Exploring the relationship between age stereotypes and older adults' physical performance

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Abstract

There is a wealth of research exploring the biological, physical and physiological changes that occur with age to subsequently impact on older adults' physical ability and performance. In contrast, there is much less research exploring psychological determinants of older adults' physical ability and performance, despite some compelling evidence that age stereotypes can have an impact. This thesis explores the potential impact of age stereotypes further taking a mixed methods approach.

Using an experimental design, Studies 1 and 2 aimed to replicate and extend age-based stereotype threat (ABST) theory. ABST is the concern that someone has for confirming a negative stereotype of their age-group, when they are required to perform in the stigmatized task domain and evidence suggests it has a detrimental impact on cognitive tasks (Lamont, Swift, & Abrams, 2015), as well physical tasks such as hand-grip (Swift, Lamont, & Abrams, 2012). Study 1 extends Swift et al (2012) by using more precise physical and physiological measures. Study 2 extends ABST understanding by exploring the impact on a new physical performance task measuring balance. These studies find partial support for ABST. Study 3 used existing survey data (ELSA) to test the hypothesis that internalised negative age stereotypes are associated with physical performance outcomes and subsequently puts older adults at increased risk of a fall. Studies 4 and 5 explore the associations between negative age stereotypes and physical performance in applied settings, including a dance group (Study 4) and a care home (Study 5). The studies reveal that physical activity can be an effective intervention for improving older adults' attitudes to age.

The findings are discussed in relation to psychological theories, ABST and stereotype embodiment theory, as well as proposing the integration of findings with biological models of age related change. Limitations and future recommendations are also discussed.

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Abbreviations

ABST – Age Based Stereotype Threat

ApEn – Approximate Entropy

AP - Anterior-posterior

APB – Abductor Pollicius Brevis

COP – Centre of pressure

EMG – Electromography

FCU – Flexor Carpi Ulnaris

GL – Gastrocnemius Lateralis

IPM – Integrated Process Model of Stereotype Threat

Kg – Kilograms

M - Mean

MAP – Mean Arterial Pressure

ML – Medial-lateral

MVPA – Moderate-Vigorous Physical Activity

N - Newton

PL – Peroneus Longus

SD – Standard Deviation

TA – Tibialis Anterior

SEM – Structural Equation Model

SENIAM - Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles

STEP – Stereotyped Task Engagement Process Model

Chapter 1 - Introduction

Globally, the number of individuals over 80 years are projected to triple by 2050 (United Nations, 2017). In the UK, the number of people over 75 is projected to double in the next 30 years (Age UK, 2015), and by 2050 1 in 4 people are expected to be 65 or over (Office of National Statistics, 2019). As a consequence of increasing life expectancy and declining fertility, this growth in the older age demographic is forecast to be unmatched by the working age population.

The socio-economic impact of an ageing society presents both challenges and opportunities. In the UK, an estimated £136 billion was spent on health and welfare provision for older adults in 2007. This is forecast to grow by £80 billion (59%) by 2030 (WRVS, 2011). However, these rising costs can be set against increasing economic contributions. In 2007, older adults made an estimated net contribution of around £45 billion and this is expected to rise to an economic value of £82 billion by 2030. On balance, costs are offset by tax revenues enabled by the abolition of the default retirement age and rises in state pension age. In addition, there are many contributions from older adults that bypass the exchequer, such as spending power (the contribution of the 'grey pound' is estimated to hit a net contribution of £127 billion to national economy by 2030); volunteering through formal and informal roles (a contribution expected to be worth £15 billion by 2020), and uptake of care roles (estimated value £34 billion in 2010 projected to £52 billion by 2030) (WRVS, 2011).

Ageing is a multifactorial process, which can present challenges to individuals in later life, such as physical and mental health deterioration, social complications, psychological difficulties, frailty and sarcopenia (BMA, 2011). Sarcopenia is the reduction in muscle mass experienced as people get older, and it affects 13-24% of 65-70 years old and 50% of those over 80 years. It is characterised by the loss of approximately 3-8% muscle mass per decade after the age of 30 (Roubenoff & Hughes, 2000), and can lead to frailty. Frailty is a state characterised by age-related physical and social deterioration, disability and loss of independence. It is defined by the impaired capacity for physiological systems to adapt to internal or external stressors (Li, Manwani, & Leng, 2011). Approximately 10% of adults over 65 and around a third of those over 85 are categorised as frail (The British Geriatrics

Society, 2014). Many of these will experience mobility-related impairments, such as reduced gait speed and stride length (Cashman, 2013), reduced strength (Amaral et al., 2014), and increased risk and likelihood of experiencing of a fall (Age UK, 2012). This changes can make typical daily activities such as chores, hygiene, and climbing stairs more challenging, and can have negative repercussions on independence and wellbeing (Shumway-Cook, Gruber, Baldwin, & Liao, 1997). Crucially, research suggests frailty is a potentially preventable clinical condition, and in some circumstances, may even be reversible. However, for most, frailty represents an irreversible phase of health decline (Hoogendijk et al., 2019).

It is important to understand the role of mobility in preserving independence and wellbeing as people age. Incidence of mobility difficulties increases exponentially as at people age, 38% of adults aged 70 and over have a difficulties with mobility, compared with 12% at age 16 and 18% at age 60 (Age UK, 2015). Impairments in movement and balance contribute to an increased risk of experiencing a fall. Falls are the largest cause of emergency admissions for older people, and have a significant impact on morbidity and mortality (Age UK, 2012, 2015). Research by Age UK suggests every hour one person over 65 dies from a hip fracture as a consequence of a fall (Age UK, 2012).

As people get older, everyday activities can present more challenges and risks leading to withdrawal from everyday tasks (Garber et al., 2011). Research thus far tends to focus on the impact of physical age-related changes and decline. However, psychology and gerontology disciplines contend that age stereotypes and attitudes to age can also negatively impact on physical performance, can limit engagement in physical activity, and can increase likelihood of disease. The Risks of Ageism Model proposes age stereotypes and negative attitudes towards ageing can negatively impact on health and wellbeing outcomes through the internalisation of negative age stereotypes, the experience of stereotype threat, and by being a target of age discrimination (Swift et al. 2017). Stereotypes are overgeneralised beliefs about a group of people. However, they can also be held about one’s own group. Age stereotypes are nuanced compared with many other forms of stigmatization, because people form age stereotypes of the lower status older group when they are young, before growing older themselves. As people get older they internalise these age-stereotypes as they become relevant to themselves (Levy, 2009). This internalisation of negative stereotypes can have negative repercussions in later life (Kornadt & Rothermund, 2012). For example, data from longitudinal surveys shows endorsing negative age stereotypes predicts worse cardiovascular outcomes (Levy, Zonderman, Slade, & Ferrucci, 2009), dementia (Levy, Ferrucci, et al., 2016), and mortality (Levy, Slade, Kunkel, & Kasl, 2002). Indeed, when people hold more negative age stereotypes, they are less likely to believe they have control of their own health outcomes (Sargent-Cox & Anstey, 2015).

Furthermore, there is strong evidence that the threat of confirming a stereotyped view of ageing can reduce older adults cognitive performance (Barber, 2017; Barber, Mather, & Gatz, 2015; Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Popham & Hess, 2015) This kind of threat to one's identity, is known as age-based stereotype threat (ABST). However, while mechanistic understanding of ABST on cognitive tasks is relatively well understood (Beilock, Rydell, & McConnell, 2007; Johns, Inzlicht, & Schmader, 2008; Schmader, Forbes, Zhang, Berry, & Mendes, 2009), there is comparable scarcity in terms of understanding the effects of ABST on physical performance. A few studies have demonstrated impairments in older people's physical performance as a result of ABST (Swift et al. 2012; Barber 2020). For instance, in Swift et al. (2012), older people's grip strength was reduced when ABST was elicited. This means that older adults' physical abilities in everyday situations could be curtailed by negative age stereotypes. It also means that clinical decisions based on older people's physical performance could be biased by ABST. It is therefore essential to explore these findings to better understand how older peoples' attitudes to age impact on physical performance in order to mitigate these effects.

Research suggests that self-relevant age stereotypes may present a modifiable risk factor for physical functionality in later life, but this research is limited to specific performance domains, and to date, has only explored performance outcomes. Little research has explored effects of ABST at neuromuscular level, which is essential to explain how a psychological based threat can have consequences on physical performance outcomes. Exploring these avenues further could help understand how to mitigate effects of ABST, which could have many benefits, including reducing frailty and falls risk as people age, as well as improving older adults' health and wellbeing. Additionally, the research findings will have application for rehabilitation professionals and general public health, and in ensuring quality standards of gerontological research are upheld.

Aims of the thesis

The thesis aims to extend our understanding of the consequences of age stereotypes on physical performance measures across a range of domains, including hand-grip (Chapter 4, Chapter 6), balance (Chapter 6), and walking (Chapter 6), as well as adverse events related to physical performance such as falls (Chapter 6). The aim is to provide new evidence for how age stereotypes and age-based expectations influence older adults psychologically, behaviourally and physiologically, and expand on the existing theoretical frameworks of ABST, stereotype embodiment, and biological models of ageing.

The thesis also aims to explore the extent to which interventions to promote and increase physical activity can influence attitudes to age in an applied context. Chapter 8 explores the extent to which engagement in an intergenerational physical activity group can promote positive attitudes of ageing, while Chapter 9 investigates the relationship of care home residents' age attitudes and physical performance with their engagement in a physical activity programme.

Methodological approaches

This thesis employs a range of methodological approaches. For instance, Studies 1 and 2 presented in Chapter 5 and Chapter 6 are experimental. Study 3 presented in Chapter 7 uses existing national survey data, and Studies 4 and 5 presented in Chapter 8 and Chapter 9 are intervention observational field studies. Each of these five empirical chapters will consist of separate introduction, description of method, results, and discussion.

Organisation of thesis

This thesis is made up of three parts; the literature review, the empirical part and the discussion. In the literature review, biological aspects of the ageing process are presented. Specifically, how neuromuscular and skeletal systems are affected as people get older and how this impacts on movement. After this, an overview will be presented outlining how attitudes to age and age stereotypes can interact with the physical health risks of ageing to exacerbate mobility difficulties in older age. The empirical part Chapter 5 to 9 present 5 studies investigating a range of ways attitudes to age impact on physical performance and other health outcomes of ageing. Findings from all studies are then discussed collectively in Chapter 10, considering the interpretation of the studies in terms of theoretical understanding and applications to research and clinical practice.

Chapter 2 - Defining old age and physical performance

The purpose of this thesis is to explore how psychological factors, such as endorsement of age stereotypes and age-based stereotype threat can impact on older adults' physical performance, but also their beliefs about physical activity, engagement in physical activity and falls risk. However, the term 'older adult' is subjective, there are no unified definitions on when some reaches 'old age' or becomes an 'older adult'. In addition, there are different perspectives on what constitutes 'physical performance' or engagement in 'physical activity', therefore, these terms will be explored and defined in this chapter.

Defining Age

Age can be used to define who we are, and can be important part of social identity (Harwood, Giles, & Ryan, 1995; Tajfel & Turner, 1979). We celebrate birthdays to recognise chronological age, and we also categorise the life course in distinct age groups such as baby, toddler, child, teenager, young adult, middle-aged, older adult and elderly. This is relevant to this thesis as these groups are perceived to have descriptive (character traits) and prescriptive (expected behaviours) features. These features can come from social structures and age-based stereotypes, and this is discussed in more detail in Chapter 4.

Chronological definition

The point at which a person becomes an older adult can be defined in chronological terms, as in when they reach a certain birthday. However, while this may seem an objective approach, this threshold is still determined with some subjectivity. This means there is still ambiguity about when a person becomes an older adult. For example, in the UK, National Health Service (NHS) guidance and services for older adults include all those age 65 years and over (NHS, 2019), the Department of Work and Pensions defines older workers as those over age 50 years (DWP, 2021), WHO defines older adults as people over 55 years (WHO, 2006). The definition of when someone becomes an older adult can differ by context, culture, the point in time, and by individual (Abrams, Russell, Vauclair & Swift 2011).

As will be discussed in Chapter 3 and Chapter 4, these changes do not occur uniformly across all people and the trajectory of these changes are not fixed (Tampubolon & Maharani, 2018). For example, while adverse events such as frailty and disability are increasingly common with age (Roubenoff, 2000), it is not age per se that determines these outcomes. Similarly, although there is a negative relationship between age and grip strength (Massy-Westropp, Gill, Taylor, Bohannon, & Hill, 2011), there is variance between individuals in terms of strength performance and the trajectory of performance decline. Further, adults age 65 years will have greater variance in physical ability than older adults at age 95 years. That is, even at the same chronological age, there are fundamental differences in health and psychosocial composition that influence physical performance, which mean that interpretation of ageing literature should be cognizant of a range of factors beyond chronological age alone as an indicator of functional ability. This means that a definition of older age in terms of 'years since the date of birth' is lacking in precision in terms of capturing physiological health and physical ability of individuals, despite the empirical support for this relationship across the general population.

Life course definition

An alternative definition of age is proposed by Laslett (1987, 1989). This definition segments the life course into four ages. The first age is characterised by immaturity, dependence, and learning, and the second by work and responsibility. The third age is described as the age of fulfilment. In this age then many of responsibilities of the second age are eschewed, especially that of career duties. This age is lived freely, as individuals have mental and physical health. Finally, the fourth age is defined by dependence and death. These ages are theoretically determined by personal choice. However, as the third age is in turn defined by retirement, this choice is usually restricted by policy regarding state retirement age and pension age. The third age may not be reached in some cases, for example if ill health besets an individual in the second age forcing dependence. Also, depending on circumstance, third and fourth ages may be longer or shorter for individuals. The hope is generally for a prolonged third age to maximise fulfilment, and a brief fourth age to minimise dependence. Crucially, presence or absence of wellbeing does not define these ages, as wellbeing is not restricted to youth or independence.

Many studies of physical performance include covariates for biological health such as mental and physical comorbidities, alongside chorological age (Tomioka, Kurumatani, & Hosoi, 2017). As third and fourth ages are differentiated by the restriction of health causing dependence, this bridges the gap between the chronological age and life course age definitions to some degree. Additionally, many studies target populations who are community dwelling without social care needs, or they target individuals receiving care. So, regardless whether they use Lasletts's (1987) terminology, these sampling strategies restrict participants to either third or fourth ages.

Following the life course definition, differentiation of the young-old, old-old, and oldest-old are made. These categories distinguish physical performance (Reinert, Kinney, Jackson, Diestelkamp, & Bigelow, 2017) and physical activity engagement (Sims, Hill, Davidson, Gunn, & Huang, 2007). Older groups engage in less physical activity and perform poorly on physical measures compared to younger categories. These life course definitions reflect ageing as a transitive process which is not defined by chronological age. However, in attempt to reflect the progression of age, age categories can be descriptive and aid interpretation, but lack precision (Cohen-Mansfield et al., 2013), and so the corresponding chronological ages for age categories can be subjective (Bytheway, 2005). For example the European Social Survey (ESS; 2008/09) asked respondents in 29 countries to define 'old' and 'young' by chronological age. On average young ended at 40 and old started at 62, but this differed significantly by respondents' own age, gender, country, and by their own self-categorization (Abrams et al., 2011; Baslevent, 2010).

Policy perspective

Many social policies aim to increase quality and length of life, and manage health and social care costs associated with an ageing population. Such aims are captured in the European Council (2010) definition of active ageing which aims to "create opportunities for staying longer on the labour market, for contributing to society through unpaid work in the community […] and for living autonomously and in dignity for as much and as long as possible […].” The active ageing approach recognises that ageing is a positive transitive process, and moves away from traditional views of older age as a pathological state. As such active ageing is not a single state of health and wellbeing that individuals achieve but instead the process itself may be successful. Rowe and Khan (1987) define this successful ageing as “low probability of disease and disease-related disability, high cognitive and physical functional capacity, and active engagement with life.” . This has received some criticism as it implies that some ageing processes may be a failure (Bowling & Dieppe, 2005; Butler, Oberlink, & Schechter, 1990). This suggests that if someone is not ageing successfully, for example if they have a disease-related disability, then they are ageing unsuccessfully or failing to age well. More recently, there has been a shift in focus to healthy ageing. The World Health Organisation describe this as “the process of developing and maintaining the functional ability that enables wellbeing in older age” (WHO, 2018). There is recognition that supporting healthy ageing is a system-wide endeavour, where effort is required at the family, community, and economy level. Crucially, this definition of healthy ageing focusses on the relationship between functional ability and wellbeing, and focusses on maintaining wellbeing, in spite of changes to physical functioning.

Much research has focused on understanding the determinants and factors that contribute to healthy, active and successful ageing. Some research has identified and explored specific physical factors such as healthcare, water, work environment, and transport (Bambra et al., 2010; Dahlgren & Whitehead, 2007). However, a concise and useful summary is provided by the Swedish National Institute of Public Health (2009), which notes the following determinants: physical activity and healthy eating, social interaction and a sense of meaningfulness, and a sense of personal control and empowerment.

These determinants are explored throughout this thesis. For example, in the intervention studies in Chapter 8 and Chapter 9, the relationship between social interaction, physical activity, and personal control is explored in regards to age attitudes. The relationship between physical activity and the lack of personal control in the form of age stereotypes is investigated. Of note in this regard, Study 3 (Chapter 7) demonstrates the relationship of self-perceptions of age on physical activity levels, which is in turn also associated with physical performance (grip strength and walking speed) as well as falls risk. Where stereotypes are seen to restrict personal control, then Study 1 and Study 2 (Chapter 5 and Chapter 6) also address healthy ageing components. It is import mat to note that the focus of this thesis is on age stereotypes specifically and not healthy ageing. However, the components of healthy ageing are interdependent with age stereotypes and mediators of threat. This means that this thesis has implications for healthy ageing more generally. Indeed, WHO (World Health Organisation, 2002) recognise removing ageism and negative age stereotypes is a key part of enabling active ageing.

Old age in this thesis

This thesis investigates the effect stereotypes and age-based stereotype threat (ABST) on physical performance. This perceived identity threat means that age of participants is subjective. Research suggests that vulnerability to ABST is dependent on age identity and self-relevance of the threat (Barber, 2017; Weiss & Lang, 2012). In the older age groups, research findings are mixed regarding the vulnerability to stereotype threat. Some research suggests that the young-old group is more susceptible to ABST because the fear the of ABST is greater (Hess & Hinson, 2006). Conversely, other research suggests that the heightened relevance of the threat in older samples leads to greater vulnerability (Colton, Leshikar, & Gutchess, 2013). For this reason, perceived threat is measured in the experimental studies, which allows this to be explored further.

