of limitations in the clinical measurement of physical ability used in this current study. For example, in the case of health - related quality of life participants completed clinical measurements relating to general functioning, but interview data captured more detail regarding how these physical issues specifically impacted PA programme adherence. As the association between programme adherence and physical health was identified qualitatively but not quantitatively, this discrepancy may also be a function of participants` perceptions of their health, supporting the assertion that subjective individual level data can be an important determinant of programme adherence. However, in the literature the theme of physical health was not identified in one previous study of barriers and facilitators to PA programme adherence (Hancox et al., 2019). In addition, although age was not a significant variable in the quantitative analysis, many participants reported believing that older age necessitated slowing down and being less active, and expressed a belief that decline was to be expected at "their age" and was outside of their control. This points to the concept of subjective or perceived age as another possible determinant of adherence in a similar manner to subjective memory issues and physical health.

In general, programme adherence was found to be low. However, low home session adherence may have brought down the mean total adherence rate. Both qualitative and quantitative data pointed toward home session adherence being more challenging than class session adherence (49% and 63% respectively) and the qualitative findings provided some possible explanations for the differences in programme adherence according to setting. For instance, qualitative findings demonstrate that motivation and support needs of individuals with MCI in conjunction with practical and cognitive issues associated with individuals experience of MCI negatively impacted home sessions. The formatting of class sessions provided support in a number of ways. For example, the guidance and supervision from an instructor and the routine and structure of scheduled classes provided practical support for adherence, especially for individuals with physical and memory issues. The class, or group, formatting also enhanced support through social channels and was valued by participants. In addition, the class sessions provided a source of external motivation for adherence through a sense of feeling accountable to instructors. These factors likely explain the significant difference in programme adherence between settings and suggest that the provision of support both from programme providers and other participants (peers) are key contributing factors in PA programme adherence in individuals with MCI. This is in line with other studies reporting that supervised PA programmes achieve greater adherence than unsupervised programmes in people with cognitive impairment (Di Lorito et al., 2020) and that interventions to support memory, and providing practical and emotional support are facilitators of PA programme adherence (Hancox et al., 2019). As both of these studies included people with dementia, these findings also suggest the adherence needs for individuals with MCI may be similar to those with a dementia diagnosis. Although these integrated findings also suggest that support needs differ depending on participants subjective cognitive complaints to a greater extent than objective cognitive functioning. PA programmes that are implemented in a home or individual setting may also benefit from these findings. For example, by incorporating a social element such as encouraging individuals to recruit a partner for PA or regular “checking in” by instructors to foster a sense of accountability could provide some of these practical and group support needs outside of a class or group setting.

Neither intervention condition (stretch and tone versus aerobic) or duration of the programme were associated with programme adherence in either strand of findings. Qualitative data suggested that time constraints negatively impacted adherence, though statistical analysis showed no significant difference in programme adherence between 6 and 12 months. This is in contrast with two previous studies, the first of which found that PA programme adherence decreased from 6 to 12 months (Cox et al., 2013), and the other which reported a small but non – significant decrease in adherence over a longer duration (Di Lorito et al., 2020). In the qualitative literature, neither intervention condition nor duration were identified as barriers to programme adherence (Hancox et al., 2019), in line with the findings of this current study. Collectively, these findings point to programme setting as the most important programme related factor to impact adherence.

The integration of quantitative and qualitative strands of data in this thesis generated more detailed findings than was possible using single – method analysis and highlighted the importance of taking an individual approach to PA programme design which accounts for participants subjective cognitive and physical ability in addition to clinical indicators of capability. Qualitative findings added explanatory data to quantitative findings and provided a greater understanding of the individual level determinants of PA programme adherence in individuals with MCI.

9.5 Recommendations

To enable the formation of policy and programme level recommendations based on the findings of this mixed methods study, integrated findings as per the COM – B model were applied to the 9 intervention functions of the BCW (Michie et al., 2011) and intervention functions relevant to the objective of enhancing PA programme adherence were selected. The intervention functions identified to target programme adherence were modelling, environmental restructuring and education to address capability, education and persuasion to target opportunity, and training, persuasion, and enablement to address motivation. The relevant selected BCTs per the BCT v1 to implement these intervention functions through policy and programme design are presented in Table 27. From these, two main recommendations for future health policy and intervention design were developed. These are discussed in the following sections.

As mentioned in Chapter 6 (section 6.5) the following recommendations are heavily based on qualitative findings as opposed to quantitative analysis as the quantitative study was found to be underpowered. As such, these recommendations should be interpreted as suggestions for future research and practice that require further elucidation from quantitative sources.

Table 27.

Mapping of COM – B and BCW Components to BCTs – Steps 5 - 7

COM – B Domain	Barrier/ Facilitator	BCW Intervention Function	Policy Category	Example of BCT	Recommendations
Psychological capability	• Lack of awareness	• Modelling	• Fiscal measures • Regulation	• 5.1 Information about health consequences	• Public health initiative to promote awareness of PA (guidelines, cognitive benefits) • Provision of group - based instructor led PA programmes
Physical capability	• Memory complaints • Physical health • Attitudes to cognitive/physical decline & aging	• Restrictions • Education	• Guidelines • Environmental/ social planning	• 12.2. Restructuring the social environment • 12.1. Restructuring the physical environment • 3.2. Social support (practical) • 5.1 Information about health consequences	• Public health initiative to promote awareness of PA (guidelines, cognitive benefits) • Provision of instructor led/ supervised PA programmes (group – based instructor led classes)
Physical opportunity	• Needing routine/ structure • Needing guidance/ supervision	• Incentivisation • Persuasion	• Communication/ marketing • Environmental planning	• 8.3 Habit formation •	• Use of healthcare providers to encourage active behaviours (public health initiative) • Provision of structured PA programmes to encourage regular engagement (group – based instructor led classes)