There is a wide range of ages in this body of research. The mean ages of participants in the experimental chapters range from 64 - 85 years. Across these studies, participants have differing levels of independence and comorbidity and range from young-old with physical performance within norm ranges, to oldest-old whose performance is in range of frailty definition. Primarily, these characteristics are defined by recruitment. For example, Study 1 and Study 5 (Chapter 5 and Chapter 9 respectively) are recruited from older adult care facilities. This dependence on care and support means that generalising to the entire older adult population is not possible, and neither is this the intention. This study extends previous research (Swift et al. 2012) and so targets the same population, in the fourth age, the oldest-old. The second experimental study (Chapter 6) recruits individuals active in community groups, targeting people in the third age of life. In Study 3 (Chapter 7), ELSA data recruits a stratified sample of the English population and samples across people age 50 years and over. This means that respondents are not restricted to specific ages, although all are at least in third age or young old. While this means that findings between studies in this thesis are not directly comparable, this approach enables the application of age stereotype theory to a cross-section of the older adult population and forges the application of these theories to this research with a range of participants. As the age group of participants in the studies differs depending on recruitment, then each study targets a different age group. This means that the studies here are contributing to what is known about ABST effects in different old-age groups. This furthers understanding in these populations and paves the way for future studies to develop on these initial findings.

Where recruitment does not define the level of dependence, baseline ability variation can also be controlled statistically by modelling measures of health. For example, this is achieved in Study 1 (Chapter 5) by including comorbidities affecting performance, as well as pharmaceutical covariates which can affect grip strength, and in Study 3 (Chapter 7), where presence of a health conditions is included in models to examine the effect of self-perceptions of ageing on a range of performance outcomes.

Defining physical activity

Physical activity is a broad term which refers to any bodily movement requiring energy beyond the basic requirements to stay alive. Physical activity can be defined in terms type (e.g. walking, football, or sailing), frequency (measured by number of events in a period of time), duration (time), and intensity (how physically demanding the activity is) (Katsukawa, 2016). Physical activities can also be defined in terms of being structured in a micro (e.g. a session) or macro cycle (e.g. a resistance training, weight loss, or running performance programme), or unstructured (e.g. a walk with a friend through a park).

Studies show an inverse relationship between physical activity with mental ill health (White et al., 2018) and physical ill health (Biswas et al., 2015; Booth, Roberts, & Laye, 2012). Physical activity is associated with a range of positive social, psychological, and health outcomes for people of all ages (Hamer, Lavoie, & Bacon, 2014; McPhee et al., 2016; Paterson, Jones, & Rice, 2007; Warburton, Nicol, & Bredin, 2006). Sedentary behaviour refers to the absence of physical activity, such as lying down or sitting down. As the opposite of physical activity, sedentary time has been associated with adverse physical and mental health outcomes (Biswas et al., 2015). The benefits of physical activity engagement are cumulative, such that frequent and regular activity sessions lead to greater magnitude of benefits, such as greater muscular strength and endurance (Geidl et al., 2019; Hamer, Stamatakis, & Steptoe, 2009). For more detail see Chapter 3 (in particular see the section 'Is the trajectory of physical decline modifiable?').

Physical activity may be performed out of necessity, such as for work (e.g. a builder, gardener, or military), medical or health reasons (e.g. if recommended by a doctor, or for self-care), or for leisure and fun (Lieberman, 2015). These reasons may be important because for some physically demanding occupations the benefits of physical activity are absent or subdued (White, Bennie, Abbott, & Teychenne, 2020). This may be because of limited overload, lower psychological benefits, or demographic factors. This can also be important because higher pleasure from physical activity is associated with greater psychological benefits and reduced dropout (Acevedo & Ekkekakis, 2001; Ekkekakis, 2017).

Exercise

Exercise is subcategory of physical activity, and refers to a repetitive activity demanding physical effort, and structured around a health or fitness-related goal, such as to improve or maintain strength (Dasso, 2019; Lieberman, 2015). While the terms exercise and training are not mutually exclusive, training tends to be used more to specifically refer to physically demanding activities that are outcome-goal orientated, such as preparation for completing for a 5 kilometre run, achieving a 100kg leg press, or related to mastery of skill for a sporting endeavour (Langhammer, Bergland, & Rydwik, 2018). In contrast, the term exercise tends to be used more generally, and refers to the goal of maintaining health. With training and exercise, physical performance will improve when the overload principle is achieved. That is, when there progressive stimulus towards the maximum of an individual's physical limit then physical activity can lead to improvements in physical performance. According to the principle of specificity, then it is also important that overload occurs specifically in the movement where improvements are sought (Nader, 2006). In some cases ignoring specificity can reduce performance gains. For example, combining endurance and strength training reduces improvements in strength (Wilson et al., 2012), although endurance performance can benefit from this combination (Coffey & Hawley, 2017).

Physical performance

Physical performance refers to the quantifiable outcome related to a physical activity event such as a race time in minutes, or maximal strength test in kilograms. It could also demonstrate an improvement in mastery of a skill. Physical performance in third and fourth ages is important because it reflects the ability to carry out physical tasks which may be encountered in everyday life such as carrying shopping or doing household chores. Better performance improves the relative ease with which these tasks can be carried out (Murphy, Donnelly, Breslin, Shibli, & Nevill, 2013). This in turn can influence the likelihood that these activities of daily living will be carried out without external support (Ouden, Schuurmans, Arts, & van der Schouw, 2013). For example, being able to walk to a bus, carry grocery shopping bags, and housework require a threshold of physical function. Physical function signifies physical fitness, motor control, and regular physical activity (Garber et al., 2011). Physical performance is also used as a prognostic and diagnostic tool for a range of applications, discussed already in this chapter (Leal, Mafra, Fouque, & Anjos, 2011; Nordin, Moe-Nilssen, Ramnemark, & Lundin-Olsson, 2010).

Physical activity contributes to healthy ageing because of its potential for improving physiological resilience to disease, and for maintaining functional abilities which allows people to maintain tasks of daily living, as discussed later in this chapter. Physical activity can also provide a social function, and can have psychological benefits (see Chapter 9 in particular). This shows that benefits of physical activity are not limited to physical function. It is important therefore to understand the common trajectory of physical performance with age, and the effect of physical activity on that trajectory in the next chapter.

Chapter 3 - Age-related physical functioning

In this part of the literature review, the physiological aspects of ageing will be explored. First, the neuromuscular structure will be considered. Next, the changes to this system that are increasingly common as people get older will be discussed. For example, older people tend to have less muscle mass as they age and the muscle innervation changes that occur with age will be explored. When these limitations accumulate then a state of frailty may be reached in later life. So, frailty will then be considered. Finally, the ways in which the trajectory of these limitations may be attenuated, and the physiological barriers in doing so, will be reviewed.

As negative age stereotypes may present a potential modifiable risk factor for the deterioration in physical functionality as people age, age stereotype and attitudes to age will be reviewed in the next chapter. This part will provide an overview of the content of old-age stereotypes from the perspective of the Stereotype Content Model. The consequences of these stereotypes on behaviour will be explored. As different factors are proposed to influence the relationship of negative stereotypes on behaviour, a brief overview of prevalent theories will be presented.

The Ageing Neuromuscular System

The complex and multifaceted aetiology of physiological ageing means that defining and exploring all the processes that contribute to healthy ageing is vast and beyond the scope of this review. Therefore, this literature review will deliberately concentrate on factors of healthy ageing most pertinent to physical functionality and neuromuscular control. In this chapter, the ways in which the trajectory of ageing may be modified through engagement with physical activity will be discussed. In the following chapter, the modifiability of this trajectory via psychosocial factors will be explored. The effect of physical activity and psychosocial factors will then be tested in the empirical chapters.

This section focuses on the changes in various systems that contribute to decline in physical function. Principally, deterioration in these systems contribute to the loss of muscle mass, known as sarcopenia. However, it is unclear if sarcopenia is a result of physical inactivity or vice versa, and better understanding this relationship will help promote healthy ageing.

Anatomy and physiology of a motor unit

Before further exploring how the neuromuscular system's structure and output changes with age, it is important to briefly review what typical healthy functioning of the motor unit to contract a muscle looks like. A motor unit is comprised of muscle fibre that contains proteins which bind to contract the muscle fibre, and an innervating motor nerve cell. One motor nerve cell may have multiple terminals that can innervate more than one muscle fibre. Fewer muscle fibres per motor nerve aids fine motor control (e.g. handwriting), whereas more muscle fibres per motor nerve is better for gross (large) movements (lifting a heavy shopping bag).

The process of voluntary muscle contraction originates in the motor cortex in the brain. When enough axon terminals collectively innervate the same soma (nerve cell body), summation occurs. This is the depolarisation threshold to produce an action potential, a pulse of electrical current. Subsequently, the action potential will travel along the alpha motor neuron of the central nervous system of the brain and spinal cord, to the peripheral nervous system in the limbs and trunk, then to the skeletal muscle. These axons are protected by the myelin sheath from interference. The action potential travels to the neuromuscular junction where the axon terminal meets the muscle fibre surface. This causes depolarisation of the postsynaptic membrane and sends an endplate potential along the muscle and down T-tubules into the myofibrils. Calcium is released from the sarcoplasmic reticulum as depolarisation opens the voltage dependent calcium channels, and then energy can be extracted by mitochondria from adenosine triphosphate (ATP) in the cytoplasm. As a result, actin-myosin cross bridges are formed and the 'rowing' motion that is generated as they bind causes shortening of the fibre and creates a muscle twitch. If this contraction in a flexor is met with unmatched force on the opposing extensor muscle, the limb will flex (e.g. bend arm). Alternately, twitch in extensor unmatched by flexor will produce extension (e.g. straighten legs). The contraction of the muscle will last longer than the action potential due to the elastic properties of the muscle, and for the clearance of calcium involved in depolarisation. A sustained contraction is comprised by multiple successive action potentials. Higher frequency firing helps to produce smooth movement, and greater forces will be produced when multiple muscle fibres are innervated simultaneously. Additionally, the speed at which the muscle contracts is also dependent on the protein and organelles in the fibre. The composition of mitochondria and proteins determine how efficiently the mitochondria use oxygen to release ATP as in slow twitch fibres, or whether the fibres are dependent on glycogen and ATP stored within the muscle to exert force as in fast twitch fibres. Slow twitch fibres are less fatigable than fast twitch fibres, although they are unable to exert force as great as fast twitch fibres which are recruited later than slow twitch fibres (Enoka, 1988).

Sarcopenia and the underlying physiological changes

Considering then, that muscle strength is determined by how much muscle protein is available to produce force and how well that muscle is activated, it is important to acknowledge how this system changes as people get older. With age, strength and muscle mass reduce, and this loss is known as sarcopenia. Sarcopenia advances from the age of 60 (Lauretani et al., 2003), and reflects cumulative detrimental effects of neural and muscular atrophy (Cruz-Jentoft et al., 2010; Hoeijmakers, 2009; Mulero, Zafrilla, & Martinez-Cacha, 2011). These changes are both attributable to, and cyclically exacerbate, dysregulation of multiple physiological systems such as protein synthesis, metabolic function, hormone regulation, and neural pathways (Burnett, Laidlaw, & Enoka, 2000; Erim, Beg, Burke, & de Luca, 1999; Hunter, Pereira, & Keenan, 2016).

In terms of the skeletal muscle mass, advanced age is associated with reduced number and size of muscle fibres, and with increased cartilage and fat in the muscle tissue (Fan et al., 2016; Keller & Engelhardt, 2013). This means that there is similar mass but less force producing capacity. Still, it is difficult to distinguish whether reduced muscle mass leads to reduced muscle strength or if strength loss precedes loss of muscle mass (Goodpaster et al., 2006). The loss of muscle tissue can occur as a result of an imbalance of protein synthesis and protein degradation. The issue is to do with the loss of energy producing mitochondria, and reduction in contractile protein synthesis rather than catabolic processes, because some protein synthesis increases with age but the rate of whole body protein turnover is shown to decline (Rall et al., 1996; Rooyackers, Adey, Ades, & Nair, 1996; Ronenn Roubenoff & Hughes, 2000). This is important as the loss of mitochondria means that ATP is not so readily released, which means that energy is not available for actin-myosin cross bridges to be formed to contract muscle and exert force. Additionally, a reduction in myosin heavy-chain proteins means that the contractile units to exert this force are also less abundant.

In addition to age-related effects to muscle fibres, the nervous system is also affected by the ageing process. For example, biological cell death is accelerated in later years, driven by internal, endogenous sources (accumulation of reactive oxygen species, and alkylating agents) and exogenous sources (radiation, UV, chemicals) of DNA damage (Hoeijmakers, 2009). For example, at the neural level, Schwann cells form the protective myelination of the peripheral nerve system. They are rich in fatty acids, which are susceptible to such oxidation as fat provides substrates for the reactive oxygen species (Selman, Blount, Nussey, & Speakman, 2012). Among other consequences, this leads to a progressive deterioration of the myelinated glia of the PNS; which impairs conduction velocity and eventually leads to the retraction of nerve terminal endings at the neuromuscular junction (Ceballos, Cuadras, Verdu, & Navarro, 1999; Elder, Friedrich, Margita, & Lazzarini, 1999).

As synthesis of proteins required to maintain cell integrity is outweighed by natural cell death, there is a reduction in the number of large diameter fast-conducting motor neurons (Christie & Kamen, 2010; Elder et al., 1999; Laidlaw, Bilodeau, & Enoka, 2000; Manini, Hong, & Clark, 2013). This worsens the ability to quickly exert large force. Exacerbating this, a process of denervation occurs, which is where motor neurons become decoupled from muscle fibres, in a way “dying back” (Campbell, Mccomas, & Petito, 1973; Comley et al., 2011).

Denervation is fundamental to loss of neuromuscular control in older age. However, this process may be attenuated through reducing sedentary behaviour (Wilkinson, Piasecki, & Atherton, 2018). Therefore, prolonging quality physical activity and reducing sedentary behaviour throughout later years of life is essential to preserve strength and muscle mass. This is reflected in public health messaging, which includes recommendations about strength training twice per week (NHS, 2018).

The retraction of nerve terminal endings in denervation means that neuromuscular junctions (NMJ) in older adults develop larger motor endplates which generalises the innervation of muscle fibres and impairs controlled movement. There is evidence to suggest that denervation precedes muscle atrophy and therefore directly contributes to it (Demontis, Piccirillo, Goldberg, & Perrimon, 2013).

After denervation, the orphaned muscle fibre is reinnervated by smaller diameter-axon spinal motor neurons, which is called collateral sprouting. So these smaller axon motor neurons form overall larger motor units due to the alterations in innervation ratio, a process known as neuromuscular junction remodelling (Enoka et al., 2003; Erim et al., 1999; Lexell, 1993; Lopez-Otin, Blasco, Partridge, Serrano, & Kroemer, 2013).

The remodelling of the neuromuscular system in older age means that for the same target force fewer motor units need to be activated as the same single motor neuron that innervated a few muscle fibres in younger age instead innervate a greater number of muscle fibres (Lexell, 1993). However, the preserved muscle fibres have reduced force production capacity as the ratio of muscle fibres to each motor unit is increased, and the muscle itself is reduced in mass from atrophy (Davis, Burrin, Fiorotto, Reeds, & Jahoor, 1998). Consequently, the contractile power of older adults' muscle is proportionally more dependent on larger motor units innervating atrophied muscle fibres, which ultimately leads to overall weakening and slowing of muscle contraction in older adults, and a reduction in neuromuscular control (Connelly, Rice, Roos, & Vandervoort, 1999; Sosnoff & Newell, 2006). The difference in firing rate is shown in Kamen et al. (1995). Maximal discharge rate in second digit isometric abduction was significantly reduced ($p<0.05$) in the older population (31.1 impulses/sec) compared to the younger population (50.9 impulses/sec).

Age differences in motor unit firing rate could implicate neuropsychological factors in the reduction of muscle strength with age. For example, the measurement of neuromuscular electrical signal using electromyography (EMG) shows decreased power at higher frequencies and increased power at lower frequencies when older adults are compared with younger individuals at a range of forces (Enoka et al., 2003; Kwon, Baweja, & Christou, 2012; Vaillancourt, Larsson, & Newell, 2003). This could contribute to the reduction in explosive exertion of force with age, although changes at the muscular level (e.g. contractile properties and muscle mass) cannot be overlooked (Mau-Moeller, Behrens, Lindner, Bader, & Bruhn, 2013) .

There is evidence that neuromuscular remapping could lead to a decrease in the variability of motor unit discharge rates in older adults. This can reflect impaired ability to sustain high forces (such as carrying a heavy shopping bag). For example, older adults (Age *M* = 75.1 years, *SD* = 3.9), demonstrated decreased motor unit discharge variability for both rigid and inert loads of the biceps brachii compared to younger (Age *M* =28.0 years, *SD* = 3.8) people (Pascoe, Gould, & Enoka, 2013). Although discharge variability was similar at recruitment for the older and younger participants during the steady contraction, the discharge pattern of motor units in older adults was seen to be more repetitive while a more intermittent discharge pattern was observed in younger adults once motor units had been recruited (Pascoe et al., 2013). Motor units are activated and deactivated to sustain the force. Younger people show use of a larger proportion of fast twitch muscle fibres to intermittently sustain force production this way. Due to reduced number of motor units as a result of neuromuscular remapping, older adults typically have less capacity for this. This could reflect a general reduced capacity to adapt to physical stimuli(Lexell, 1993; Merletti, Farina, Gazzoni, & Schieroni, 2002).

To summarise, strength and co-ordination abilities are reduced with advancing age due to changes at the central nervous and peripheral nervous level, and the muscular level. These consist of the reduction in muscle mass and denervation, which directly affects the capacity for muscle fibres to be innervated in order to contract. Although, collateral sprouting can allay this decrement, it comes at some cost, as there is reduction in both the ability to exert large forces, and the ability to sustain a high force for a long time. This has repercussions for activities of daily living, and therefore, wellbeing too. Nevertheless, there is opportunity for the integrity of these systems to be preserved through physical activity. Therefore, understanding the psychological barriers to reduce sedentary behaviours is essential. It is also important to understand the risks when these systems cannot be preserved, which result in frailty.

Frailty

As changes in skeletal muscle and neural composition have been discussed in isolation as part of the ageing process, it is pertinent to now explore how these factors combine to contribute to the phenomenon known as frailty. In this section first, frailty will be defined in terms of presenting symptoms and physical limitations. Then biological causes of frailty will be reviewed.

What is frailty?

Although there is no international agreement on a definition of frailty, it is commonly understood to refer to a state of high physical and personal dependency with vulnerability to disease and injury (Hoogendijk et al., 2019). It encompasses multiple interacting factors at the physical, psychological, environmental, and social level (Markle-Reid & Browne, 2003), but is broadly seen as an age-related vulnerable state in which people's resources to cope with acute or daily stressors is chronically compromised (Bandeen-Roche et al., 2006; Fried et al., 2001). Due to this, increased dependency on external support is common when people are frail (Fried, Ferrucci, Darer, Williamson, & Anderson, 2004). As such, frailty is associated with risks of long hospital stays, loss of independence, increased time to recover from illness or injury, mobility difficulties, disability, and mortality (Makary et al., 2010; Mitnitski, Graham, Mogilner, & Rockwood, 2002). Although frailty is not necessarily age-dependent, it is increasingly prevalent as individuals get older: 10% of people over 65 years, and between 25-50% people over 85 years are estimated to have some degree of frailty (NHS England, 2014). Frailty is both an outcome and predictor of multi-morbidity and mortality (Clegg, Young, Iliffe, Olde Rikkert, & Rockwood, 2013; Rockwood, Andrew, & Mitnitski, 2007). When cardiovascular health cohort data of 5317 men and women over 65 was investigated, people who were frail had a higher mortality adjusted hazard rate 1.63 (95% CI 1.27-2.08) (Fried et al., 2001). Compared to fit older adults, mortality risk for is doubled for individuals with mild frailty and quadrupled for those with severe frailty (The British Geriatrics Society, 2014).

Clinical presentation of frailty

Fried (2001) suggests a frailty phenotype, which describes a cyclical decline in energetics and physical performance (see Figure 3.1 - Cycle of Frailty). Signs of frailty include physical exhaustion, unintentional weight loss (10lbs in last year), low physical activity levels, and lowest quintile physical performance in handgrip strength, and slow walking speed. Fried (2001) defines frailty as the presence of three or more of these signs of frailty. These signs, such as handgrip strength, have been linked to morbidity and mortality. For instance, in a large cross-cultural study, Leong et al (2015) revealed that adults in the lowest third of the population for handgrip strength had greater chance of hospitalisation or mortality for chronic health conditions in follow up four years later. Use of physical performance to predict health status later in life is corroborated in a similar study in Sweden of 17 year follow up too (Strand et al., 2016). Additionally, grip strength also predicts hospital length of stay, even when controlling age, sex, and disease severity (Mendes, Azevedo, & Amaral, 2014; Roberts, Syddall, Cooper, & Aihie Sayer, 2012). Therefore, understanding the accuracy of handgrip measures and whether they are vulnerable to bias is vital for understanding health risk in later life, and implementing prevention and rehabilitation strategies.

Walking speed is also one characteristic of frailty in Fried's (2001) phenotype. Walking speed is dependent on co-ordinated muscle contractions in order to generate locomotion. Many physical performance symptoms described in Freid's (2001) phenotype are correlated because they are all underpinned by the integrity of skeletal muscle. For example, in a study of older adult's grip strength, Sallinen et al (2010) identified that hand grip strength below a threshold (normal BMI men = 33kg, women = 20kg) was associated with increased risk of mobility limitation (Men: OR=2.73, 95% CI 1.91-3.88; Women: OR 2.73, 95% CI 2.10-3.54), defined as difficulty in walking 0.5km or climbing stairs. Mobility difficulties impede activities of daily living (ADLs), which additionally limits independence, with adverse implications for individuals' wellbeing. Mobility difficulties are inversely associated self-esteem (Delbaere, Crombez, Vanderstraete, Willems, & Cambier, 2004), and this in turn provokes disengagement from health behaviours (Suzuki, Ohyama, Yamada, & Kanamori, 2002; Yardley & Smith, 2002).

Fried et al (2001) identified that 27% of people with disabilities inhibiting ADLs also were frail. This may suggest that ADL disability precedes frailty, such that the source of disability or the disability itself debilitates individuals from maintaining health and vigour. However, these findings are from cross-sectional, rather than longitudinal data, therefore, one limitation is that directional causality cannot be inferred and therefore, we cannot know which comes first empirically. It is difficult to disentangle the unique contribution of these effects. Longitudinal cohort data such as the English Longitudinal Study of Ageing (see Chapter 7) go some way to establish causality. However, such programs of research are complicated and financially expensive. An alternative explanation for the finding is that some individuals may be protected from frailty despite disability, further corroborating that some cases of frailty may be preventable, or that the onset can be delayed. Impaired mobility impacts on more than just an individual's activities of daily living. Limitations in physical functioning are exacerbated as the physiological and psychological benefits of being physically active will also not be realised. This suggests there is a need to understand the psychological barriers to maintaining healthy behaviours to promote physiological health. In the next chapter, these barriers will be discussed more.

When mobility is severely restricted the likelihood of experiencing a fall is increased (Lundin-olsson, Nyberg, & Gustafson, 1998). Falls can be fatal, they can result in bleeding from open wounds or internal bleeding, heart attack from the shock of trauma, or from pneumonia due to being unable to recover oneself from the floor. Falls that are not immediately fatal can lead to complex health conditions, requiring equally complex treatment, which can be exacerbated by frailty. In these cases, fractures can take extended periods to recover and require changes to residential arrangements when discharged from hospital (Ensrud et al., 2007). Notably, requiring assistance to be recovered from the floor following a fall can be especially traumatic. The length of this 'long lie' has been linked to serious illness such as dehydration, hypothermia, bronchopneumonia and pressure sores (Rubenstein & Josephson, 2002; Tinetti, Liu, & Claus, 1993). Frailty is associated with limitations in physical performance that impair mobility and reduce the ability to carry out everyday tasks. The reduction in physical capabilities increases fall risk, and also limits resilience to disease and increases mortality risk. Therefore, frailty and its precursors should be mitigated or minimised where possible. In order to understand how this might be achieved, it is important to understand the causes of frailty.

Causes of frailty

As individuals live longer, the life-course exposure to stressors is greater resulting in cumulative cellular damage (Cesari, Vellas, & Gambassi, 2013). From this perspective, frailty is a distinctive age-related health state in which multiple functions of homeostasis lose their natural reserve-capacity, resulting in increased vulnerability to disease and physiologic stress as well as increased risk of mobility difficulties. Indicators of multisystem dysregulation include elevated cytokines and chemokines, weakened IGF-1, DHEAS and leptin, disruptions in neutrophil, monocyte, and white blood cell pathways (Fedarko, 2011). Collectively, deterioration in these systems reduces the body's ability to repair itself, and increases susceptibility to disease caused by inflammation. Inflammation is a known major cause of cellular damage, and plays a central role in both ageing and frailty. For example, frailty may be indirectly and directly affected by protein degradation and metabolic pathway disruption caused by pro-inflammatory cytokines (Li, Manwani, & Leng, 2011).

This degradation in multiple physiologic systems presents symptomatically when the physiological buffer of homoeostatic reserve begins to decline, although a tangible threshold is inherently complex to define and monitor (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013). Some early warning signs may present as pre-frailty, particularly when faced with external stressors such as acute illness, injury, or psychological stress, which are associated with increased risk of mortality and morbidity (Hanlon et al., 2018). Stress in this sense reflects the inability to effectively cope with exogenous and endogenous stimuli (Cesari et al., 2013).

As this multisystem dysregulation results in reduced capacity to cope with stressors, reduced physiologic complexity and diminished homoeostatic control is also observed (Goldberger, Peng, & Lipsitz, 2002). This means that as physiological systems deteriorate with age, resources to adapt to environmental or physiological perturbations decline (Manor et al., 2014). This is reflected in Fried's Cycle of Frailty shown in Figure 3.1. As physiologic systems are consequently unable to adapt to internal or external perturbations, then susceptibility to disease, disability, and mortality increases (Lipsitz, 2004). An individual's response to a stressor is dependent on baseline resilience, and an example of this is shown in

Figure 3.2. When resilience is high then a stressor is more easily recovered and the individual continues to live independently. When resilience is low then a stressor can push the individual to become dependent on external support. These models present opportunity to explore the individual, societal and cultural factors that can influence the trajectory of age-related physical decline and resilience. The focus of the next section will be on exploring the role of physical activity in the trajectory of physical performance decline with age.

Figure 3.1: Cycle of frailty (from Fried et al., 2001)

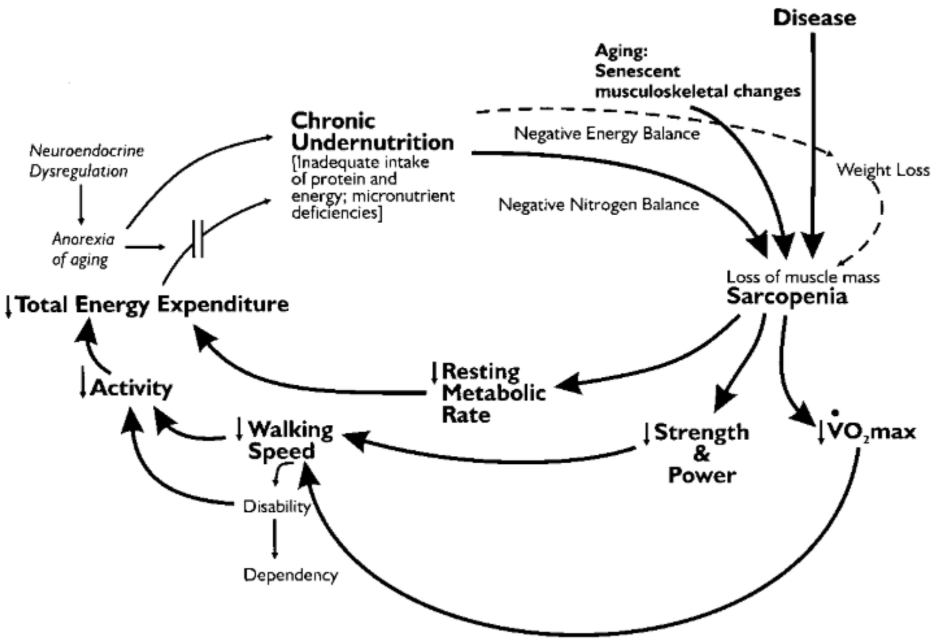
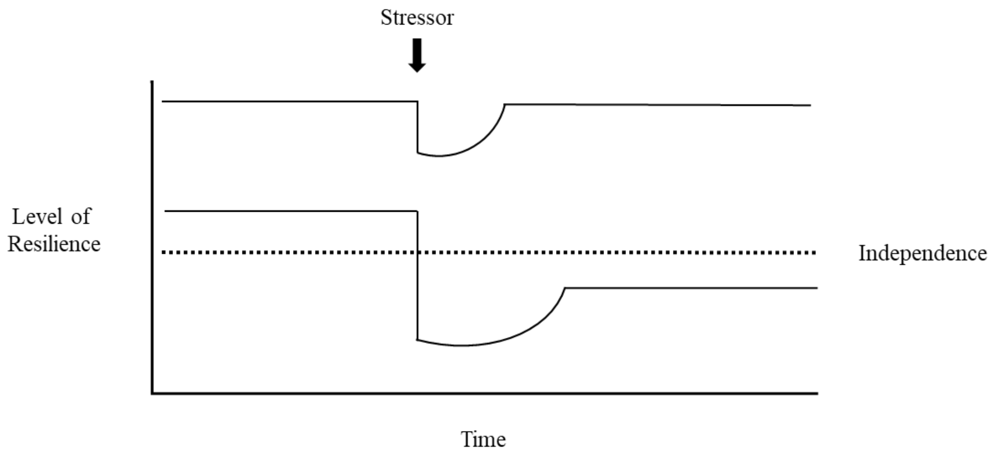


Figure 3.2: The effect of a stressor on independence



Stressor marked by arrow. The dotted line demarks the line between dependence and independence. Individuals with greater level resilience before the stressor have greater chance of full recovery and least risk of falling into dependence.

Is the trajectory of physical decline modifiable?

A central question to many Gerontologists, Sports Scientists, and Physiologists is the extent to which the trajectory of age related physical decline is modifiable. This part of the review will concentrate on physical activity in order to preserve physical function in older age.

It is also important to note that physical activity and healthy diet are linked as they regulate net caloric intake which has a knock-on effect to metabolic functioning, hormone regulation, and protein synthesis. Both healthy diet and exercise are consistently advocated in public health messages for older individuals to maintain physical health (NHS, 2018; The British Geriatrics Society, 2014; Wilson, 2016). For instance, exercise is recommended for people over 65 years age: per week, 150 minutes at moderate intensity or 75 minutes at vigorous intensity (NHS, 2018). Meanwhile, specific advice is given to combat malnutrition in older adults, including sufficient caloric intake, preventing diabetes, and ensuring adequate vitamin and mineral intake with fruit and vegetables (NICE, 2018). In contrast, prolonged sedentary behaviour is associated with disease (Biswas et al., 2015; Booth, Roberts, & Laye, 2012) such as obesity (Smith, Thomas, Bell, & Hamer, 2014), type 2 diabetes (Rockette-Wagner et al., 2015), cancer (Cong et al., 2014), heart disease (Brocklebank, Falconer, Page, Perry, & Cooper, 2015; Warburton, Nicol, & Bredin, 2006), and greater mortality risk (Rezende, Rey-López, Matsudo, & Luiz, 2014).

Whilst these recommendations to ensure healthy diet and adequate exercise appear relatively simple, difficulties with implementation and adherence are common. For example, the ability to maintain a healthy diet is often compromised through financial difficulty, and by practical obstacles such as getting to the shops and preparing meals (England, 2017). In terms of meeting physical activity guidelines, a small survey using accelerometery data showed that 67% of older adults (age over 60 years) were sedentary for more than 8.5 hours a day (Stamatakis, Davis, Stathi, & Hamer, 2012). However, despite following guidance, the difficulty in maintaining skeletal muscle integrity increases with age. This is because of the blunted training response which occurs in older age.

Age differences in exercise training response

There are age-related changes that make physical exercise and training in older age distinct from training when younger. Sixteen weeks of resistance training showed blunted hypertrophic training response in older adults (age 60-75 years) compared to younger (age 20-35 years) people (Kosek, Kim, Petrella, Cross, & Bamman, 2006). That is, there is evidence of age differences in underlying protein synthesis mechanisms apparent from a single bout of exercise (Hameed, Orrell, Cobbold, Goldspink, & Harridge, 2003). The protein synthesised from the same exercise bout is greater in younger than older people. From human skeletal muscle tissue taken before and after the bout of exercise (6 sets of 10 repetitions, 80% maximal voluntary contraction (MVC) leg extension), researchers identified that signalling of protein synthesis was lower in older adults compared to younger participants. Similar findings of anabolic resistance in older adults are common (Shad, Thompson, & Breen, 2016; Welle, Totterman, & Thornton, 1996). This means the challenge to maintain strength and muscle is greater in older age.

Difficulties in maintaining strength and muscle mass in later life are further compounded by the effects of sarcopenia. This means that the neuromuscular resources to achieve the same training stimulus could be limited. Therefore, greater effort may be required in older ages to reach an equivalent training stimulus. This has implications for the perceived effort-reward relationship for goal setting and motivation, such as when deciding to adopt or continue an exercise program.

The challenge of maintaining strength in later life is compounded by medication side effects too. For example, as cardiovascular medications can impair grip strength (Ashfield et al., 2010). Whilst this has direct implications for ADLs, this also mean that maximal training loads are dampened. Additionally, training response under pain-relief medication (i.e. non-steroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen and aspirin) may be blunted as these pharmaceuticals could inhibit the healing process (Lilja et al., 2018). This means that efforts to preserve function may be attenuated by the drugs that make the physical work tolerable. As is common, this research is conducted with younger populations, with a markedly different physiology. Evidence suggests that NSAIDs may even improve hypertrophy in older adults (Trappe et al., 2011), although this may be due to reduced training programme attrition rather than improved training response per se (Jankowski et al., 2015). Despite side effects of medication, there are several benefits of engagement in physical activity.

The importance of exercise in older age

Despite the increasing challenge to maintain physical health in older age, physical activity is shown to regulate hormones and protein expression in older adults (Wideman, Weltman, Hartman, Veldhuis, & Weltman, 2002). Benefits of physical activity are not limited to musculoskeletal health, as research demonstrates protective benefits to brain tissue. This is relevant to neuromuscular functioning as neurological functioning affects central control processes. Neuroanatomy of the ageing brain shows both white and grey matter atrophy, as well as degeneration of white matter integrity accumulate as people get older (Anatürk, Demnitz, Ebmeier, & Sexton, 2018). Local (i.e. specific cortical area) and global (i.e. total brain) tissue atrophy and lesions were observed to increase with age in this study. Additionally, leisure activities may not only have a benefit on psychological wellbeing and physical performance directly, but also show a neuroprotective effect (Anatürk et al., 2018). That is, involvement in socio-intellectual activities directly associated with structural integrity of older adult's brain, using magnetic resonance imaging (MRI). This association may be underpinned by both cognitive reserve and brain reserve (Arenaza-Urquijo, Wirth, & Chételat, 2015). This is important as it supports the relationship between the function and structure of the brain: as cell damage occurs then too does cognitive function.

Exercise also regulates the hypothalamic-pituitary axis, which uses signalling hormones to regulate metabolism and energy use, linking the brain and the endocrine system (Bishop, Lu, & Yankner, 2010). As such, it mediates the stress response to threatening stimuli (Jones, Meijen, McCarthy, & Sheffield, 2009). Activation of this pathway leads to glucocorticoid production which stimulates liver gluconeogenesis in anticipation of 'fight or flight' behaviours. Psychosocial stressors can activate this pathway too (Kern et al., 2008), and regulation may come from unavailability of coping or control resources, or reductions in novelty (Abelson, Khan, Liberzon, Erickson, & Young, 2008). Over-activation of this pathway can result in chronic stress, leading to inflammation and disease. Promisingly, this neurological pathway can be regulated with exercise, attenuating hormonal and cytokine response to stressful situations (Stranahan, Kim, Ae, & Mattson, 2008). Therefore, identification of the processes by which psychosocial factors predict this susceptibility to stressors, and the role of exercise in this moderating this relationship, is crucial for maintaining optimal health in older ages.

To summarise, physical activity has important benefits not only to maintain the ability to carry out everyday tasks, but also to ensure adequate physiological reserves in skeletal muscle tissue and to regulate hormones and neurotransmitters to protect against disease, and to preserve structure and function of the nervous system. This highlights the way physical activity has many interrelated benefits.

Physical activity can also part-reverse some symptoms of frailty. For instance, randomised controlled trial evidence shows that some symptoms of frailty may be reversible through resistance training and balance exercises (Cameron et al., 2013). However, research is yet to define the stage whereby frailty is remediable, past which point palliative care is most suitable course of treatment (Hoogendijk et al., 2019). As such, helping people live safely with frailty is a growing social concern and best practice recommends community-based solutions as people with frailty tend to deal better in this environment where they are able to receive adequate support (The British Geriatrics Society, 2014). It is therefore important to establish parameters of this support, whereby considerations should reflect the multidimensional aetiology of frailty. With this objective the SPRINTT (Sarcopenia and Physical fRailty IN older people: multi-componenT Treatment) randomised controlled trial is an ongoing 36 month trial with over 1500 participants. It aims to identify best treatment for healthy ageing lifestyle, involving physical activity, nutrition, and information and communication technology (Landi et al., 2017; Marzetti et al., 2018).

Even when physical abilities cannot be maintained, the risk of harm can still be reduced. Promisingly, with training then fallers may ‘learn’ to get up from the floor independently, although this may only be applicable for pre-frail and not frail older adults (Faber, Bosscher, Chin, Paw, & Van Wieringen, 2006). As such, the floor transfer test could be used to assess an older adult’s suitability for independent living (Ardali, Brody, States, & Godwin, 2019). Fall prevention training can decrease avoidance of activities and fear of falling, and improved perceived health quality of life (El-Khoury et al., 2015).

Conclusion

In this chapter, biological perspectives of the ageing process with particular relevance to neuromuscular physiology have been explored. Sarcopenia increases the risk of mobility difficulties, frailty, and mortality. While physiological systems lose some ability to respond as effectively as people get older, there is evidence that age-related mobility and health detriments may be offset by modifiable behaviours such as physical activity. Therefore, there is a need to identify ways to address barriers to being physically active in older age.