Social opportunity	• Group support • Enjoyment	• Education • Persuasion	• Environmental planning	• 12.2 Restructuring the social environment	• Provision of supervised programmes providing monitoring of adherence and feedback on behaviour and outcomes (group-based instructor led classes)
Reflective motivation	• Routine • Guidance • Feeling accountable • Believing in/ seeing a benefit	• Persuasion • Training	• Service provision	• 5.1. Information about health consequences • 8.2 Behaviour substitution • 2.2. Feedback on behaviour • 2.7. Feedback on outcome(s) of behaviour	• Increasing awareness of cognitive benefits of PA (public health initiative) • Provision of supervised programmes providing monitoring of adherence and feedback on behaviour and outcomes (group-based instructor led classes)
Automatic motivation	• Group support • Internal motivation • Baseline PA	• Enablement	• Regulation • Service provision	• 12.1. Restructuring the physical environment • 12.2. Restructuring the social environment	• Provision of group – based classes • Use of healthcare providers to encourage active behaviours (public health initiative)

Note: Adapted from "The behaviour change wheel: A new method for characterising and designing behaviour change interventions" by S. Michie et al., (2011), *Implementation Science, 6* (1), Copyright 2011 licensee BioMed Central Ltd.

9.5.1 Recommendation 1: Increase Awareness

The findings of study 2 (PA programme adherence) reflect the findings of study 1 (engagement) in terms of barriers such as memory and physical issues, and a lack of awareness of PA and PA guidelines etc. Therefore, recommendations arising from each study are similar. This is discussed further in the discussion chapter of this thesis (Chapter 10, section 10.4). The development of a public health campaign to promote awareness of the PA guidelines, emphasising the physical and cognitive benefits of PA and suggesting ways of being physically active for older adults is advised. This can be disseminated through television and radio to ensure coverage of the message. Healthcare providers such as GPs and geriatricians can be used to reinforce this message among their patient bases. Such a campaign would provide information regarding health consequences (5.1 per the BCT v1) and thus address a lack of awareness surrounding PA demonstrated in this study. There is some support for the efficacy of the provision of educational material for supporting PA programme adherence (Chong et al., 2020). In addition, it would help to challenge the negative perceptions of cognitive and physical decline and ageing discussed in Chapter 8 (section 8.3.1.1) that may impact motivation for adherence to PA programmes and help support a belief in the benefits of PA for cognitive health. Health care professionals, in addition to reinforcing awareness of the benefits of PA for individuals with MCI, can encourage their patients to substitute behaviours (8.2, BCT v1) (i.e., walking instead of driving) and to form a PA routine (8.3, BCT v1) to encourage PA adherence.

9.5.2 Recommendation 2: Intervention Design

Based on the findings of this integrated analysis it is suggested that interventions for individuals with MCI incorporate some key elements to provide the supports necessary to enable PA programme adherence in this cohort and reduce barriers to adherence. These have been outlined previously in Chapter 6 (section 6.5.3) but in summary, restructuring the physical environment (12.1, BTC v1) may be needed to cater for individuals with MCI who may have physical and cognitive issues that may require specialised equipment and qualified instructors who can cater for such abilities. The provision of interventions that are supervised by a qualified instructor would achieve this. In addition, qualified instructors could reiterate the message regarding the benefits of PA (5.1, BCT v1) to increase awareness and challenge negative attitudes. Instructors should provide feedback regarding individuals progress and discuss the outcomes of their progress (2.2, & 2.7, BCT, v1) to encourage accountability and motivation. The provision of sessions in a structured and regular format would enable habit formation (8.3, BCT v1) and support the development of routine which was a key determinant of class adherence in this study. The provision of PA interventions in a group format is also advised to enhance social support through restructuring the social environment (3.2 and 12.2, BCT v1) and enhance enjoyment of the intervention to maintain motivation to adhere as demonstrated by this study's findings. The literature supports this approach as incorporating supervision and social interaction, and providing information regarding PA have been found to support PA programme adherence in individuals with SCI and MCI (Chong et al., 2020; van der Wardt et al., 2017).

Finally, we suggest that assessment of capability for PA programme adherence, cognitive and physical, conducted on an individual basis according to the individuals` own experience of MCI and related symptoms, possibly using self-rated measures of health may be beneficial. There is some support in the literature for the efficacy of tailoring PA programmes to individual ability to promote adherence (Chong et al., 2020).

9.6 Conclusions

These findings show that the determinants of PA programme adherence in individuals with MCI are cognitive (memory issues) and physical (injury, co – morbidity) at a practical level (individual experience), and these can impact on adherence through related needs for support and motivation. Individual perceptions of physical and cognitive status and beliefs regarding ageing and decline may be more sensitive predictors of programme adherence than objective measurement, and considering subjective experience may be advisable in assessing or promoting adherence to PA programmes in this sub – population as part of an individualised approach to adherence.