Psychosocial factors could offer a means to do this. Drawing on psychological theories, such as social identity theory (Tajfel & Turner, 1979; Tajfel, 1981), can provide a fruitful avenue for intervention (Jetten, Haslam, & Alexander Haslam, 2012). For example, targeting the way that someone sees themselves in terms of their social identity, such as their age, could be beneficial to health and wellbeing. Moreover, negative age attitudes are associated with many of the same weakening of physiological systems as characterised by the ageing process, such as chronic inflammation and early mortality (Levy et al., 2009; Pietrzak et al., 2016). Therefore, the next chapter will discuss how age stereotypes, and more specifically, age-based stereotype threat and negative age attitudes, impact on the biological process of ageing. Also, it will explore how these attitudes affect physical performance tasks which are often used as indicators for evaluating the transition from healthy ageing to clinical states of disease and illness. Moreover, the impact of age stereotypes and age identity on physical activity engagement will also be discussed, as engagement in these behaviours are shown to attenuate the hallmarks of the ageing process.

Chapter 4 - Age Attitudes and Stereotypes

As described in the previous chapter, the ageing process is characterised by fundamental physiological changes that are associated with declining physical health (Roubenoff, 2000) and limited neuromuscular performance (Pascoe et al., 2013; Payne & Delbono, 2004). It is therefore not surprising that some people tend to see declining physical health and physical performance synonymous with older age (Cuddy, Norton, & Fiske, 2005; Ory, Kinney Hoffman, Hawkins, Sanner, & Mockenhaupt, 2003; Stewart, Chipperfield, Perry, & Weiner, 2012). These physiological processes of ageing provide an element of truth on which to found generalised beliefs and attitudes about ageing (Levine & Campbell, 1971).

Yet, these beliefs and attitudes may exacerbate biological decline with age through the process of stereotyping and social categorisation (Swift, Abrams, Drury, & Lamont, 2018). These processes see older adults being treating as a homogenised group, where beliefs become overgeneralised to those seen or categorised as 'old'. Although stereotypes are cognitive shortcuts, they are damaging because they are overgeneralisation, and so are applied erroneously to individuals 'perceived' as old. Indeed, an individual may apply these stereotypes to themselves. Crucially, there is not always a clear correlation between the psychological perception of old age and the biological ageing process. Importantly then, ageing can be seen as a social construction because there is no clear consensus on when someone becomes old (Abrams, Vauclair, & Swift, 2011; Hoogendijk et al., 2019; Becca Levy, 2009). As a social construction, age can influence an individual's age-related thoughts, feelings and behaviour. Evidence suggests age stereotypes can propagate a self-fulfilling prophesy where individuals' behaviour and performance is constrained to underperformance and physical inactivity, which validates the beliefs and attitudes, and confirms the bias (Vick, Seery, Blascovich, & Weisbuch, 2007; Wheeler & Fitzsimons, 2004).

Although age stereotypes abound social, health, and economic domains as well as many others (Kornadt & Rothermund, 2011), this review will concentrate on those that relate to older adults' physical health, which are most pertinent to this thesis. First, attitudes to age and age stereotypes are described. Then, the chronic and acute consequences of age stereotypes will be discussed. Finally, current theoretical models that describe how age stereotypes can effect task performance will be presented.

Attitudes to age

Social psychologists define attitudes as the enduring mental tendency to which ideas, people, or objects are evaluated (Eagly & Chaiken, 1995). This predisposes people toward positive or negative reactions to novel stimuli. On presentation of novel stimuli, a cognitive, emotional, or behavioural evaluative reaction is adopted to form the attitudinal structure towards that stimuli. This process informs evaluative responses of the stimuli. An attitude is formed when this evaluative response is established. Attitudes, i.e. how we think about and feel towards objects, reliably predict behavioural responses (Fishbein & Ajzen, 1975; Fishbein, Ajzen, & Ajzen, 2011). For example, attitudes towards physical activity strongly predicts exercise intentions (Stolte, Hopman-Rock, Aartsen, Van Tilburg, & Chorus, 2017), as well as engagement in physical activity (Poobalan, Aucott, Clarke, & Smith, 2012; Trost & Brown, 2016). Healthy eating habits are predicted by attitudes towards dieting (Lahmann & Kumanyika, 1999). This means that when people have negative attitudes about health behaviours, then they are unlikely to engage in that behaviour and, therefore, not benefit from it. A wealth of psychological research explores these processes, for instance see the theory of planned behaviour and self-determination theory (Hagger & Chatzisarantis, 2009; McEachan, Conner, Jayne Taylor, & Jane Lawton, 2001).

Attitudes to age is a collective term which includes attitudes towards ageing as well as older people. Therefore, in order to understand people's attitudes measures often explore the extent to which people endorse age stereotypes (see next section). A review of measurement tools used in age research reveals many explore stereotypes, attitudes or both, in domains of work, housing, family/interpersonal/ intergenerational relationships, physical change/ appearance, loss and growth, knowledge of ageing, activity, death, own ageing experiences, will-to-live as well as cognitive/ memory capacity and dependence (Swift & Steeden, 2020). It is important to acknowledge that the measures used to study attitudes of age may bias representations of old age as they are predominantly focused on negative traits (Levy

& Macdonald, 2016). This bias in measures of ageism could jeopardise the validity of estimates of the prevalence of ageism (Ayalon et al., 2019). Laidlaw's Age Attitude Questionnaire (Laidlaw, Power, Schmidt, & WHOQOL-OLD Group, 2007) entails scales against positive ("As people get older they are better able to cope with life"), negative ("Old age is a time of loneliness"), and physical change ("I keep as fit and active as possible by exercising") factors. This highlights how important it is to be aware of methodological limitations and differences when evaluating ABST literature.

Targeting age attitudes such as 'older adults are physically weak' may offer a way to modify physical activity engagement (Wolff, Warner, Ziegelmann, & Wurm, 2014). In support of this, longitudinal analyses shows that more positive expectations of ageing are associated with better health behaviour and longevity (Meisner, Weir, & Baker, 2013). This shows how attitudes can predispose outcomes later on.

Age attitudes are shown to exert a long-term effect on health in later life through influencing engagement with health behaviours through the life-span. However, the relationship between attitudes and behaviour is not exact (Kraus, 1995). Situational pressures can also influence behaviour, sometimes even in spite of a person's attitudes about a behaviour. In contrast to attitudes, these pressures are context-dependent and therefore acutely influence behaviour. In the context of older adults' cognitive and physical performance, situational pressure may arise known as stereotype threat, which is explored more later in this chapter. Briefly, this phenomenon arises when someone feels that they are at risk of confirming a negative stereotype for a group they belong. This can impair older people's physical or cognitive performance, even if they do not believe that the stereotype is accurate (Lamont, Swift, & Abrams, 2015). This shows that task performance and health outcomes can be affected by the attitudes that individuals hold about age and ageing, and the stereotypes that they may or may not endorse, it is now important to review stereotype literature, including description of stereotypes of older adult and ageing.

What is a stereotype?

A stereotype is an over-generalised belief about a particular type of person or object based on their category membership (Esses, Haddock, & Zanna, 1993). This means that an individual can be stereotyped in terms of over simplified traits and expectations that are characteristic of the group they belong to. Stereotypes are not inherently detrimental. They represent our world, including people and groups of people, as schema that enable us to simplify and cope with the complex word around us. Once formed, stereotypes can influence subsequent information we receive and how we process it. This can have both positive (i.e. quicker information processing) and negative consequences, such as leading to biases and errors in information processing, (e.g. confirmation bias). Therefore, they have the potential for impairing decision making where assumptions are made on stereotype rather than on available evidence (Ross, Lepper, & Hubbard, 1975).

An example of this is an investigation by Asch (1946), who investigated how preconceived traits could affect decision making. Trait words (e.g. wise) presented earlier in a list influenced participants' subsequent judgement of a person. When the trait list started positively, then more favourable evaluations overrode less desirable characteristics, and when the trait list started negatively, then later evaluations were less favourable. These effects are likely to result from the heuristic operation of schema, influenced by memory and cognitive processes. Schema allow us to make estimated decisions when all necessary information is lacking. For example, words such as 'shy' and 'reserved' are falsely remembered when participants are presented with an 'introvert' character (Cantor & Mischel, 1979). When these mental shortcuts are applied to groups, then stereotypes may over-generalise through illusory correlations. That is, the expected group behaviours are the ones that are salient and then later remembered (Snyder, 1984). This is pertinent to the older people's view of their age, as it tells us about how stereotypes are learnt. What people expect to experience is remembered, and this has consequences later on. The consequences of self-stereotyping will be discussed more, later in this chapter.

Age-based stereotypes

In terms of the content of age stereotypes, positive stereotypes of older people concern emotional traits. For example older people may be characterised as good natured, moral, reliable, dependable, experienced, wise and able to make good financial decisions and be good at interpersonal problem solving (Swift & Steeden, 2020). Conversely, negative stereotypes concentrate on poor performance generally (incompetent, unproductive, poor adaptability, mentally slower, unable to learn new things), and being in worse physical condition (physically weak, ill health, declining physical and cognitive health). These positive and negative dimensions are summarised by the Stereotype Content Model, which proposes that all stereotypes may be seen across two dimensions, warmth and competence (Fiske, Cuddy, Xu, & Glick, 2002). Older adults tend to be judged positively as warm and friendly but also negatively as incompetent. This is known as the 'doddering but dear' stereotype (Cuddy et al., 2005). It is generally endorsed by younger people, and many older adults also endorse this stereotype (Carvalho, 2014; Swiery & Willitts, 2012). These findings are broadly cross cultural, occurring across individualistic European nations, and collectivist East Asian nations (Cuddy et al., 2009). As a result of being perceived as high in warmth but low competence, there is an emotional consequence that older adults are pitied, but not respected (Cuddy & Fiske, 2002). Although older adults might sometimes be stereotyped as wise, the negative stereotype of older adults' cognitive abilities has a kernel of validation in findings that cognitive performance is inversely correlated with age (Baltes, 1993; Dionigi, 2015). Similarly, the attribution of physical inferiority with advancing age is validated with biological research (Hayflick, 1998; Pereira-Smith & Ning, 1992). Crucially, age stereotypes may exaggerate the decline in performance with age. Typically, western cultures do not view the trajectory of older adults' health positively (Horton, Baker, & Deakin, 2007). Therefore, discrimination in medical institutions may occur, whereby older adults' symptoms are more likely to be dismissed as part of the ageing process, rather than assessed clinically as would be the case for younger people (Bowling, 2007; Ory et al., 2003; Zebrowitz & Montepare, 2000). Broadly, the stereotype of ageing is synonymous with low status, disease and disability (Dionigi, Horton, & Bellamy, 2011).

This is especially true for stereotypes of older adults' physical health, where stereotypes of ageing include the deterioration in ability and declining vitality, frailty, disability, disease, isolation, and vulnerability (Wearing, 1995). Lately, more positive cultural attitudes have emerged, which suggest it is possible to maintain quality of life in older age, and that illness can be offset through physical activity despite physiological decline (Dionigi et al., 2011; Grant, 2001). Therefore, there is an opportunity to better understand the interaction of age attitudes and age stereotypes on physical activity engagement as part of the healthy ageing process.

There are likely to be many factors that influence engagement in physical activity. Outgroup feelings of admiration and pity, while well-intentioned, maintain the stereotype of older adults as incompetent or unable to assist themselves (Cuddy et al., 2005). Emotional reactions help to perpetuate the stereotype. Feelings of pity lead to increased helping behaviour which reinforces stereotypes of incompetence (Cuddy, Glick, & Fiske, 2007). This reduces independence, limits physical activity where it would otherwise be of benefit to both physical health and mental wellbeing, and further exacerbates and confirms the stereotype of age-dependent incompetence, the belief that "I'm too old for that" (Coudin & Alexopoulos, 2010; Robertson & Kenny, 2016). Essentially, the stereotypes of older people describe them as inferior to younger people physically, mentally, and socially (Wearing, 1995). This is detrimental to older adults' wellbeing and to their physical performance. Further, well-intentioned actions by others could act as implicit external cues for older adults to self-limit their physical or cognitive performance. These effects will be discussed later in this chapter.

Consequences of age-stereotypes

Unlike stereotypes for discrete outgroups, such as ethnicity or gender, age stereotypes are unique because they eventually become self-relevant, as we age. Our attitudes and stereotypes about age and older adults are learnt in younger age as an outgroup member. Then, as people age they become part of the older adult social group, adopting that social identity (Levy, 2009). Indeed, whether these stereotypes are assimilated or endorsed is essential in determining the extent of their impact and how adverse these are (Barber, 2017). This is important because it means people's exposure to age stereotypes in younger age is crucial in influencing their social identity in later life.

Social identity is defined as the "part of the individuals' self-concept which derives from their knowledge of their membership of a social group (or groups) together with the value and emotional significance attached to that membership" (Tajfel, 1981). Negative age stereotypes degrade individuals' performance, decision making, and self-esteem through social comparisons demonstrating the inferiority of older adults' social identity compared to other groups. As such negative age stereotypes contribute to the social devaluation of older adults (Cuddy, Glick, & Fiske, 2007). Therefore, it is important to understand the processes by which negative age stereotypes can make people vulnerable to underperformance, in order that these risks can be mitigated or eliminated.

There is not a single pathway by which these stereotypes operate to influence behaviour. The Risks of Ageism Model (RAM; Swift, Abrams, Lamont, & Drury, 2017) describes three core modes: experienced discrimination, stereotype embodiment, and stereotype threat. Age stereotypes are clearly damaging when misapplied to other people. However, while discriminatory actions are damaging in their own right, they can also reinforce negative stereotypes that older people hold relevant to their own age identity. As such, these stereotypes are even more damaging when people apply them to themselves. For example, negative age self-stereotypes are predictive of cardiovascular outcomes (Levy, Zonderman, Slade, & Ferrucci, 2009), risk of Alzheimer's Disease (Levy, Ferrucci, et al., 2016), and increased mortality risk (Pietrzak et al., 2016). These self-stereotype modes will now be discussed specifically. The next part of this review will concentrate on stereotype embodiment and stereotype threat as predictors of these outcomes.

Stereotype Embodiment Theory

Stereotype embodiment occurs when people internalise the stereotyped behaviours and attitudes, which are then later manifested by the individuals. Specifically to age and health, stereotype embodiment is where cultural stereotypes of age are assimilated into the fabric of social identity that influence function and health (Levy, 2009). Learning about age stereotypes occurs across the life course. For example, young children typically draw more negatively stereotyped drawings of old compared to their drawing of young people (Falchikov, 1990), although they may also draw some active older adults (Weber, Cooper, & Hesser, 1996). Children from young ages may learn about negative older-age stereotypes through story books (Levy, 2009), media (Donlon, Ashman, & Levy, 2005), and role modelling behaviour (Marx, Monroe, Cole, & Gilbert, 2013). These stereotypes serve a purpose in younger age by elevating the status of the younger persons ingroup through social comparison. Later in life when individuals transition into the older adult age group, these stereotypes of older age become self-relevant and are internalised.

Older adults (age 65-85 years) who hold more negative attitudes toward their age are less likely to be physically active (Wurm, Tomasik, & Tesch-Römer, 2010), and this may be because positive attitudes about ageing help thwart motivational barriers to exercise. People with more negative age attitudes are also likely to withdraw from health behaviours in other ways, such as not seeking timely health care (Sarkisian, Hays, & Mangione, 2002; Sarkisian, Lee-Henderson, & Mangione, 2003; Sarkisian, Prohaska, Wong, Hirsch, & Mangione, 2005). Gravely, older adults who endorse negative stereotypic beliefs about age-related illness have greater mortality risk (Stewart et al., 2012) and lower levels of preventative health behaviour (Levy & Myers, 2004). This shows how age-stereotypes are internalised and embodied, and how they later manifest in health outcomes. Therefore, there is a need to understand more about how stereotypes can affect engagement with health behaviours such as physical activity.

Embodied stereotypes work unconsciously: they are implicit and involuntary. There is ample evidence to demonstrate the automatic operation of stereotypes (Hess, Hinson, & Statham, 2004). For example, subliminally flashing negative age stereotype words made subsequent handwriting shakier and less legible, as rated by independent judges (Levy, 2000). In contrast, blatant stereotype cues are more easily counteracted (Kornadt, Voss, & Rothermund, 2015). Stereotype embodiment can be positive too, and could offer opportunity for therapeutic intervention. For example, participants’ walking speed was faster following subconscious priming of positive age stereotypes by playing a computer game (Hausdorff, Levy, & Wei, 1999).

Although, the study is limited by comparing to a negative prime rather than neutral control.

Age stereotypes have also been primed in younger participants. For example, an older adult stereotype was evoked in university students via a word-scramble task and this later led participants in the stereotype condition to subsequently walk slower as timed by a surreptitious experimenter (Bargh, Chen, & Burrows, 1996). That is, they found that the young participants behaved akin to the older adult stereotype that had been evoked. Importantly no effects were found for negative emotional affect in a validating experiment so emotional valence was not the underpinning factor. This research suggests that evoked stereotype-traits can affect performance despite the individual not identifying as a member of that group. Implicit processes may explain these findings (Wheeler & Petty, 2001). It is asserted that the interaction between trait activation and behavioural representation lead to assimilatory behaviour. For instance, by activating stereotype constructs in individuals who are not identified with the stigmatized group, assimilation of stereotype-relevant traits is elicited such as lower math performance from an African-American stereotype (Wheeler, Jarvis, & Petty, 2001), or impaired accuracy on memory recall from an elderly stereotype (Dijksterhuis, Aarts, Bargh, & Knippenberg, 2000). However, the results of Bargh et al. (1996) have failed to be replicated and the results are contested (Doyen, Klein, Pichon, & Cleeremans, 2012). Indeed, Notthof et al. (2018) showed that older subjective age was only associated with slower walking when someone was watching. This could imply the potential for demand characteristics in these studies or it could highlight the debilitating effect on performance from the potential for negative evaluation based on age. These studies highlight the inherent risks in activating negative stereotypes in real world settings. Also, these studies present potential confounding factors, such as strength of group identification, when attempting to understand other psychological phenomena such as stereotype threat.

Importantly, self-relevance increases the salience of stereotypes, and therefore, stereotype priming effects are greater for individuals when the stereotype is relevant. For example, longitudinal analysis demonstrates that age stereotype priming effects are short-term, and do not persist (Kornadt & Rothermund, 2012; Kornadt et al., 2015). Such findings are evident in a memory task where older but not younger participants were susceptible to age stereotype priming (Hess et al., 2004). Further, older but not younger people show delayed effects of stereotype priming on a will to live questionnaire (Marques, Lima, Abrams, & Swift, 2014). This is because the stereotype primes were more relevant to the older participants (e.g. diseased, slow, sage, and grumpy) and could more easily be dismissed by the younger ones. In contrast, it is posited that self-relevance is likely to create age group dissonance and stereotype contrast effects when negatively biased, threatening stimuli are presented (Weiss & Freund, 2012).

Finally, Levy (2009) proposes that there is not a unitary pathway on which stereotype embodiment operates. It is asserted that internalisation of stereotypes operates along psychological, physiological, and behavioural routes. In the psychological route, stereotypes are embodied leading to self-fulfilling prophesies of ageing, driven by expectations (Levy & Leifheit-Limson, 2009). More negative priming words (e.g. senile, frail) produced worse performance subsequently on a cognitive (photograph memory) and physical (five times sit-to-stand) task. The opposite stereotype matching was true for positive words (e.g. spry, wise). Notably, effects of stereotype priming are greater when the performance task is matched or congruent to the stereotype. For example, ‘frail’ affected the physical tasks, ‘senile’ affected cognitive and memory tasks. In the physiological route, exposure to age stereotype stimuli elicits a cardiovascular and endocrine stress response (Levy, Hausdorff, Hencke, & Wei, 2000; Levy, Moffat, et al., 2016). Such stress reactivity is associated with cardiovascular disease and increased mortality risk (McEwen, 2015; Smith, Birmingham, & Uchino, 2012; Steptoe, O’Donnell, Badrick, Kumari, & Marmot, 2008). The risk of these health outcomes can be made worse by the behavioural routes of stereotype embodiment. For instance, frequent physical activity is less likely to be taken by those with negative self-perceptions of ageing (Hermann & Vollmeyer, 2016; Levy, Pilver, Chung, & Slade, 2014). However, regular exercise is known to alleviate biological stress reactivity (Morley et al., 2013; Stranahan et al., 2008; Webb et al., 2013). This means that risks to biological ageing processes are compounded. Avoidance of physical activity means that gains to neuromuscular performance are not realised, and that the stress response further depletes physiological reserves.

However, evidence of age stereotype embodiment is not ubiquitous across the population (Levy & Langer, 1994), perhaps because these effects are subject to individual differences. For instance, endorsement or activation of positive age stereotypes has a protective impact on performance. As such, there may be scope for leveraging these more positive attitudes to address older adults' physical health and mobility needs. For example, negative age stereotypes could lead older adults to believe that physical abilities are fixed (Bastian & Haslam, 2007). Demonstrating this, when an incremental mindset is evoked in older adults, then strength measures were better than participants in either the fixed mindset or neutral condition (Emile et al., 2016). The incremental mindset encompasses the belief that ability is malleable and so can be changed with effort, compared to fixed/ entity beliefs that ability is innate or immoveable (Haslam et al., 2012; Weiss, 2016). This shows the critical role of attitudes of ageing to older adults physical performance (Levy, 1996). This supports the assertion of different pathways by which stereotypes can affect performance.

Physical decline is perceived by many older adults to be inevitable and irreversible and this attitude of ageing could affect whether older adults continue to engage in activities which promote physical health and independence (Lachman et al., 1997). The entity perspective of ageing leads to lower intrinsic motivation as it is thought that physical activity will do no good or could even do harm, which reduces the likelihood of older adults' engagement in physical activity. It is asserted that there is an interaction between reduced perception of control and exposure to negative age stereotypes (Hehman & Bugental, 2003). This research showed perceived control had a moderating effect on age-related framing. Older adults performed worse in a cognitive task than younger participants when negative age-related stereotype framing was presented with lower perceived control. Therefore, perceived control over the ageing process could influence whether age stereotypes are embodied.

Indeed, attitudes about the malleability of the ageing process appear to be important in understanding how disengagement of tasks might occur. For example, attitudes about whether the ageing process is fixed were found to moderate the relationship between negative age stereotypes on memory performance and cardiovascular reactivity (Weiss, 2016). Older adults demonstrated either assimilation or reactance to negative age stereotypes depending on whether they viewed the process of ageing as fixed and inevitable, or not, respectively. The researchers found that when negative age stereotypes were activated by a multiple-choice quiz (e.g. "How many people above the age of 90 years suffer from dementia?"), then a cardiovascular threat response (increased systolic blood pressure) was elicited in participants with fixed beliefs about decline in health and ability with age. This is crucial to health, as cardiovascular stress reactivity is predictive of cardiac disease in older adults (Steptoe & Kivimäki, 2012). As such, believing that the ageing process is malleable may offer protective benefit from adverse health outcomes (Weiss & Reitz, 2017). Indeed, perceptions of behavioural control are well documented to benefit health and wellbeing (Ajzen, 2002). Also, this informs us how threat is appraised in emotional states (Jones et al., 2009).This research helps to explain why negative stereotypes seem to affect some but not all older adults and highlights the chronic risks to older adults' health from such implicit attitudes.

Psychologically distancing oneself from one's group also seems to provide defence against negative age stereotypes. Older adults tend to rate themselves as younger than their peers (Chopik & Giasson, 2017), as well as demonstrate reduced favouritism for their own age group (Chasteen, 2005). As such, older adults regard themselves as atypical rather than representative of their group (Bultena & Powers, 1978). These findings are compatible with social identity theory, whereby members of low status groups increase group dissonance (Tajfel & Turner, 1979). Such effects are supported experimentally too: lower subjective age and reduced age-identification are invoked when older adults are presented with negative age stereotype information (Weiss & Lang, 2012), and greater initial age group identification leads to more negative affective responses under stereotype threat (Kang & Chasteen, 2009). Therefore, age group dissociation can reduce the effects of negative age stereotypes on older adults' memory performance (Armenta, Scheibe, Stroebe, Postmes, & Van Yperen, 2018; Kang & Chasteen, 2009) and self-esteem (Weiss, Sassenberg, & Freund, 2013).

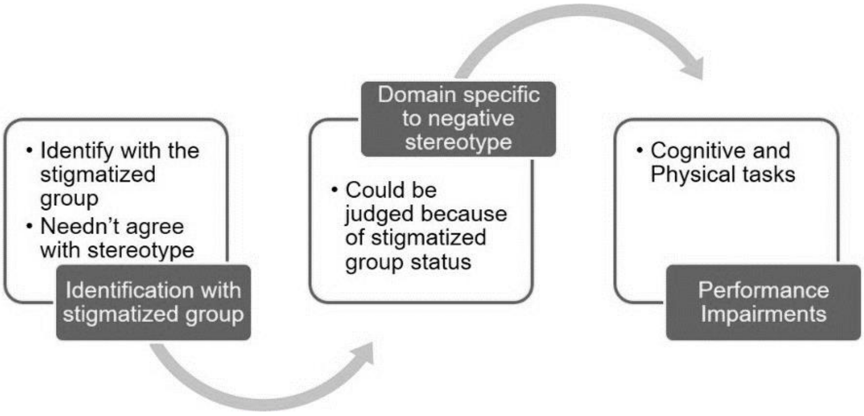
Despite these advantages of age group dissociation, it does not seem to provide fail-safe protection. Group identification may encourage disengagement with age-relevant activities such as adherence to medication prescription, or to exercise and rehabilitation. For example older adults were more likely to see falls prevention interventions as highly important for their age group generally, but individually they believed that they would be exempt from needing such programs (Haines, Day, Hill, Clemson, & Finch, 2014). Identification of the optimal strategy for encouraging older adults' engagement in health behaviours such as physical activity remains an important consideration that is underpinned by older adults' social identity, influenced by attitudes and stereotypes of their age.

In summary, much of the evidence for stereotype embodiment comes from experimental priming studies, or longitudinal survey research. These studies demonstrate the detrimental effects of negative age stereotypes on a range of outcomes. However, there are a few important moderators of these effects, which suggests the applied implications of studies can be limited. For example, some experiments can lack ecological validity (Notthoff et al., 2018). Therefore, it is necessary to review Age Based Stereotype Threat (ABST) which is a situation-dependent threat to identity that can be encountered in daily life.

Stereotype Threat

Stereotype threat is a phenomenon where individuals' performance on a task is compromised by psychosocial factors, underpinned by stereotypes. As shown in Figure 4.1, first, the person knows that they belong to a negatively stereotyped group, regardless of whether they agree that the stereotyped view is true. Second, the task being performed is aligned to the stereotype, with the stereotype denoting under-performance in the task (Beilock & McConnell, 2004; Steele, 1997; Steele & Aronson, 1995). This results in behaviour that unintentionally confirms the stereotyped view. When the stereotype, and corresponding threatened identity is age, this phenomenon is known as age-based stereotype threat (ABST). This can have damaging effects to a range of tasks that affect older adults' ability to maintain wellbeing (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005). By understanding the mechanisms by which ABST operates, it could be possible to develop interventions that protect individuals from stereotype threat. The following section will now describe stereotype threat in more detail, before reviewing proposed theoretical models.

Figure 4.1: Determinants of stereotype threat (based on Steele & Aronson, 1995)



The classic study of stereotype threat was conducted by Steele and Aronson in their investigation of African-American academic performance, in a culture where there are negative stereotypes that African-Americans are academically inferior to their White counterparts (Steele & Aronson, 1995). African-American college students were administered a test where, in one condition, this test was described as diagnostic of ability, and the students were instructed to stipulate their ethnicity pre-test. The diagnostic test combined with raising the students' awareness of their stigmatized identity presented a threat 'in the air' as the prevalent view of African-Americans in American culture at the time was of low academic ability. In the other group, students were simply asked to complete the question paper. The threatened group performed poorer on the test than the other students. These findings have been successfully replicated with studies with threat regarding Latino/ Euro-American ethnicity (Guyll, Madon, Prieto, & Scherr, 2010), and male/ female gender (Stricker & Ward, 2004). Older adults have also been found to be vulnerable to stereotype threat effects on cognitive tasks (Abrams et al., 2008; Eich, Murayama, Castel, & Knowlton, 2014; Hutchison, Smith, & Ferris, 2012; Popham & Hess, 2015). For example, when ABST is activated then older adults memorise fewer items in a free recall task compared to non-threatened control participants (Kang & Chasteen, 2009). It seems that the effect of stereotype threat on cognitive performance is more significant than the effect of chronological age (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005). Moreover, there is a relationship between experiences of threat and performance. The more that ABST is experienced, then the greater the decline in performance on cognitive and memory tasks. This is linked to 'dementia worry', the anxiety related to negative expectations of age related to memory and cognition (Barber, 2017). This can impair cognitive performance and have negative health consequences. Therefore, it is important to better understand the risks presented by ABST.

Does ABST impair physical performance?

In contrast to the volume of literature documenting ABST effects on cognitive performance, there is comparatively less evidence supporting the effect of ABST on physical tasks. Research by Swift et al (2012) revealed older adults (mean age = 82 years) performed worse in a hand-grip task as measured by maximal grip strength (lower under threat) and grip duration (shorter under threat) when stereotype threat had been evoked. The threat was activated by telling the experimental group they would be compared to younger individuals to see if the assumption about physical capabilities declining with age was true. The control group was simply informed the data was being collected to see how different people interact with the world.

However, ABST on physical performance outcomes have not been uniformly replicated. For instance, ABST had no effect on older adults' handgrip performance in a study recruiting older adults from community centres (Horton, Baker, Pearce, & Deakin, 2010). To explore potential boost (i.e. an uplift in performance) and threat effects, participants read fictionalised news articles with positive or negative age bias and watched a TV news bulletin seemingly about the study. Participants answered questions about these to ensure that the information had been absorbed, including a Likert scale about how positive or negative the article was. A neutral condition did not take part in these aspects of the study. The stereotype threat manipulation did not cause participants to underperform on the different tasks (recall, flexibility, walking speed, grip strength). It is possible that this sample may have been biased by recruitment as respondents may have had some psychologically or physiologically protective benefit against threatened performance from their reason for being in that community space, e.g. leisure centres or social spaces. This is supported as participants in the threat group did not rate the news article as negative. Additionally, the study included a memory task component. The inclusion of this task may have been sufficient to threaten all of the participants irrespective of group. Further, in another study (Marquet et al., 2018), ABST had no effect on participants' (mean age = 72 years) performance in a battery of physical tasks including walking speed, grip strength, and balance performance, despite reiteration of the threat before each task). It is therefore important to understand the differences between these studies.

It is plausible that the difference between Marquet et al. (2018) and Swift et al. (2012) is attributable to stereotype threat stimuli. The former used a fact-based manipulation, which has been identified in meta analyses as explicit and therefore more easily dismissed, contrasted, or otherwise protected against (Lamont, Swift, & Abrams, 2015). In contrast, Swift et al. (2012) used a more subtle verbal statement to invoke the stereotype. It is important to note that stereotypes are more powerful than facts when they are evoked (Lamont et al., 2015; Wheeler & Petty, 2001).

Additionally, Marquet et al. (2018) and Swift et al. (2012) may differ because of the age of the participants are not the same, as the former study used participants approximately a decade younger. While this age difference may only account for 5kg difference in maximal values obtained across groups (Dodds et al., 2014), it might also explain differences between groups. The increased self-relevance of the threat in the older group may have heightened differences between the experimental and control conditions. This is especially true as the participants in Swift et al. (2012) were older, recruited from Age UK day centres. Furthermore, these younger participants in Marquet et al. (2018) were included only if they did not present a fall risk. Therefore, it is plausible that increased frailty also contributes to the self-relevance of physical tasks, where concern for physical performance is already heightened, and the threat stimulus tipped the balance in Swift et al. (2012), but salience was not apparent in Marquet et al. (2018).

In summary, there is some evidence that ABST affects physical performance (Swift et al., 2012). While some studies have contrary conclusions to this (Horton, Baker, Pearce, & Deakin, 2010; Marquet, Boutaayamou, et al., 2018), these differences may be underpinned by methodological dissimilarities such as recruitment strategy and the type of manipulation used to evoke ABST. Overall, these studies highlight stereotype threat as a dynamic situation-dependent threat to identity, drawing attention to the crucial role of certain types of contextual cues in affecting performance. Other issues of the empirical reliability of the stereotype threat phenomenon will be discussed in detail later in this review, see also Chapter 5 and Chapter 6.

Theoretical models of stereotype threat

Steele & Aronson (1995) outlined a model by which underperformance resulted from threat to social identity. They posit that being aware of stereotypes that denote lower academic ability compared to White counterparts, reduces expectations of their own achievement, and can increase feelings of anxiety which 'diverts attention' away from the task. Since then, research has extended and developed two explanatory models to explain stereotype processes, the Stereotyped Task Engagement Process Model (STEP Model; Smith, 2004), and the Integrated Process Model (Schmader, Johns, & Forbes, 2008). These models will now be discussed in more detail.

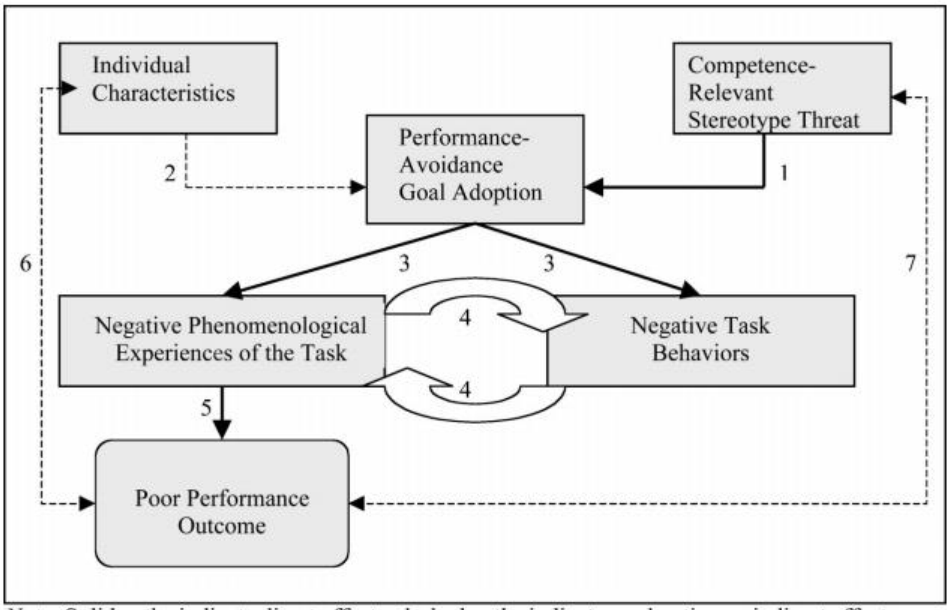
The Stereotyped Task Engagement Process Model

Achievement goal research broadly describes that an individual's performance is dependent on the combination of the situation and the self, operating through cognitive engagement, affect, motivation, and behaviour (Ryan & Ryan, 2005). Achievement goals are described as either approach goals, mastery goals, or avoidance goals. Approach goals are evident when individuals are generally positive about their ability to succeed and they seek to improve performance. Mastery goals are seen when individuals seek to improve their performance. Conversely, avoidance goals are associated with lower task involvement and worse performance (Elliot & Church, 1997; Stoeber & Crombie, 2010).

The Stereotyped Task Engagement Process Model (STEP Model; Smith, 2004), shown in Figure 4.2, presents a model incorporating the achievement goals adopted for a task (arrow 1), as well as acknowledging individual level sources of variation (arrow 2). These factors determine the individual's experience of their performance and their behaviour (arrow 3), and these experiences and behaviours interact (arrow 4) to produce an outcome (arrow 5). These outcomes are also directly influenced, and influence, individual characteristics and future achievement goal setting. The STEP model accounts for the finding that under threat individuals take fewer risks and often report lower identification with the task (Keller, 2007). This means, for example, that cognitive ability or performing well on a learning task is rated as less important to people when stereotype threat is present (Mangels, Good, Whiteman, Maniscalco, & Dweck, 2012). Essentially, stereotype threat leads to greater avoidance goals, whereby individuals strive to avoid appearing incompetent. This is in comparison to non-threatened controls who are more likely to adopt approach goals and strive to demonstrate skill and ability. In this regard, negative stereotypes propagate a self-fulfilling prophesy of under-performance and withdrawal of effort in later life. However, much of this research is drawn from cognitive task performance, and examples with physical task outcomes are relatively less common. In one study, using gender-based stereotype threat, then as expected female soccer athletes reported more avoidance goals (Chalabaev, Sarrazin, Stone, & Cury, 2008). However, these goals were not related to eventual performance. Perhaps this is because of individual characteristics of the players, such as trained behaviour, or demand characteristics in completing self-rated questionnaires. In terms of ABST, while some empirical evidence in terms of achievement goals are made (Hess, Hinson, & Hodges, 2009), few studies demonstrate this with physical tasks.

The polarity of avoidance and approach goals are represented as regulatory focus (Higgins, 1997). Emile et al. (2016) manipulated older adults' regulatory focus against either stereotype consistent or stereotype inconsistent information about the task. When task information was stereotype inconsistent and when incremental goals were elicited, then grip strength and rate of force development was greater than in control or stereotype consistent/ entity conditions. This showed that how someone perceived the task, and their expectations of success, were crucial in determining performance. Moreover, this highlights the powerful effect that stereotypes can have on older adults' how physical performance through affect and motivation.