This study has added to the existing literature regarding the determinants of PA programme adherence in this sub – group of individuals which have been previously under – represented and rates of PA programme adherence in a sample of Irish individuals with MCI. In addition, it has added to existing knowledge regarding the type of PA programme formatting most supportive of adherence and has provided explanations of why this might be the case. Increasing awareness surrounding PA and cognitive health in individuals with MCI through media and health care providers may promote adherence. PA interventions targeting individuals with MCI may benefit from the use of a group – based, supervised, structured format to support adherence. Programmes tailoring according to individual assessment of capability and needs is advised.

9.7 Chapter Summary

This chapter presented an integrated analysis of the determinants of PA programme adherence in a sample of Irish adults with MCI. Based on these findings, it is recommended that health policy focus turns to increasing awareness and promoting the cognitive benefits of PA in the general older population. It is also recommended that PA interventions targeting this cohort incorporate supervision and are group – based but individually tailored to provide practical and group support for adherence.

Chapter 10: Discussion and Conclusions

10.1 Discussion Overview

The aim of this thesis was to conduct a mixed methods investigation of the determinants of physical activity (PA) in individuals with MCI to address gaps in the available literature and the dearth of MCI specific data relating to PA in this patient group. The research objectives were to understand PA engagement and PA programme adherence in this cohort using multivariate analysis of the correlates and covariates of engagement and adherence and a series of individual interviews exploring barriers and facilitators, with participants sampled from a 12 – month PA intervention programme for individuals with MCI. The mixed methods study objective was achieved by the integration of both sources of data to identify the determinants of PA engagement and PA programme adherence to inform recommendations for PA promotion and PA intervention design targeting cognitive health in older adults.

The findings from each empirical study have been discussed in their respective chapters (Chapters 4 – 9). A summary and interpretation of the main findings within the context of the available literature is presented in section 10.2. The contributions of this thesis are discussed in section 10.3 and recommendations for future research and policy are discussed in section 10.4. The implications of these findings in light of current policy is discussed in section 10.5. The strengths and limitations of this study are outlined in section 10.6, and the final conclusions of this body of research are presented in section 10.7.

10.2 Summary of Main Findings

10.2.1 Low levels of PA Engagement and Programme Adherence in Individuals with MCI

Rates of PA engagement were low as measured by self-report (0% achieved PA guidelines) and objectively, using actigraphy (30% achieved PA guidelines). The objectively measured finding is consistent with some of the literature (O'Connell et al., 2015; Rovner et al., 2016) which found similar mean weekly PA and % achievement of PA guidelines in this population but is in contrast to two studies which reported higher levels of weekly PA engagement. One of these reported rates of PA in LMICs (Vancampfort et al., 2018), which may not be comparable to rates in the Irish population because of socioeconomic or cultural differences between the two study populations. The other reported a very high mean daily PA of 216 minutes among individuals with MCI attending a PA programme in a sports university and for this reason may be a biased sample. The low levels of PA engagement in MCI may reflect a low level of PA engagement in Irish people in general, as 62% of cognitively healthy Irish adults do not engage in 150 minutes of PA per week (Murtagh et al., 2015). Similarly, PA programme adherence was low overall in this study, but was in line with previously estimated PA programme adherence in MCI populations (Di Lorito et al., 2020; Tak et al., 2012; van Uffelen et al., 2008).

10.2.2 Poor Agreement Between Self-Report and Objectively Measured PA Engagement

The level of agreement between self – reported PA engagement and Actigraph PA data was poor, suggesting that the measures were not equivalent in what they are assessing or that there is a difficulty with using self-report PA engagement in individuals with MCI. This discrepancy between self -report and objectively measured PA engagement is in contrast with a number of studies that have reported positively on the reliability of the LAPAQ in cognitively healthy individuals (Harris et al., 2009; Stel et al., 2004) but consistent with findings in cognitively impaired individuals (Siebeling et al., 2012). There are some possible explanations for this as evidenced by the integrated findings. Memory issues experienced by individuals with MCI may contribute to inaccurate reporting of past PA. Also, a lack of knowledge regarding PA (i.e., understanding what is meant by PA) could have contributed to an under – estimation of self - reported PA data found in this study. Alternatively, it could be that inherent differences in the units of measurement, i.e., bouts of sustained activity of 10 - minute durations or longer (Freedson bouts as recorded via the Actigraph) versus estimates of time spent in specific tasks (LAPAQ) may have contributed to this finding. To illustrate this point, imagine losing an object such as a TV remote control for example. One could conceivably spend ten minutes or more searching for this object in various places but actigraphy would record this as one ten-minute Freedson bout of PA. However, it is unlikely that one would then recall this incident when completing a PA questionnaire and report it as time spent in PA. Thus, objective tools and self – report may not be capturing the same data. However, although there was poor agreement between measures, self – reported PA may be useful for providing more information regarding the context of activities (Ogonowska-Slodownik et al., 2021; Van Holle et al., 2015) and there is some support from research in cognitively healthy older adults that using a combination of both objective and subjective PA data provides more holistic information (Kortajarena et al., 2019; Kowalski et al., 2012). Based on this finding, it is recommended that future PA data be collected using objective methods as well as by self-report in individuals with MCI to improve the reliability of the data, while still being able to gather information regarding the context of PA.