Figure 4.2: Stereotype Task Engagement Process Model (Smith, 2004)

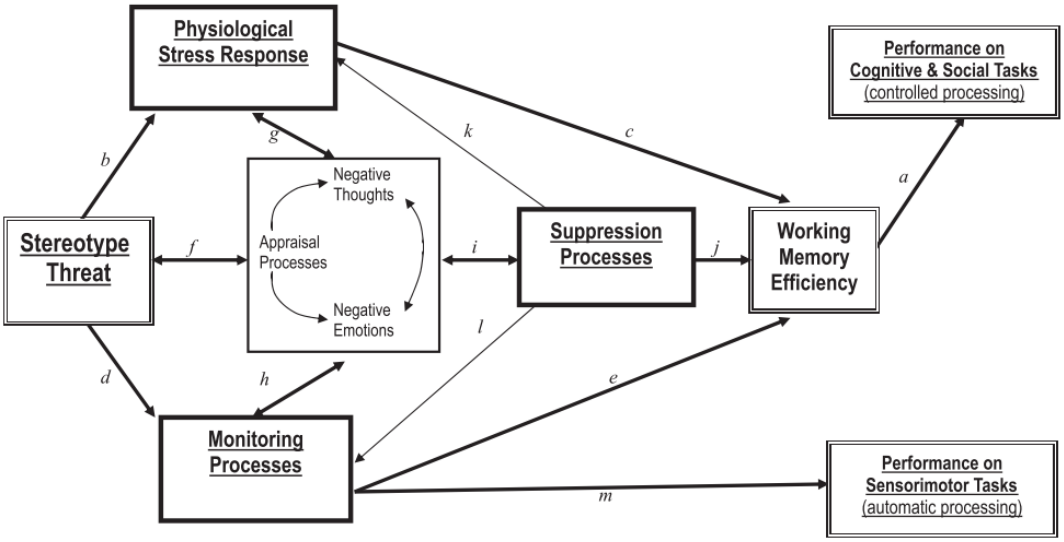


Note: Solid paths indicate direct effects; dashed paths indicate moderating or indirect effects.

Integrated Process Model

In contrast to the STEP Model, which is motivation goal-based, the Integrated Process Model (Schmader et al., 2008) purports the relationship between a range of sympathetic and cognitive factors implicated in stereotype threat. At the conceptual core of this model is the impact on cognitive and social tasks of reduced working memory efficiency related to negative emotional affect. Critical to sensorimotor tasks such as grip and balance, they argue, is the relationship between negative affect and monitoring processes that mediate biopsychological systems and performance. Figure 4.3 shows this model, and describes the conceptual pathways by which stereotype threat may affect physical, and cognitive, performance.

Figure 4.3: Integrated process model of stereotype threat effects on task performance (Schmader, Johns, & Forbes, 2008)



A limitation of the model is that whereas cognitive tasks rely directly on working memory for successful task completion almost by definition, the pathway for sensorimotor tasks is lacking a psychophysiological understanding of the stereotype effect pathway. For instance, the model does not explain the effect on neuromuscular pathways. Furthermore, it is important to differentiate between automatic and controlled tasks, as although a task may require a strong physical element, it can also require controlled processing to complete, such as hand eye coordination tasks (Huber, Brown, & Sternad, 2016; Huber, Seitchik, Brown, Sternad, & Harkins, 2015; Martiny et al., 2015). As such this model may be currently limited in describing the impact of stereotype threat on physical tasks such as hand grip (Swift et al., 2012) because the threat stress-response may affect the fundamental physiological systems necessary for completion of the task itself.

However, while the STEP model provides a useful framework from which to understand motivational perspectives of ABST, the Integrated Process Model is an appealing option because of the role of working memory being both a process and a stereotyped domain for older adults. With this model the stereotype threat effects that are well documented in cognitive tasks is well accounted for (Beilock, Rydell, &

McConnell, 2007). Nevertheless, as physical tasks may require differing degrees of cognitive involvement, the way in which stereotype threat affects different tasks largely remains to be empirically demonstrated.

In order to study this further, it is necessary to understand more about the role of anxiety and working memory components of the model. Anxiety and working memory have been shown to affect physical performance (Cheng, Hardy, & Markland, 2009; Hauck, Carpenter, & Frank, 2008; Jones & Swain, 2008; Jones et al., 2009; Mabweazara, Leach, & Andrews, 2017; Masters & Maxwell, 2008). As anxiety and working memory each constitute a vast volume of research, only aspects that are most relevant to stereotype threat will now be reviewed.

The role of anxiety

The negative affective response to the stereotype threat situation is a core component of the Integrated Process Model. This state comprises anxiety. Anxiety is a negative emotional state which manifests in cognitive form such as worry, and somatic form such as stomach churning and sweaty palms . It can be experienced when an individual perceives that they do not have required resources to cope with the demands of a task, when the consequences of the task are important to them. When anxiety is experienced this way, a stressful threat state is reached (Skinner & Brewer, 2002). Conversely, when an individual has belief that they have resources to cope with task demands, a challenge state is reached (Jones et al., 2009; Lazarus & Folkman, 1991; Tomaka, Blascovich, Kelsey, & Leitten, 1993). The short-term acute effect of anxiety on physical performance is well established: when anxiety is experienced then physical performance is impaired (Arent & Landers, 2003; Bell & Hardy, 2009; Masters & Maxwell, 2008; Mullen & Hardy, 2000; Rathschlag & Memmert, 2013). There are psychological exaplanations for this, such as task avoidance (Lazarus, 2000), distraction (DeCaro, Thomas, Albert, & Beilock, 2011), and the depletion of information processing resources (Wilson, Vine, & Wood, 2009). There is evidence that ABST provokes a similar acute effect of anxiety too. When ABST was triggered through with a maths test, anxiety levels were increased (Abrams et al., 2008).

Physiologically, anxiety presents in cardiovascular responses such as increased heart rate and vasorestriction (Noteboom, Barnholt, & Enoka, 2001), and in hormonal response (Pauly et al., 2019). Indeed, such physiological signs have been identifed with stereotype threat. In gender-based stereotype threat with a maths task, the physiological effects of anxiety were shown. When under threat then participants' cardiovascular response (reduced cardiac output and increased total peripheral resistance) showed signs of anxiety (Vick, Seery, Blascovich, & Weisbuch, 2008). Additionally, increased activation of an inflammation process protein (Interleukin-6) was elicited when socio-economic class based stereotype threat was presented to students with an academic task (John-Henderson et al., 2014).

There is some evidence that ABST can impair cognitive task performance via anxiety pathways such as on episodic memory (Bouazzaoui et al., 2020). It is posited that this is because of a reduction in the efficiency of cognitive processing (Eysenck, Derakshan, Santos, & Calvo, 2007). Essentially anxiety, such as worrying thoughts, occupies the working memory resources, via thought suppression for example (Bertrams, Englert, Dickhäuser, & Baumeister, 2013; Derakshan & Eysenck, 2009). This means that available resources for task completion are limited. Conversely, increased vigilance under threat may also benefit performance, depending on the task, such as looking for anxiety-related words (Johns et al., 2008). Whether ABST affects anxiety in physical tasks and how this relates to performance is unknown. This is especially challenging to investigate as the effect of ABST on physical task performance does not have the same empirical reliability as cognitive task performance. It is important to understand the role of anxiety in the effect of ABST on physical task performance because the way that anxiety affects physical tasks is well established. This means that some older people could be at risk of underperforming in physical tasks that affect independence, quality of life, or clinical care.

Furthermore, when anxiety is experienced for longer durations, chronic stress can be incurred. Cardiovascular resistance and stress reactivity are known to exacerbate sarcopenia and increase vulnerability to diesase in older people (Gruenewald, Seeman, Karlamangla, & Sarkisian, 2009; Hamer & Molloy, 2009; Karlamangla, Singer, Mcewen, Rowe, & Seeman, 2002). This means that frequent experiences of ABST could accelerate the hallmarks of biological ageing. Therfore it is important to understand the impact of ABST on anxiety in physical tasks.

The effect of anxiety on cognitive performance is established, and the consequence of ABST on working memory through anxiety is well known too (Johns, Inzlicht, & Schmader, 2008). However, physical tasks differ in their working memory demands. For example, opening a stiff jar differs in the cognitive requirements of planning and controlled execution than preparing a meal. This means that different physical tasks could be affected by ABST to different degrees, or by different pathways.

Working memory

Working memory is essentially the cognitive system that handles information we are currently engaged in processing (Baddeley & Hitch, 1974; Engle, 2002; Turner & Engle, 1989). For example, this includes functions such as paying attention to different sensory information, planning and decision making, and task monitoring and evaluation. There is evidence that in states of anxiety the overall efficiency of this system is impaired; worrisome thoughts interfere with coding, storage and retrieval of information which is a role of working memory (Eysenck, Derakshan, Santos, & Calvo, 2007; Eysenck & Calvo, 1992). It is argued that worry consumes some of the limited working memory capacity available for a task, which means that an increase in effort is required for maintaining performance, else task failure is likely if demand outweighs capacity.

In cognitive tasks, working memory deficits are well evidenced in ABST, such as shorter digit span in a memory task, and fewer targets identified in a letter cancelling task (Popham & Hess, 2015). Working memory may be occupied under stereotype threat because there may be motivated efforts to suppress negative thoughts, (Johns et al., 2008; Logel, Iserman, Davies, Quinn, & Spencer, 2009), because of increased vigilance of monitoring processes (Schmader, Forbes, Zhang, Berry, & Mendes, 2009), excess self-regulation (Baumeister, 1984; Beilock et al., 2007), or because worries interfere with task specific resources (Beilock et al., 2007).

There is less evidence of demonstrating these effects in physical tasks. There is some evidence that ABST can lead to underperformance in simple tasks such as handgrip (Swift et al., 2012), or more complex tasks such as driving (Joanisse, Gagnon, & Voloaca, 2013). However, it seems that some physical tasks may be less affected than cognitive tasks, or that physical tasks are prioritised. For example, this study used a within-subjects design, and evoked ABST in older adults participants (mean age = 81) via manipulation about the purpose of the study ("to examine walking differences older and younger adults"). Stroop task performance was worse under threat while a walking task was simultaneously performed. On the whole, while these studies suggest there is theoretical grounds that ABST may result in underperformance in physical tasks, they do not help us understand the mechanisms by which this underperformance is caused. There is a need to identify the pathways by which ABST can affect different physical tasks. This will help us understand the risk of ABST in different tasks, and will inform the development of interventions to minimise the ABST risk.

Socio-demographic factors that can increase situational pressures

While the STEP and Integrated Process model describe theoretic pathways by which stereotype threat operates, they are not unanimously supported by research. There exists a multiplicity of other environmental and intrinsic factors that might affect the way that ABST could affect physical performance. For example, demographic factors such as age, health status, socio-economic class, financial wealth, physical activity, and education may all affect these pathways. For physical performance, other factors could also be considered such as health conditions or muscle mass. Some psychological factors could provide resilience to ABST effects. For example, there is evidence that social identification, either less strongly with older age or more strongly with a higher status group can protect from experiencing threat (Canada, Stephan, Caudroit, & Jaconelli, 2013; Weiss & Lang, 2012). Despite the plethora of significant individual factors, the sequential order and interactions of mediators and moderators on physical performance stereotype threat effects is currently unclear.

To date, these models provide a useful framework for understanding and investigating ABST effects, but they are not without limitation. For example, working memory deficits can affect some physical tasks differently. This is particularly relevant for some older adults who find everyday tasks require extra attention to be executed safely, for example, picking up a newspaper or carrying a hot drink. Also, the models do not describe sufficiently the link between anxiety and physical performance. This certainly applies to older adults, who are socio-demographically heterogeneous, far beyond simply sharing a similar age. For example, despite finding that ABST lead to increased anxiety and decreased performance in a memory task, not all participants were threatened (O'Brien & Hummert, 2006). Those with low age group identification seemed to be inoculated against ABST effects. This seems to be reliably demonstrated (Kang & Chasteen, 2009; Weiss & Lang, 2012). It is valuable to note that the identification of these socio-demographic factors are established in cognitive task methodology. There is potential to further demonstrate how socio-demographic and other psychological factors can influence the effect of ABST on physical performance. This might help deliver prevention methods, coping strategies, or other interventions that could reduce the risk posed from ABST on physical performance.

Conclusion

This section reviewed how attitudes to age and age stereotypes may implicitly bias underperformance, through the acquisition and embodiment of age attitudes and stereotypes occurs across the life course. Ageing is considered synonymous with decline and cognitive and physical impairment. These stereotypes may have some benefit for speeding up cognitive processing, or they may bolster the maintenance of positive social identity for those who are young. However, while the biological ageing process encompasses functional deterioration (Fedarko, 2011), there is evidence that the trajectory of physiological functioning is not fixed. It may be attenuated with effortful physical activity (Mijnarends et al., 2016). Further, it is currently unclear whether negative age stereotypes could disrupt physical performance (Swift et al., 2012), as it does in cognitive settings (Levy, Zonderman, Slade, & Ferrucci, 2012). This could have an impact on the validity of clinical assessments, for example. In these cases, physical performance assessments inform perioperative decision making (Revenig et al., 2015, 2014). Therefore, there is potential for the risks posed to health and wellbeing from disease, disability, or frailty to be minimised.

Unlocking this potential depends on better understanding the psychosocial determinants of physical activity engagement. Specifically, there are gaps in the current literature in understanding how attitudes to age and age stereotypes can affect older people's physical activity performance. This should gap should be addressed by moving forward current theoretical models, where there is a shortfall in describing the relationship between psychological and neuromuscular processes. By doing this, interventions to ameliorate acute and chronic instances of physical activity withdrawal may be established.

Research Objectives

To date, the majority of age attitude and ABST literature has been concerned with cognitive performance. When physical performance is studied, it is poorly defined in terms of physiological and psychological processes involved. Additionally, the reliability of results is underwhelming and this could be associated with the rigor of the studies. For example, many studies fail to demonstrate control of biases in a field that is fundamentally determined by social influences. This lack of rigor undermines understanding of this area, with potentially severe health implications. Further, it also undermines the credibility of the academic field of study and impedes the reputation of quality and adequate research attention where it is required.

The risks of not having solid grasp of whether ABST and age attitudes affects physical performance is great. ABST affects many of the psychological processes that are involved in physical tasks. This means that there is potential that it could affect the diagnostic and prognostic reliability of physical tasks such as handgrip and walking speed tests which are common place in clinical and research settings (Leong et al., 2015; Strand et al., 2016). Social demographic factors such as income and education may be currently-accepted covariates of the relationship between handgrip strength and longevity. If this relationship is also influenced by factors such as age attitudes or ABST, then there could be opportunity to enhance the prognostic value of applications of physical tasks, such as handgrip strength, as a marker of vitality and resilience. There is shortfall in current theoretical models and empirical literature in describing these relationships.

Therefore, the core research objectives of this thesis are to:

i) Provide a robust methodology in order to understand whether ABST can affect neuromuscular performance,

ii) Identify the psychological and neuromuscular pathways by which ABST can affect physical performance,

iii) Describe the relationship between attitudes to age, physical activity and physical performance, and

iv) Establish how physical activity interventions interact with age attitudes and ABST.

Ultimately, the purpose of this thesis is to extend understanding of ABST and age attitudes in relation to physical activities, and therefore contribute to the international endeavour of supporting healthy ageing.

Chapter 5 - Stereotype Threat affects older adults' neuromuscular control and peak force during handgrip strength and time to task failure

Abstract

The damaging effects of age-based stereotype threat (ABST) on older adults' cognitive performance is well established (e.g. $d = 0.36$, Lamont et al., 2015). However, little is known about how ABST might affect physical performance. This has important ramifications for research and clinical practice, because handgrip strength is an indicator of health and clinical risk in older patients. To investigate how ABST might affect physical performance, older adults (n=85, mean age=83.5 years) were recruited from seven Age UK day centres. Participants were randomly assigned to one of three conditions in a double-blinded procedure. Participants either received the ABST instruction (Threat Before Maximal voluntary contraction, TBM) or non-threat instruction (Control) and completed handgrip peak force and time to task failure (TTF), or they completed the peak force task before the instruction and the TTF afterwards (Threat After Maximal voluntary contraction, TAM). During handgrip, electromyography (EMG) measured neuromuscular activity. Self-reported anxiety, and perceived threat were measured after handgrip. When comparing TBM and non-threatened participants, only an indirect effect of threat was found via anxiety on hand grip strength ($ab = -5.91$, LLCI = -13.12, ULCI = -0.67). This indirect effect via anxiety was marginally significant for sustained contraction time ($ab = -5.27$, LLCI -12.74 to ULCI -0.04). Effects of condition on the EMG were also demonstrated, as synergist (FCU) percentage activation was lower in TBM and TAM compared to non-threatened participants. This suggests lower performance in threatened participants. Results are discussed in terms of extending ABST theory and the implications for ensuring valid handgrip strength measurements in clinical settings [1].

A version of this study has been submitted for publication. Swift, H., Farr, I., Winter, S. (In publication) Get a grip: Neuromuscular effects of age-based stereotype threat on handgrip performance. *Psychology of Sport & Exercise*.

Introduction

Stereotype threat occurs when an individual fears confirming a negative stereotype about a group they belong to (Steele & Aronson, 1995). When age is the salient identity under threat, this is known as age-based stereotype threat (ABST). Compelling evidence that ABST has a detrimental impact on older adults' cognitive performance is presented in a review and meta-analyses (Lamont, Swift, & Abrams, 2015). For example, when ABST is evoked then older adults remember less items in a memory task than when the threat is not present (Chasteen et al., 2005). Previous research has demonstrated the role of anxiety as a mechanistic factor in ABST in cognitive tasks (Abrams et al., 2009). However, there is paucity of research describing stereotype threat effects on physical performance. Addressing this gap is important to ensure validity of research and clinical physical performance assessments, and to better understand how ABST might affect older adults' engagement with physical activity.

For instance, Swift, Lamont and Abrams, (2012) randomly assigned 56 community dwelling adults (mean age 82.5 years) to either the control or to the threat condition. Threat was elicited by informing participants that the purpose of the task was a social comparison with younger participants, whereas controls received a statement without reference to the social comparison. Results showed that under stereotype threat, participants gripped with less force and for shorter time, even once relevant individual differences including, gender, education, age, and arthritis were controlled for.

In contrast, Horton, Baker, Pearce, and Deakin, (2010), randomly assigned 99 adults between the ages of 60 and 75 to either a positive, negative or control (no stereotype activation) condition. A fictionalised news article and newscast which highlighted either positive or negative age stereotypes was presented to those assigned to the positive or negative condition. No effects of threat were found on any of the dependent measures. These included cognitive measures and physical performance measures such as sit and reach task to measure flexibility, grip strength and walking speed.

More recently, Marquet et al. (2018) assigned 64 older adults (mean age 72 years) to either a low-threat condition or a high-threat condition. Completion of a short survey that gave participants information about how physical capabilities decline with age was used to invoke stereotype threat. Seven physical performance tasks were then completed by participants, including four different walking tests, timed up and go test, one leg standing test and handgrip strength. Before each measure, the high threat group received a reminder of the study aims to keep the threat salient. However, only the tandem walking task showed significant group differences. When threat was higher, participants stride was wider. This is relevant as a wider stride increases the base of support and so aids stability. As people age, they adopt a greater step width is noted, which increases gait stability (Hamacher, Singh, Van Dieen, Heller, & Taylor, 2011). Notably, falls and fear of falling are associated with increased step width (Maki, 1997), to combat the threat of falling.