10.2.3 Subjective Accounts of Memory Impairment but not Objective Measures of Cognitive Function are Associated with PA Engagement and Adherence in Individuals with MCI

Our findings show that subjectively defined accounts of memory issues were associated with PA engagement and PA programme adherence, but cognitive function as measured using the MoCA was not. Further, subjective accounts of memory issues did not correspond with objectively measured cognitive function in this study. This is in contrast with the findings of a number of studies that have reported a negative association between cognitive function and PA engagement (Gagliardi et al., 2016; Kobayashi et al., 2016; Rovner et al., 2016; Stuckenschneider et al., 2018; Vancampfort et al., 2018) and PA programme adherence (van Uffelen et al., 2009). However, as discussed in Chapter 3 (MMRS) the theme of memory issues was commonly identified as a barrier to PA engagement (Chong et al., 2014; van der Wardt et al., 2019) and PA programme adherence (Hancox et al., 2019) in the qualitative literature and qualitative studies have evidenced a more consistent association with engagement and adherence and cognitive health than has been seen in quantitative studies. In addition, in this study, barriers to PA engagement differed according to individual accounts of memory issues. Participants who described milder memory issues reported the barriers of lack of time and bad weather more frequently. Whereas participants with more problematic memory issues more often reported a lack of time, memory issues and physical limitations to PA engagement.

The same was true of subjectively reported physical health barriers which were associated with poor PA engagement and PA programme adherence, whereas objectively measured physical health indices were not. This is contrary to current, albeit inconsistent, quantitative evidence regarding physical health and PA engagement (Rovner et al., 2016; Vancampfort et al., 2018) and programme adherence (Cox et al., 2013; Tak et al., 2012), but again is in line with qualitative reports of physical health (injury or illness) which has been found to be a more consistent barrier to PA engagement (Chong et al., 2014; van der Wardt et al., 2019). The conflicting findings between strands of data in this current study may be due to the small number of subjects included but also could be a function of the objective measures of physical health used in this study. For example, physical health was measured using medication counts and grip strength which may have been too narrow to accurately represent the construct of physical health.

The mismatch between self-report and objectively measured cognitive and physical health and PA engagement and adherence suggests that individuals with MCI experience cognitive and physical barriers to PA engagement and programme adherence that may not be captured through objective measurement and that objectively measured cognitive and physical data may not be sensitive enough to determine capability for PA engagement or programme adherence in this cohort. Given that this is the first study to combine qualitative and quantitative evidence regarding the role of cognitive and physical issues associated with MCI in PA engagement and PA programme adherence, this study expands on what is known about how MCI related issues impact PA in this group of individuals. The findings of this thesis, in conjunction with the current literature, also highlight the importance of understanding the impact of memory and physical issues associated with MCI on the individual and thus on PA engagement and programme adherence.

Overall, these findings suggest there is a need for a personalised approach to PA assessment and promotion for individuals with MCI, as has been suggested by others (Chong et al., 2020). This may involve assessment of capability on a case – by case basis using self – report tools to capture subjective cognitive and physical health status in addition to objectively recorded cognitive and physical function as part of a holistic approach to contextualise and understand the data (Power & Lawlor, 2013). Therefore, based on these findings, we suggest that using a combination of self – report and objective measures of physical and cognitive health would improve PA assessment and enable tailoring of PA programmes to enhance PA engagement and programme adherence in this population.

10.2.4 Barriers to PA Engagement and PA Programme Adherence are Potentially Modifiable

Barriers to PA engagement were physical (physical capability/injury), cognitive (memory issues), practical (weather, lack of time), and a lack of knowledge of the cognitive benefits of PA and PA guidelines. Facilitators were enjoyment (social aspect, being outdoors, goal/purpose, defining PA, acceptable pace), and health (physical, psychological). Barriers to PA programme adherence were memory complaints and poor physical health, low motivation for PA and a lack of practical support for adherence (i.e., routine and guidance). These findings are consistent with much of the qualitative PA engagement and programme adherence literature for individuals with MCI. For example, the impact of memory issues (Chong et al., 2014; Hancox et al., 2019; van der Wardt et al., 2019), physical health (Chong et al., 2014), perceived physical health (van der Wardt et al., 2019), acceptable pace (van der Wardt et al., 2019) and enjoyment of social aspect of PA engagement (Chong et al., 2014; Hancox et al., 2019; van der Wardt et al., 2019) on PA engagement and programme adherence in mixed MCI and dementia populations have been documented. This study has contributed to the literature by adding support to the idea that these factors, in addition to a lack of knowledge or awareness regarding PA and its cognitive as well as physical benefits, are determinants of PA engagement and PA programme adherence in individuals with MCI. In addition, Chapter 8 (section 8.3.4) of this thesis has described how these barriers might interact within the three main themes of motivation, support, and individual experience of MCI to impact on PA programme adherence in this cohort. For example, more problematic memory and physical issues resulted in a greater need for practical support for programme adherence.

These findings suggest that some barriers to PA (engagement and programme adherence) in MCI may be modifiable. Factors such as memory issues can be addressed by using memory supports such as reminders (van der Wardt et al., 2017). Physical barriers could be modified by tailoring activity to suit physical capability (Chong et al., 2014). A lack of awareness of PA could be addressed through dissemination of information and educational material (Chong et al., 2014) and motivation for PA could be enhanced through incorporating a social element or group – based design into PA programmes (Chong et al., 2014; van der Wardt et al., 2017). However, it should be noted that there is currently a lack of evidence regarding the effectiveness of these adherence support strategies (van der Wardt et al., 2017) and their effectiveness should be evaluated in future studies.

10.2.5 Better PA Adherence found in Class Based Sessions

Adherence to class sessions was significantly higher than for home sessions. Although previous studies have suggested that group – based formats may achieve greater programme adherence in individuals with MCI and in cognitively healthy adults (Arikawa et al., 2011; Courneya et al., 2012; Cox et al., 2003; El-Kotob & Giangregorio, 2018), this is the first study to assess differences in rates of adherence between these two types of programme settings. Qualitative findings supplemented the quantitative data regarding higher rates of class session adherence compared with home sessions, and it was found that class sessions met the need for practical and group support which home sessions lacked. It is likely that this is responsible for the higher levels of class adherence demonstrated. The provision of guidance and supervision, routine and structure and the group support provided by peers encouraged and motivated participants' class adherence. Practical and group support needs were impacted by individual experience (i.e., the severity of memory/ physical issues) with more problematic issues, such as more serious memory loss, resulting in greater need. From the participants perspective, memory issues negatively impacted PA programme adherence through forgetting and confusion which was problematic especially in terms of implementing home session adherence. Further, the integrated findings showed that higher class adherence was driven by the provision of guidance and supervision (in the form of an instructor), routine and structure (through set class timetables and encouraging habit formation) and group support which enhanced adherence through enjoyment and the social element it provided. In contrast, these elements, or supports, were lacking for home sessions and it is thought that this resulted in the statistical differences in adherence rates between settings. This finding may also explain the overall low adherence to the programme as the lower rates of home session adherence likely drove down the mean rate of programme adherence. These findings are convergent with previous research which determined that routine, practical and emotional support, memory support, and having a purpose for PA were key determinants of adherence to a home – based PA programme in individuals with MCI (Hancox et al., 2019) and the findings of this study demonstrate the differences in adherence when these determinants are addressed (in a class setting) compared with when they are not (as in our home – based condition). Thus, this suggests that class and group-based formats that provide guidance and supervision as well as routine and reminders may help to support PA programme adherence in individuals with MCI.

In agreement with the quantitative findings, programme setting was the only programme related factor impacting adherence from the participants perspective. This is in line with one previous study (Di Lorito et al., 2020) but in contrast with others (Cox et al., 2013; Uemura et al., 2013) regarding the impact of programme duration and intervention condition. However, our data suggests that, at least in this sample of Irish individuals with MCI, programme setting may be a more important determinant of PA programme adherence than duration or intervention condition. This finding has implications for PA intervention design in terms of how best to optimise adherence and thus cognitive benefits.

10.2.6 Lack of Awareness Regarding PA in MCI

In general, there was a lack of knowledge or awareness surrounding many aspects of PA in individuals with MCI. The PA guidelines were largely unknown and there was little awareness of the cognitive benefits of PA. Where these benefits were outlined to participants, the result was the expression of intention to be more physically active, suggesting that increasing awareness of the benefits might motivate greater PA engagement. In addition, participants varied in their understanding of the concept of PA, likely resulting from a general lack of information regarding the topic. For example, participants were unaware of what exactly was meant by PA and what counted toward achievement of the PA guidelines. Activities such as gardening and housework were not considered as PA. In many instances PA was understood as an intentional effort be active to benefits ones` health and therefore participants may have discounted instances of what is understood as PA as they did not perceive them to be relevant. This perception of what PA is, i.e., an intentional effort to be active for health is more in line with the concept of “exercise” as distinct from “physical activity” in the current literature, whereas physical activity refers to any bodily movement that requires physical effort (Caspersen et al., 1985). Thus, this finding suggests there was a lack of understanding in this cohort that not only “exercise”, but any form of PA contributes to achievement of the PA guidelines, in addition to a lack of awareness of the guidelines. This may have implications for self – reported PA data as activities that would theoretically be considered PA in research terms may have been discounted by participants through a lack of knowledge or consistent definition of PA. For example, though the LAPAQ provides lists of activities considered PA, it is not exhaustive, and the individual may feel that an activity they engaged in is irrelevant as it is not mentioned in the list, and fail to record it. It is possible that the poor agreement between objectively and self – reported PA in this thesis may partially be explained by a lack of understanding of what is considered PA in this way. This finding has implications for national health policy as it shows that Irish adults with MCI require more information regarding many aspects of PA, as it is likely that knowledge of the PA guidelines and how to achieve them, and the cognitive benefit to them, could enhance their attainment.

10.3 Thesis Contributions

This is the first study to report on PA engagement and PA programme adherence in individuals with MCI in an Irish context and to use a mixed methods design to explore this under researched topic. Due to the lack of focus this topic has received in the literature, the mixed methods approach was intended to expand on current knowledge and provide new insights. As a result, this thesis has contributed new information regarding rates of PA engagement and PA programme adherence in Irish individuals with MCI and the factors that influence it. This is also the first study to explore differences in rates of adherence between a class – based and home – based format in PA interventions for individuals MCI. The use of a mixed methods approach enabled the identification of factors that contributed to greater levels of class compared with home session adherence such as guidance and supervision, routine and structure and group support, and highlighted ways that these factors can be used to support adherence to PA interventions for this cohort in future studies. In addition, this thesis found that that self-report on PA can provide important contextual data but should be supplemented where possible with objective measurement in individuals with MCI to counter inaccuracies of recall related to memory impairment.