These mixed results could be due to the nuances in the ABST manipulation, different sampling strategies employed by studies, difficulty of the task, or the perceived demands of the task. For instance, Lamont et al. (2015) revealed that effects of ABST were greater for stereotype-based (such as highlighting an age-based social comparison), as opposed to fact-based manipulations. The manipulations of ABST used by Horton et al. (2010) and Marquet et al (2018) contain fact-based elements to highlight the abilities of older adults on the tasks. Moreover, Maquet et al. (2018) suggests that the focus of their ABST manipulation on balance disorders may not have been relevant enough to elicit threat on the handgrip task which is a test of strength, not balance. In addition, the mean age of participants in both studies were approximately ten years younger than participants recruited in Swift et al. (2012), which accords with some, but not all research (e.g. see Popham & Hess, 2015), suggesting that ABST effects correlate positively with identification to the old age group (Haslam et al. 2012) and value placed on the performance domain (Hess, Auman, Colcombe, & Rahhal, 2003). Therefore, this study aims to strengthen ABST theory by replicating Swift et al. (2012) with improved and more accurate measure of handgrip strength. This study also aims to extend Swift et al. (2012) by exploring the role of anxiety and by exploring the ABST effect at the neuromuscular level.

The considerable prognostic power of hand grip strength is well established; predicting all-cause mortality (Leong et al., 2015), cancer survival (Kilgour et al., 2013), old age disability (Rantanen et al., 1999), as well as cardiovascular (Celis-

Morales et al., 2018), and renal outcomes (Chang et al., 2011). The predictive effect of hand grip was evidenced cross-culturally, as handgrip predicts all-cause mortality and hospital admission rates in a four year follow up in 17 countries (Leong et al., 2015). It is therefore unsurprising that health risk is indicated by the proxy measure of hand grip strength and that this measure is used to inform clinical practice. Exploring ABST on handgrip is crucial because if psychosocial factors can affect physical performance, then this has significant implications for the application of handgrip tasks in clinical and research settings. As psychological factors, such anxiety, can affect physical performance, it is crucial to ensure that ABST does not present a source of interference when using handgrip strength tests in research and clinical settings which would limit the validity of such tests.

The wider literature on physical performance suggests that anxiety can play a key role in determining physical performance. For example, participants who are more anxious have shown decreased golf putting accuracy (Masters, 1992) and more errors driving vehicles (Gotardi et al., 2019). Anxiety experienced by older adults has been correlated with increased and therefore worse, sit to stand time (Lord et al. 2002). Anxious performances are associated with less efficient energy expenditure as measured using electromyography (Weinberg & Hunt, 1976). Pertinently, anxiety may be evoked from psychosocial factors such as stereotype threat (Pennington, Heim, Levy, & Larkin, 2016). Therefore, it could be reasonable to expect that ABST impacts negatively on physical performance via increased anxiety. However, mechanisms underlying ABST effects on physical performance have not been empirically demonstrated.

The Integrated Process Model (Schmader et al., 2008) suggests that stereotype threat can lead to cognitive and physical task underperformance. For tasks with minimal cognitive demands, such as handgrip, then the model proposes that threat elicits a physiological stress response which is negatively appraised. This somatic anxiety is combined with cognitive anxiety such as negative thoughts, and impairs monitoring processes which negatively impacts physical performance. In contrast, controlled tasks such as memory or social tasks, are affected by the negative impacts of these systems upon working memory efficiency. These conceptual pathways are supported by findings that anxiety impairs cognitive processing and physical performance (Eysenck et al., 2007; Inzlicht, Bartholow, & Hirsh, 2015; Mullen & Hardy, 2000).

It is important to note that although anxiety is a negative state of heightened arousal, not all individuals experience arousal similarly. Indeed, arousal can facilitate physical performance (Jones & Swain, 2008). Whether individuals interpret a situation as a challenge or threat influences the nature of this arousal (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004; Mendes, Blascovich, Lickel, & Hunter, 2002). Challenge and threat situations lead to differing physiological effects. For example, threat is associated with increase mean arterial pressure and reduced heart rate variability (Blascovich, Spencer, Quinn, & Steele, 2001; Elliot, Payen, Brisswalter, Cury, & Thayer, 2011). Anxiety could lead to increased effort and neural activation, or could lead to underperformance if overcompensation leads to quicker fatigue (Wegner, 1994; Masters & Maxwell, 2008; Stone, 2002), or if there is insufficient motivated effort (Hagger, Wood, Stiff, & Chatzisarantis, 2010). However, empirical support for the Integrated Process Model comes solely from cognitive performance tasks and so there is a gap in understanding how anxiety from ABST can physical performance such as handgrip.

In this study, the impact of ABST on physical performance will be investigated using a more precise measure of handgrip strength and sustained contraction, and will investigate the role of anxiety in these effects. This research will enable the neuromuscular activity underpinning effects to be examined. While some research has described the effects of ABST on gross physical performance, this research will address a current gap in describing the neuromuscular mechanisms involved in physical performance effects. Additionally, by investigating when threat is presented before or after an initial attempt at the handgrip task, it will be possible to explore whether prior performance affects the magnitude or mechanisms of ABST effects. Furthering understanding of the way ABST operates, implicit attitudes will also be studied. For example, previous research has demonstrated that when an implicit attitudes test is presented to participants as diagnostic of racism, white participants show a stereotype threat effect as stronger pro-white scores (Frantz, Cuddy, Burnett, Ray, & Hart, 2004). It is expected that, ABST could increase bias of negative age attitudes. However, this has not been studied in ABST, and so will help identify potential for targeted intervention for physical performance tasks.

During isometric contractions, lower frequencies and greater amplitude in electromyographic (EMG) signal in the agonist muscle may imply greater levels of muscle fatigue (Enoka & Duchateau, 2017). As shorter contraction times are expected when the age-stereotype is activated, it follows that muscular physiological state will be less fatigued, therefore it is hypothesised that agonist amplitude and average frequency will be lower in the stereotype threat conditions. Stereotype threat is also expected to result in lower peak force and reductions in sustained sub-maximal contraction time.

In the handgrip task the activation of three muscles are of interest. The agonist contracts to flex the joint, the synergist supports this movement, and the antagonist opposes this movement. Muscle fatigue during effortful isometric contraction is shown by a significant reduction in EMG frequency and amplitude over time as muscle fibres synchronise to maintain handgrip force. Conversely, reduced effort may be identified by comparatively little change in muscle activity in frequency or amplitude over time, or by low frequency or amplitude at the beginning of the handgrip task. Physiological changes will be measured with blood pressure. Lower pressure is expected when participants are not threatened.

To summarise, this study aimed to extend the stereotype threat literature in two important ways. First, by exploring the role of anxiety and whether this mediates the effect of threat on physical performance outcomes of older adults (as proposed by Schmader et al. 2008), and second, by investigating the neuromuscular activity of muscle contraction to explore whether muscle activity differs under threat.

Hypotheses

Four outcomes are expected when ABST is invoked.

1) Increased anxiety, self-reported perceived threat, and increased physiological threat demonstrated by increased blood pressure and heart rate, compared to participants in the control condition
2) Reduced handgrip performance, demonstrated by lower peak force, and shorter time to task failure, compared to participants in the control condition.

3) Corresponding with underperformance on the sustained contraction task, EMG measures of frequency and amplitude were expected to be lower for ABST participants. Although participants in all conditions are likely to experience some decline in EMG mean frequency over time as muscles fatigue, the reduced effort when ABST is present should result in a smaller reduction in activity.
4) Greater bias for stereotype congruent stimuli in the implicit attitudes test.

Method

In order to test the effect of ABST on handgrip this study employed a between-subject design. First, based on previous research (Swift et al., 2012), the usual control vs threat design was employed in which participants are provided with the task instructions (control) or Threat manipulation Before the handgrip Maximal voluntary contraction (TBM). An additional exploratory condition was also included in which Threat was presented After the Maximal voluntary contraction (TAM), before the sustained contraction. This condition was added so that sustained contraction force under threat could be normalised to an individual's unthreatened peak force. This means that the effect of ABST can be seen separately on sustained contraction time and peak force. Research ethics were approved by the University of Kent Research Ethics Advisory Group (Prop 127_2016_17).

Procedure

In a private room within each day centre handgrip maximal voluntary contraction (MVC) was measured and then a 50% of this maximum was sustained in isometric contraction until task failure was reached. EMG electrodes were situated on a total of three sites on the hand and forearm to collect neuromuscular activity data during the hand grip tasks. Following the physical tasks, anxiety and implicit attitudes were measured. Resting heart rate and blood pressure were taken before conditions were assigned, then again immediately following the sustained contraction.

Participants

Based on Swift et al. (2012), an effect size of d = 0.58 was expected for handgrip strength. A priori estimations of sample size suggested 69 (80%) to 90 (90%) people required to detect an effect across three conditions. Eighty-five participants (mean age= 83.5 years, SD= 7.83) were recruited from seven Age UK day centres across Kent. Day centre staff acted as gatekeepers to identify those with capacity to consent. Participants without self-reported neurological impairment and who were otherwise fit to participate were included. Written informed consent was obtained from all participants following approval of all procedures by the School of Sport and Exercise Sciences Research Ethics Board at the University of Kent (Prop 80_2016_17).

Manipulation and procedure

Stereotype Manipulation- Participants were assigned to one of three conditions, either threat before MVC (TBM), threat after MVC (TAM), or control condition. To assign participants to condition, participants chose from three apparently identical envelopes containing different experimental instructions. This was in order to pseudo-double blind the procedure and to randomise condition assignment. Each of the three envelopes contained two cards with instructions and information about the purpose of the study. All envelopes instructed about the MVC on the first card. Two of the envelopes simply described MVC instructions ("You will be asked to grip the hand strength device as hard as you can. It is important that you grip as hard as possible"). One of the envelopes introduced the stereotype threat at the same time as the MVC instructions "The purpose of this research is to see whether older people perform differently on various tasks and the ways in which they deal with the world in comparison with young people. Both older and young people will be taking part in this research. You will be asked to grip the device as hard as you can. Your results will be compared to younger people taking part". The second cards instructed participants to match the 50% MVC target contraction force. At this point, the envelope for people who had the stereotype threat stimulus before performing the MVC 'reminded' participants about the aim of the study ("Keeping in mind the aims of the study….Your results will be compared to younger people taking part"). The envelope introducing threat after the MVC stated “The purpose of this research is to see whether older people perform differently on various tasks and the ways in which they deal with the world in comparison with young people. Both older and young people will be taking part in this research. You will be asked to grip the device for as long as you can. Your results will be compared to younger people taking part”. The third envelope simply described the instructions for the experiment (control condition).

Table 5.1: Experimental protocol, by condition.

Control	**Threat After MVC (TAM)**	**Threat Before MVC (TBM)**
Neutral Instruction	*Neutral Instruction*	*Threat Instruction*
Peak Force (MVC)	Peak Force (MVC)	Peak Force (MVC)
Neutral Instruction	*Threat Instruction*	*Threat Instruction*
Time to Task Failure (TTF)	TTF	TTF

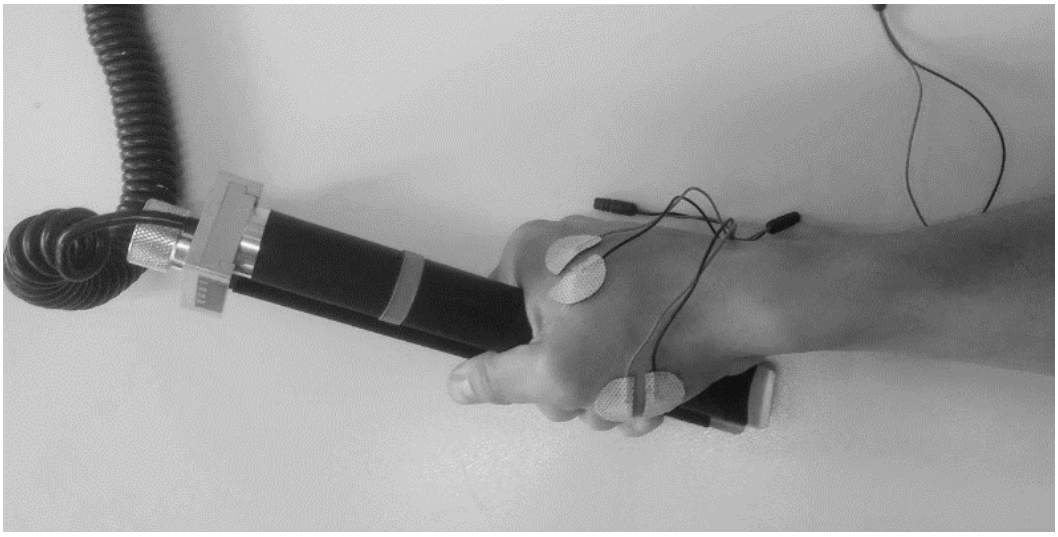
Note: MVC – Maximal voluntary contraction. Threat manipulation instructions are underlined to highlight differences between conditions. For all groups, blood pressure was taken before the first instruction card was read by the participant. After TTF, blood pressure, anxiety questionnaire, Implicit Attitudes Test (IAT) was administered.

Measures

Hand grip - A digital hand grip dynamometer was used to accurately record contraction time and force (Hand Grip Analyser, MIE: Leeds, UK). The device was operated in the participants preferred hand with elbow and hand supported on a platform (e.g. table or desk) with elbow flexed at 90° and with palms in neutral position. Maximal Voluntary Contractions (MVCs) were separated by one-minute rest. Target force for the sustained contraction was calculated as a percentage of the peak force. The 50% MVC target and contraction force bar was displayed in real time within OT BioLab software (OT Bioelettronica, Turin, Italy). Participants were instructed to maintain 50% MVC continually until the target force could no longer be met. Participants were reminded to keep force within the target range, but no encouragement was given. The fatiguing task was terminated either by the experimenter when the contraction force was outside of 10% MVC tolerance for 4 continual seconds, or voluntarily by the participant.

Electromyography- EMG recordings were recorded using bipolar silver chloride 20mm diameter electrodes (OT Bioelettronica, Turin, Italy) from first dorsal interosseous, abductor pollicis brevis and flexor carpi ulnaris according to recommended sEMG practice (Criswell & Cram, 2011; Stegeman & Hermens, 2007) and the reference wrist band was worn around the contralateral wrist. Electrode-skin impedance was reduced by preparing skin with shaving and alcohol swab. Electrodes were trimmed as necessary for accurate placement and to avoid cross talk, according to manufacturer's instruction. Signal was then amplified using A/D converter (OT USB2+, OT Bioelettronica, Turin, Italy). All EMG and grip force data were sampled at 2048Hz and amplified at a gain that identified signal without clipping the EMG signal.

Figure 5.1: EMG sensor placement.



Perceived Threat –Two questions ("were you concerned that the experimenter would judge poor performance in terms of age", "Were you worried that your ability to perform well on the test was affected by your age”) were used to assess the extent to which the manipulation had evoked ABST (1-not at all to 7-very much). An average score was calculated across these items.

Anxiety Questionnaire – Experiences of anxiety (To what extent did you feel nervous”, and somatic (“did you feel butterflies in your stomach”) and cognitive anxiety (“were you worried”) were measured via self-report Likert questions (Williams, Cumming, & Balanos, 2010). Additionally, 6 items measured the bodily experience of anxiety such as whether participants felt jittery, calm (reverse scored), or tense (Abrams et al., 2008; Abrams, Eller, & Bryant, 2006). Items converged to a single item in factor analysis and this factor was used to analyse anxiety (Cronbach’s alpha = 0.9).

Implicit Age Attitudes - Implicit Attitudes Test (IAT; Greenwald, Mcghee, & Schwartz, 1998) for age, was administered using PsychoPy software (Peirce, 2008). Participants were presented faces and judged them as old or young, and were presented words (e.g. joy, disgust) and judged them good or bad. This replicates previous methodology investigating attitudes towards ageing (Nosek, Banaji, & Greenwald, 2002). Difference between stereotype congruent (e.g. face of older person and negative word) and stereotype incongruent (e.g. face of older person and postive word) items for response time and number correct was calculated as measure of bias.

Cardiovascular measures – A Dynamap Pro 400 sphygmomanometer was used to measure baseline blood pressure and pulse (before any instructions were presented) and inflation of the cuff commenced again immediately after the sustained contraction had been finished. A change measure was calculated as values at the start minus values at the end for pulse, systolic pressure, diastolic pressure, and mean arterial pressure (MAP = (2 x diastolic pressure + systolic pressure) / 3).

Data Analysis

Force and electromyography signals were processed using custom written scripts in MATLAB (MathWorks Inc, Natick, MA, USA). Maximal contraction was identified from the three MVCs and the associated EMG activity for this trial was used as the maximal activity reference value.

For EMG data linear envelopes were created by passing the full wave rectified signal through low pass filter (Butterworth second order filter, LP cut-off 5Hz). The power spectrum was identified using Fourier transformation. From this, mean frequency was extracted for start and finish of the contraction for the first four second epoch over the target threshold, and the last four second epoch before the contraction force dropped below the threshold. Percentage activation for these epochs were also calculated as a proportion of the EMG RMS handgrip peak force amplitude. Start and finish of the sustained contraction was defined as the first above target and last point at which the force was above target before dropping below target force for more than 3 seconds.

Statistical Analysis

Multivariate outlier detection check was conducted using Mahalanobis distance, showing that there were no outliers across the three conditions. Following assessment of potential confounding variables (health condition) and covariates (age, sex) by one-tailed correlations, analysis of covariance (ANCOVA) was used to investigate between-groups effects, and Tukey's HSD post-hoc test was applied to inspect paired differences. Levene's test established homogeneity of variance before proceeding with analyses. Post-hoc, assumptions of residual normality, heteroscedascity, and outlying residual leverage were satisfied by analysis of QQ-plot, fitted vs residuals plot, and Cooks distance respectively. TBM and Control group were compared for peak force, and TAM, TBM, and control were included in TTF analyses.

Factor analysis was used to reduce factors. The number of factors with eigenvalue > 1 determined that the number of factors to extract was 1. Promax rotation was used to aid interpretation of loadings.

ABST effects on EMG frequency and percentage activation change across start and end time points were tested in mixed effects models. Variations in each model were built iteratively (Hox, 2010). This was repeated for each muscle (synergist, agonist, antagonist) and measure (mean frequency, percentage activation). Model 0 included intercept only. Model 1 included fixed factors (TAM and TBM vs control, peak force, anxiety), compared to control group. Model 2 looked at the within-person effect of time only. Model 3 combined these models and included the cross-level interaction of time by condition. As even small groups of random factors have advantage over classical regression models (Gelman & Hill, 2007), random intercept was participant nested within location. Akaike Information Criterion (AIC; Akaike, 1974) was used as the criterion for model selection. AIC is a measure of goodness of fit which adds penalty for the number of parameters in the model, thus handling the risk of model-overfitting. Conditional and marginal R-squared values are given based on Nakagawa et al. (2017). Briefly, marginal R-squared shows the variance explained by fixed effects only, whereas conditional r-squared includes random effects in variance explained.

All analysis was performed using R (R Core Team, R Foundation for Statistical Computing: Vienna, Austria).