The mixed methods design of this thesis allowed for the comparison of methodologically different strands of data to gain a greater insight into the topic area. This approach helped to highlight the finding that objective measures of physical and cognitive function do not tell the full story regarding the determinants of engagement and adherence and consequently this insight informed a recommendation for the use of an individual assessment and self – report information on the impact of physical health and memory complaints in this cohort. The findings of this thesis indicate that, at least in this sample of Irish individuals with MCI, awareness regarding many aspects of PA is low and should be targeted to enhance motivation for PA.

Finally, the use of a model of behaviour, the COM – B model, to integrate and configure the current literature and the findings from this thesis facilitated the formation of evidence-based recommendations to help support PA engagement and PA programme adherence in individuals with MCI. This study also demonstrated that the COM – B model is a good fit for PA adherence and engagement data and could be used in future research to understand the complexities of these in other clinical groups, thus furthering public health research in this area.

10.4 Recommendations

At the proposal stage of this project, and following information extracted from the mixed methods systematic review completed as part of this thesis, two areas of physical activity behaviour were identified for further study. These were physical activity engagement and physical activity programme adherence. Study 1 sought to explore the issues relating to PA engagement, i.e., general physical activity behaviour in general in a sample of adults with MCI. Study 2 was concerned with issues relating to adherence to a structured PA programme addressing cognitive decline in adults with MCI. Thus, at the beginning of this project these two areas of PA behaviour were operationalised as conceptually distinct and inherently different.

However, based on the individual quantitative and qualitative findings and the integration of both regarding study 1 (PA engagement) and study 2 (PA programme adherence), this position regarding the distinct nature of these concepts has been amended. This is because the barriers and facilitators of engagement and programme adherence were found to be almost identical, leading to a set of primary recommendations that were to be applied to both engagement and programme adherence. For example, barriers such as memory and physical issues, and a lack of awareness of PA and PA guidelines were identified in both studies. Therefore, based on the findings of this thesis it is suggested that in terms of PA in adults with MCI, general PA engagement and specific PA programme adherence are influenced by the same set of factors and in that sense are different sides of the same coin. As such, it is suggested that these should be treated as inter -related concepts in future research of this topic.

There are several recommendations arising from this thesis, albeit these are primarily derived from qualitative findings, that have application for research and intervention design and public health, both at a national policy and a community or local level. Firstly, from a research and PA intervention design perspective, we suggest that PA assessment and promotion/ prescription be based on individual assessment of physical and cognitive capability. Incorporating self – report measures of physical and cognitive health to assess capability at screening may help to achieve this in practice. The level of PA should be tailored accordingly. Secondly, it is advised that PA data be objectively measured in individuals with MCI in conjunction with self – report data to ensure full and complete recording of PA and to contextualise the information obtained Additionally, it may be advisable that PA interventions adopt a group based and supervised format to enhance motivation and support for adherence. PA can be tailored within this type of format by individual assessment of capability, as described above, which should then be translated into exercises that are modified to suit capability. For this, supervision by an instructor qualified to modify PA to suit the ability of the individual and to provide guidance on how to safely perform the exercise is necessary.

Two health policy actions are also suggested based on the findings of this thesis, both of which could be actioned at a national and community/ local level also. These were firstly to increase awareness of the benefits of PA and of the global guidelines to address the general lack of knowledge that was found. This could be achieved by disseminating information via television and radio at a national level, and at a community level, by amplifying this message through healthcare providers who are likely to encounter this clinical group, such as general practitioners, practice nurses, physiotherapists, and geriatricians, with educational material and practical guidance on how to be more physically active. Secondly, the provision of community-based facilities such as inclusive PA classes catering for older adults, including individuals with reduced cognitive and physical capacities would support PA engagement in individuals with MCI in the community. At a national level this would involve the formation of a nationwide PA initiative, including the provision of funding and promoting classes for older and/ or cognitively impaired adults. Again, it is advised that these be instructor led and group – based. Introducing these at a community level, in local gyms, community centres or parks for instance, would enhance opportunity for PA in this group and providing trained instructors to cater for physical and cognitive limitations would support engagement and adherence.

It should be noted that though PA has been shown to be a promising intervention for maintaining cognitive health and delaying progression to dementia in adults with MCI, initiatives aimed at increasing and consolidating habitual and incidental PA in the general adult population are likely to be of benefit in a wider sense. For example, it has been shown that greater levels of PA in mid – life as well as later life is beneficial to cognitive health and may reduce the risk of future MCI, dementia and AD (Apostolo et al., 2016; Ahlskog et al., 2011). In addition, early intervention is often thought to be the most prudent approach in addressing cognitive decline (Emery, 2011). As the stages of MCI and dementia are often not clearly delineated and similarly with the stages of MCI and pre- MCI (or subjective cognitive decline), it is difficult in practice to determine who should be targeted for PA interventions for cognitive health and when this should occur. Therefore, implementing interventions to increase PA at community and population levels could also improve cognitive outcomes in the general population at the earliest, and therefore most beneficial, stage for adults at risk of cognitive decline. Thus, a pragmatic approach would be to include all adults these types of initiatives by endeavouring to educate the population as a whole to the benefits of being physically active as a preventative cognitive measure. Therefore, we suggest that dissemination of educational material and opportunity for enhancing habitual and incidental PA not be limited to those presenting with cognitive impairment but be extended to account for all adults within a general population, who are also likely to benefit.

10.5 Implications of Findings in an Irish Context

These recommendations are in alignment with current initiatives to promote PA in older adults at a national level. For example, national sports policy initiatives such as the "age and opportunity" initiative funded by Sports Ireland provides a national programme for sports and PA in older adults called "Go for Life". This is a peer led community-based programme delivered nationally through local sports partnerships and Health Service Executive health promotion units. National awareness campaigns to promote a healthy lifestyle, including PA, have also been undertaken under the National Physical Activity Plan (NPAP) (Department of Health, 2018), informed by the Healthy Ireland survey 2018 (Department of Health, 2020). However, although these current initiatives correspond with the recommendations of this thesis in terms of promoting awareness of PA, there are two considerations here. The first is that though these were national campaigns, there was still a low levels of awareness of PA in this sample suggesting that the message needs additional promotion to make an impact, at least in this specific cohort as indicated by the data. The second consideration is that no participants of this study reported knowledge of or participation in "Go for Life" or any other community based national PA initiatives, suggesting that either knowledge of or access to/ uptake of these is also low. These community level initiatives are targeting PA engagement in older adults including those with disabilities, and it may be that individuals with MCI are somehow falling through the cracks and thus need additional focus as a target group. Although without proper assessment of the uptake of these initiatives in general it is not possible to determine if this is the case.

Similarly, the National Exercise Referral Framework (NERF) was proposed under action 25 of NPAP to promote PA in adults and older adults for the management and prevention of chronic conditions and non – communicable diseases (NCD`s) (Woods et al., 2016) through healthcare providers. Exercise referral schemes, also called green prescriptions, exist in many countries as a way of promoting PA through health care providers, usually GP`s, for example the “Exercise is Medicine” scheme in Australia and the National Exercise Referral Scheme (NERS) in the UK. In Ireland, the NERF proposed that all healthcare providers, including physiotherapists, occupational therapists, clinic and practice nurses and GP`s refer patients to exercise programmes, which would be based in the community and run by local sports partnerships and local leisure centres. The proposal advised that the provision of classes should be group specific such as classes for exercise referral participants or specified by condition such as obesity etc to enhance adherence, in line with the recommendations of this thesis. However, the NCD`s targeted in the proposal were cardiovascular disease, coronary obstructive pulmonary disease, coronary heart disease, asthma, diabetes and mental illness, and there was no focus on cognitively impaired populations such as dementia or MCI groups as possible candidates for exercise referral. Thus, the findings and resulting recommendations of this thesis align with the proposed NERF, albeit that MCI and dementia were not explicitly included in as an NCD condition requiring referral. This implies very specific criteria for those considered for exercise referral and indicates that individuals with MCI may not be receiving due consideration as a target group for PA intervention in health care provision. However, a NERF pre -development working group concluded in a review of the evidence for a national exercise referral framework that there was insufficient evidence of its efficacy and cost – effectiveness compared with brief consultation with healthcare providers under the “Every Contact Counts” initiative (Healthy Eating & Active Living Programme, 2017). Thus, to date, no exercise referral scheme has been implemented in Ireland.

Every contact counts is an initiative to recruit healthcare providers to routinely encourage patients to make healthy lifestyle choices to prevent and manage chronic disease. It should be noted however that it is currently unclear if GP`s routinely promote PA to individuals with MCI. This was an area of research planned as a third study within this thesis (see Chapter 2, section 2.1.2) and based on a preliminary expert interview (with a GP, researcher, and GP trainer) it is possible that the cognitive benefits of PA are not well known or promoted by GP`s to adults with MCI due to time constraints within practices, specifically in terms of the time available for consultations. Interviews with GP`s may have expanded on these suggested possible barriers to the promotion of PA by GP`s for individuals with MCI. Thus, the recommendation of this study to include healthcare providers in the dissemination of information and promotion of PA in this population may have barriers to its implementation that require further research to understand and overcome.

The findings of this thesis and the subsequent recommendations highlight the importance of including individuals with MCI as a target group in future health policy initiatives and ensuring they are considered as a target group for PA promotion by healthcare providers under Every Contact Counts. It also highlights the need to make specific provision for individuals with MCI within the context of current community – based PA initiatives such as Go for Life to promote PA engagement and PA programme adherence in this group.

10.6 Strengths and Limitations

A strength of this study was the use of the mixed methods design which allowed for analysis of data from differing perspectives, i.e., objective data and experiential accounts, to view the topic comprehensively and generate new knowledge and information on PA adherence and engagement in individuals with MCI. As the quantitative sample was small, the use of a qualitative strand of data supplemented the quantitative data and strengthened the overall study findings. In addition, the mixed methods approach highlighted the MCI participants' voice regarding the topic of PA and the findings arising from this thesis demonstrated the importance of understanding PA from the participants perspective.

The use of objective measurement of PA with actigraphy in this study allowed for a comparison of methods of PA data collection in individuals with MCI to increase the confidence in the findings regarding PA engagement. This approach has not previously been reported in the literature and is an important consideration in individuals with MCI where issues of the accuracy of recall may exist. The integration of studies and the use of a theoretical framework (COM – B) facilitated the identification of areas where current knowledge on this topic is incomplete and requires further investigation. For example, it has shown that individual’s motivation for PA engagement or adherence is a contributing factor, but motivation has not been investigated as a variable in studies of PA in individuals with MCI.

The limitations posed by the sample size in the quantitative analyses have been discussed previously in this thesis (See Chapter 4 and Chapter 7). The lack of statistical power may have introduced type II bias and masked significant effects. It is likely that this was the case; although cognitive function and physical health were not found to be statistically significant correlates, the OR`s and CI`s suggested that there was a positive association with programme adherence and cognitive function before adjustment was made for multiple comparisons. In addition, qualitative findings supported an association between cognitive and physical health and PA engagement and programme adherence. Although the possibility of type II error may partly explain the lack of significant effects in the quantitative strand, qualitative data demonstrated that subjectively described cognitive issues beyond those objectively accounted for were important determinants of engagement and adherence, as was shown by comparing MoCA with subjective reports of memory problems within the qualitative sample. Further research with larger numbers is needed to replicate the quantitative findings of this thesis.

The time frame within which PA data was collected is a limitation to this study. The LAPAQ PA questionnaire was completed when participants presented for NeuroExercise study assessments at either baseline, 6 months, or 12 months for study 1 and at 12 months for study 2. However, participants were then given the Actigraph device at those assessment time points to wear continuously for the following 7 days. This means that the PA data being compared were not for the same 7-day time period and there is a possibility that this means they did not measure the same thing. However, a question within the LAPAQ assesses this possibility with the question "You just told me about your usual activities of the past two weeks. Were the past two weeks normal as compared to the rest of the past year?". This was not possible with the Actigraph device, but manual checking through the dataset showed that the PA reported by participants was consistently much lower than that recorded objectively, thus increasing confidence in the finding that participants of this study under – reported their habitual PA. In future studies however, it would be prudent to ensure objective and subjective PA data are collected simultaneously.

Though the choice of study design enhanced this project in a number of ways, one limitation with the convergent parallel design is that it can be challenging to carry out due to the complexity of conducting multiple analyses simultaneously (Teddlie, 2009). Thus, although there were advantages in terms of addressing the topic, this type of design was challenging for use in a PhD thesis and may be more suited to projects involving a team of researchers. For example, each main study within this thesis undertook a qualitative analysis, a quantitative analysis and an integration chapter resulting in large volumes of data that was more time consuming to analyse than was originally thought. In addition, the fact that one researcher (LC) was responsible for the entirety of the analyses meant that there was an increased risk of researcher bias. As a researcher with a background in health psychology, a strong interest in PA and a belief in its efficacy as an intervention for cognitive decline and all-around good health, the introduction of bias was a possibility. This potential bias was addressed throughout the duration of the analysis and interpretation phases through regular discussion with the PhD supervisory team.

The Covid – 19 pandemic of 2020 - 2022 had several implications for this body of work. Primarily, it negatively impacted the implementation of a planned third study of barriers and facilitators to referral of physical activity as an intervention for MCI among healthcare professionals such as GP`s, geriatricians, occupational therapists and practice nurses. The subsequent lockdowns and increased pressure on the healthcare system arising from the pandemic meant that it was impossible to gain access to healthcare professionals to capture qualitative data to address this aim. Consequently, plans for this study which would have rounded out this body of research did not go ahead. Thus, this limitation resulted in this study being limited by the exclusion of a third perspective, that of healthcare professionals, to expand on our understanding of what is needed within a health care context to promote PA in individuals with MCI. This is an area for future research to further understand the barriers and facilitators of PA promotion in individuals with MCI.

Another limitation is the generalisability of the findings. The MCI sample used were recruited from the province of Leinster and most of the participants were from the Dublin area. This may have implications for the applicability of findings to other parts of the country. For example, from a national perspective, it may be the case that opportunities to be physically active or the provision of amenities to facilitate PA may differ throughout the country, particularly in urban versus rural areas. Additionally, from an international perspective, the findings and recommendations may not be generalisable outside of Ireland. Cross cultural and country or site-specific differences regarding PA for individuals with MCI occurred across the other 2 sites in the NeuroExercise trial. For example, individuals with MCI in Cologne were recruited from the German Sports University and, in contrast to the Irish participants, had a very high level of baseline PA engagement. In the Netherlands, as part of a 2-week international scholar placement at the Radboud University Hospital, Nijmegen, I conducted interviews with a number of the Dutch NeuroExercise PA programme participants. In the Netherlands cycling was common, and the infrastructure ensures its safety, and this meant that Dutch MCI participants had higher levels of habitual/ incidental PA on preliminary analysis. In addition, the setting of the PA classes differed between the Irish and Dutch study arms, with the former taking place in a hospital setting and the latter being conducted as community-based classes chosen by participants. (The collection and analyses of these data were not part of the original thesis proposal and will be reported as a cross national comparison of PA engagement and adherence separately). The differences noted between MCI cohorts and settings across the different international sites highlight the fact that the recommendations put forward in this thesis may not be generalisable to other countries and contexts. Thus, an interesting area of further research would be to explore the cultural context of PA in individuals with MCI to tease apart the impact of cross – cultural differences on engagement and adherence.

10.7 Conclusions

Adults with MCI experience cognitive and physical limitations to PA that can be targeted to improve engagement in PA and adherence to PA programmes in this clinical group. This may be achieved through individualised PA assessment and prescription using self – report cognitive and physical health data in conjunction with objective measurement to achieve a holistic perspective of capability for PA. Increasing public awareness of the global PA guidelines and the cognitive benefit of PA is recommended to enhance motivation for PA engagement at a national level. PA interventions which provide supervision and guidance, routine and structure and a group setting are likely to optmise adherence to PA programmes for this cohort. Further research is needed to examine possible cross – cultural differences in PA engagement and adherence and assess the generalisability of these findings to other populations.

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