Results

The study recruited 85 participants from the 7 locations, 27 participants were assigned control, 28 to TAM and 30 to TBM. The majority of the sample were female (72%, n = 61), and had at least one health condition (62%, n = 51). One participant withdrew before any physical performance measurements because they were called for an appointment. When TTF was included in analyses, the sample was reduced to 71 because of force that was not consistently above the 50% peak force target (i.e. less than four seconds below target, but more than three such events within a minute), which could have allowed some opportunity for muscles to recover. When EMG measures were included in analysis, the sample was reduced to 73, by 11 participants who had inaccurate EMG readings (either excessive noise or difficulties in accurate recording). Fourteen participants withdrew from IAT. Pairwise deletion was applied to statistical tests to account for missing data. Analysis of variance confirmed that participant demographics (age, gender and health) did not vary significantly by condition ($p > 0.05$).

Unlike Swift et al. (2012) peak force and contraction time did not correlate. This is due to the normalisation of the target contraction force to the 50% of peak force. Handgrip strength did correlate with gender, age and health condition, bivariate relationships are shown in Table 5.2: Correlations of demographic variables. Contraction time did not correlate with demographic variables. Again, this is due to the normalisation of contraction intensity by peak force.

Stereotype threat manipulation check

Supporting hypothesis 1, that ABST manipulation would cause threat to be experienced, there was a main effect of Condition on threat (F (2, 80) = 4.70, p = .02, η^2 = .11). The two threat conditions did not significantly differ, however, Tukey's HSD confirmed that compared to the control condition (M = 3.41, SD = 0.63), TBM participants (M = 5.97, SD = 0.61) and TAM participants (M = 5.41, SD = 0.63) reported significantly greater threat. Preliminary analysis also revealed a significant effect of condition on anxiety (F(2, 80)= 4.20, p = .02, η^2 = .12). Tukey's HSD confirmed that compared to the control condition (M = - 0.44, SE = 0.18), participants in the TBM condition (M = 0.25, SE = 0.17) and TAM condition reported more anxiety (*M* = 0.17, *SE* = 0.18), while differences between the threat conditions were not significant.

Table 5.2: Correlations of demographic variables

Variable	M	SD	1	2	3	4	5	6
1. Age	83.5	7.83						
2. Threat	5.01	3.41	.17					
3. Anxiety (Factor)	0.01	1.00	-.23	.48 **				
4. Peak Force	182.2	58.7	-.34 **	-.25 *	-.18			
5. Time to Task Failure	75.44	42.3	.07	-.21	-.17	.06		
6. Health Condition	0.66	0.48	.15	-.06	-.14	-.29 *	.13	
7. Sex	0.25	0.44	-0.14	-0.04	-0.08	0.59 **	-0.17	-0.16

Note: Means, standard deviations, and correlations with confidence intervals.
** indicates p < 0.05. ** indicates p <0.01.*

Cardiovascular measures

ANOVA revealed no significant effects of any of the three conditions to changes in either pulse ($F(2,75) = 0.027$, $p = .97$, $\eta^2 = .04$), systolic ($F(2,75) = 1.02$, $p = .37$, $\eta^2 = .02$), diastolic ($F(2,75) = 1.01$, $p = .40$, $\eta^2 = .01$), or mean arterial pressure ($F(2,75) = 1.208$, $p = .30$, $\eta^2 = .12$). This suggests that there was no difference in physiological response to the ABST manipulation.

Effect of condition on handgrip peak force and TTF

Testing hypothesis 2, that ABST would cause handgrip underperformance, one-way ANOVA showed that there was no main effect for condition on peak force, meaning that there was no significant difference between the three conditions (F(2,81) = 0.11, p = .90 , η^2 = .02). Additionally, ANCOVA showed that there were no significant results of condition on peak force even when controlling for age, sex, and the presence of a chronic health condition, (F(2,78) = 0.284, p = .75, η^2 = .01). Similarly, condition did not appear to have a significant effect on contraction time (F(2,68) = 0.12, p = .89, η^2 =.31) irrespective of covarying demographic variables (F (2, 65) = 0.12, p = .88, η^2 =.31). This suggests no direct effect of ABST on peak force and TTF.

Mediating effect of anxiety on handgrip

To explore the mediating effect of anxiety on handgrip in relation to hypothesis 2, separate analyses were conducted to explore effect of TAM condition vs control, and the effect of TBM condition vs control.

A simple mediation model was conducted for strength (peak force), controlling for gender, age and health, revealing TBM significantly increased anxiety (a = .35, SE =0.12, t =2.91, p = .005, LLCI = 0.11, ULCI= .60), and anxiety had a negative effect on hand grip strength (b = -16.76, SE = 7.93, t = -2.11, p = .04, LLCI = -32.71, ULCI = -0.81). The bootstrapped confidence interval for the indirect effect of threat on hand grip strength via anxiety (ab = -5.91) was different from zero (LLCI = -13.12, ULCI = -0.67), but there was no evidence that threat TBM influenced hand grip strength independent of its effect on anxiety (c' = 0.09, p = .44), shown in Figure 4.2 and Figure 4.3 respectively.

This mediation analysis was repeated to explore the indirect effect of threat on hand grip contraction time via anxiety. Health, gender, and sex were not significant predictors in this model, presumably because these factors were normalised by the MVCs. Comparing TBM and those in the control condition, the analysis revealed an effect of condition on anxiety (a = 0.35, SE =0.12, t =2.91, p = 0.005, LLCI = 0.11, ULCI= 0.60), and a marginally significant negative effect of anxiety on contraction time (b = -13.90, SE = 7.60, t = -1.83, p = 0.074, LLCI = -

29.19, ULCI = 1.39). The bootstrapped confidence interval for the indirect effect of threat on contraction time via anxiety (*ab* = -5.27) was different from zero (LLCI -12.74, ULCI -0.04), but there was no evidence that threat influenced handgrip contraction time independent of its effect on anxiety (*c'* = 0.12, *p* = 0.45). There was no significant mediation for TAM for time to task failure or peak force.

Figure 5.2: Indirect effect of ABST on peak force. TBM - Threat delivered Before MVC (Peak Force)

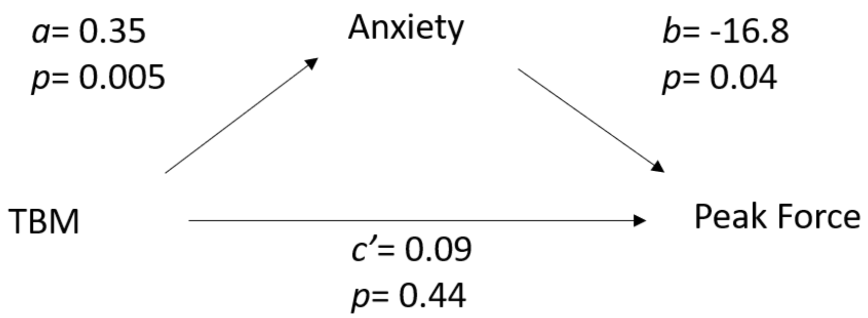
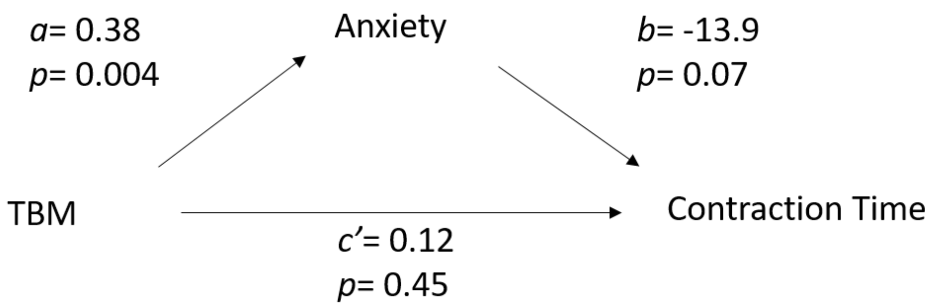


Figure 5.3: Indirect effect of ABST on contraction time. TBM - Threat delivered Before MVC. Contraction Time to Task Failure (TTF) in Seconds.



Electromyography

To test hypothesis 3, that ABST would cause differences in EMG, neuromuscular effects of condition were explored to better understand how ABST could contribute to physical task underperformance in the sustained contraction task. ABST was expected to cause lower agonist percentage activation, leading to difficulty in maintaining target force, which would indicate limited motivation.

Agonist frequency would not decline so much when threatened as participants would give up before a fatigued state had been reached. Models are reported in Table 5.3 - Table 5.7.

Synergist – Flexor Carpi Ulnaris (FCU)

The most parsimonious model showed that percentage activation was predicted by condition, anxiety, and peak force, and this effect was irrespective of time (Table 5.3, Model 1). Compared to control participants, percentage activation was reduced for TAM (b = -9.61, t(68) = -2.01, p =.04) and TBM (b = -12.71, t(68) = -2.83, p = .004). Follow-up analyses showed that TAM was slightly higher (M = 25.9%, SD = 15.5), than TBM (M = 25.7%, SD = 19.6), although these differences did not reach significance.

Model 3 showed that mean frequency was significantly predicted by anxiety (

Table 5.4, Model 3; b = 35.44, t(68) = 3.27, p = .001) and time (b = -25.17, t(68) = -2.55, p = .01). Increases in anxiety predicted higher EMG frequency. Frequency decreased with time and was lower at the end of the trial. There was no effect of condition (TBM or TAM compared to control) on FCU mean frequency.

Table 5.3: FCU Percentage activation

	Model 0		Model 1 ^		Model 2		Model 3	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	29.7 ***	2.4	25.9 ***	6.4	29.2 ***	2.5	23.8 ***	6.5
Time					1.1	1.5	4.1	2.5
Condition (TBM)			-11.9 **	4.4			-8.8	4.7
Condition (TAM)			-8.7	4.7			-7.3	5.0
Anxiety			4.5 *	1.9			4.5 *	1.9
Peak Force			0.1	0.0			0.1	0.0
Time * TBM							-6.3	3.5
Time * TAM							-2.8	3.8
Random Effects								
σ^2	83.41		83.41		82.78		79.19	
τ_{00}	213.64		179.25		213.95		181.35	
ICC	0.73		0.69		0.73		0.70	
Marginal R^2 / Conditional R^2	0.0 / 0.73		0.13 / 0.73		0.001 / 0.73		0.14 / 0.74	
AIC	1153		1150		1155		1152	

Table 5.4: FCU Mean frequency

	Model 0		Model 1		Model 2		Model 3 ^	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	198 ***	17	202.5 ***	38.5	204.1 ***	17.4	215.1 ***	38.8
Time					-11.7	6.1	-25.2 *	9.9
Condition (TBM)			-27.6	25.6			-37.6	26.6
Condition (TAM)			37.9	27.0			26.5	28.0
Anxiety			35.4 **	11.1			35.4 **	11.1
Peak Force			-0.01	0.2			-0.0	0.2
Time * TBM							20.0	14.1
Time * TAM							22.9	15.0
Random Effects								
σ^2	1336		1336		1267		1214	
τ_{00}	8087		6526		8122		6587	
ICC	0.87		0.84		0.88		0.85	
Marginal R^2 / Conditional R^2	0.0 / 0.87		0.19 / 0.86		0.003 / 0.87		0.20 / 0.88	
AIC	1551		1544		1550		1544	

*Note: ^ Best fitting model. * p<.05 ** p<.01 *** p<.001. TBM – Threat Before MVC. TAM – Threat After MVC. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Agonist – First Dorsal Interosseous (FDI)

Percentage activation for the agonist (FDI) was best fit by Model 2, time is the only predictor in this model (*b* = -3.89, t(68) = -2.18, p = .05). Compared to the start of the trial, percentage activation was lower at the end of the sustained contraction (TTF). However, marginal R^2 was very low, meaning that the fixed effects in this model (time) explained little variation in percentage activation. Agonist EMG frequency was best predicted by Model 0 intercept only, see

Table 5.6. However, it is notable that time was a significant predictor in Model 3. Mean frequency was lower at the end of the trial than at the start (*b* = -36.5, *t*(68) = -2.80, *p* = .03). There was also a significant cross-level interaction between time and TAM in Model 3. This model showed that mean frequency for control participants decreased over time (Start *M* = 262Hz, End *M* = 239Hz; *SD* = 127) whereas TAM participants increased slightly (Start *M* = 255Hz, End *M* =269 Hz; *SD* = 148). Although mean frequency for control participants was higher at the start and lower at the end of the trial compared to TAM, post-hoc Tukey HSD showed that there was no significant difference between conditions (TAM vs control) at the start (*t*(68) = 0.33, *p* = .75) or at the end (*t*(68) = 1.28, *p* = .21) of the trial.

Table 5.5: FDI Percent activation

	Model 0		Model 1		Model 2 ^		Model 3	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	24.0 ***	5.6	37.3 **	12.5	26.0 ***	5.7	38.5 **	12.6
Time					-3.9	2.0	-2.3	3.3
Condition (TBM)			-5.0	7.8			-3.4	8.2
Condition (TAM)			-12.9	8.3			-12.0	8.7
Anxiety			3.4	3.5			3.4	3.5
Peak Force			-0.0	0.1			-0.0	0.1
Time * TBM							-3.2	4.7
Time * TAM							-1.7	5.0
Random Effects								
σ^2	144		144		136		135	
τ_{00}	630		599		633		603	
ICC	0.84		0.83		0.85		0.84	
Marginal R^2 / Conditional R^2	0.0 / 0.84		0.04 / 0.84		0.004 / 0.85		0.05 / 0.85	
AIC	1230		1235		1228		1236	

Table 5.6: FDI Mean frequency

	Model 0 ^		Model 1		Model 2		Model 3	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	250***	20.9	225***	44.5	256***	21.2	236***	44.8
Time					-7.2	7.0	-23.1 *	11.1
Condition (TBM)			-9.4	27.2			-17.5	28.4
Condition (TAM)			11.8	28.9			-6.5	30.1
Anxiety			-9.3	12.1			-9.3	12.1
Peak Force			0.1	0.2			0.1	0.2
Time * TBM							16.3	15.9
Time * TAM							36.5 *	16.9
Random Effects								
σ^2	1675		1675		1649		1543	
τ_{00}	7459		7247		7472		7313	
ICC	0.85		0.84		0.85		0.85	
Marginal R^2 / Conditional R^2	0.0 / 0.85		0.02 / 0.84		0.001 / 0.85		0.03 / 0.86	
AIC	1566		1572		1567		1572	

*Note: ^ Best fitting model. * $p<.05$ ** $p<.01$ *** $p<.001$. TBM – Threat Before MVC. TAM – Threat After MVC. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Antagonist – Abductor Pollicus Brevis

There was no effect of threat, anxiety, peak force, time on the antagnoist muscle percentage activation. That is, the best fit model was model 0, the intercept only model (Table 5.7). For antagnoist mean frequency there was a significant effect which decreased over time in the best fit Model 2, Table 4.8 (b = 28.24, $t(68)$ = -2.29, p < .001).

Table 5.7: APB Percent activation

	Model 0 ^		**Model 1**		**Model 2**		**Model 3**	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	42.2 ***	5.3	41.7 *	18.6	40.0 ***	5.5	38.8 *	18.8
Time					4.4	2.9	5.8	4.7
Condition (TBM)			-12.6	13.1			-10.6	13.5
Condition (TAM)			-10.6	13.7			-10.5	14.1
Anxiety			-0.6	5.5			-0.6	5.5
Peak Force			0.0	0.1			0.0	0.1
Time * TBM							-3.8	6.8
Time * TAM							-0.3	7.2
Random Effects								
σ^2	292		292		282		281	
τ_{00}	1782		1739		1787		1745	
ICC	0.86				0.86			
Marginal R^2 / Conditional R^2	0.000 / 0.86		0.128 / 0.86		0.002 / 0.86		0.148 / 0.86	
AIC	1341		1348		1341		1351	

*Note: ^ Best fitting model. * p<.05 ** p<.01 *** p<.001. TBM – Threat Before MVC. TAM – Threat After MVC. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table 5.8: APB Mean frequency

	Model 0		Model 1		Model 2 ^		Model 3	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	235.9 ***	27.1	240.8 ***	42.8	250.1 ***	27.2	251.7 ***	43.0
Time					-28.2 ***	5.8	-21.8 *	9.5
Condition (TBM)			-1.7	22.4			4.4	23.4
Condition (TAM)			11.8	23.9			15.6	24.9
Anxiety			-1.0	10.1			-1.0	10.1
Peak Force			-0.0	0.2			-0.0	0.2
Time * TBM							-12.2	13.6
Time * TAM							-7.6	14.5
Random Effects								
σ^2	1547		1547		1148		1134	
τ_{00}	4712		4666		4912		4873	
ICC	0.85		0.84		0.88		0.88	
Marginal R^2 / Conditional R^2	0.0 / 0.85		0.004 / 0.85		0.02 / 0.88		0.03 / 0.89	
AIC	1538.160		1545.664		1519.887		1530.580	

*Note: ^ Best fitting model. * p<.05 ** p<.01 *** p<.001. TBM – Threat Before MVC. TAM – Threat After MVC. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

To summarise EMG findings, condition and anxiety significantly predicted synergist (FCU) percentage activation, as shown in Table 5.3, showing that under ABST, participants did not recruit this muscle to the same level as participants in the control condition. In all muscles, frequency decreased from the start to the end of the sustained contraction although this reduction was not significant for the agonist (FDI).

Implicit Attitudes Test

To test hypothesis 4, that ABST would cause greater negative age attitude bias, a series of ANCOVA were run on IAT to investigate whether ABST had influenced implicit attitudes in terms of number correct and response time, controlling for demographic variables. There were no significant effects of either

TBM or TAM on any of the IAT measures, either number of IAT difference score, correct responses, reaction time, even when controlling for age, sex and health condition (all $p>.05$). Pooling all participants, when congruent and incongruent trials were compared with T-tests, there was a significant bias for stereotype congruent stimuli in terms of number correct, $t(70) = 6.31$, $p <.001$. More congruent items ($M = 50$, $SD = 5$) were answered correct, compared to incongruent items ($M = 43$, $SD = 11$). This bias was also apparent for response time, $t(70) = -3.63$, $p <.001$. Congruent items were answered quicker ($M = 2.2$s, $SD = 1.2$) than incongruent items ($M = 2.9$s, $SD = 1.7$).

Table 5.9: Correlations of demographic factors, with handgrip, physiological, and psychological measures

Variable	M (SD)	1	2	3	4	5	6	7	8	9
1. Peak Force (kg)	182.2 (58.7)									
2. TTF (s)	75.44 (42.3)	-.03								
3. Anxiety (factor)	0.01 (1.0)	-.14	-.27 *							
4. Age	83.5 (7.8)	-.22	.10	-.27 *						
5. Change in Pulse	-1.15 (17.3)	.08	.08	.20	-.32 *					
6. Change in Systolic	-7.11 (7.6)	-.02	-.06	.01	-.13	.21				
7. Change in Diastolic	-0.11 (6.7)	.14	.10	.05	-.09	.48 ***	.48 ***			
8. Change in Mean Arterial Pressure	-2.44 (7.2)	.04	-.03	.02	-.13	.33 **	.95 ***	.73 ***		
9. IAT number correct	7.29 (1.2)	-.07	-.08	.01	.17	-.03	-.05	-.03	-.05	
10. IAT time (s) for correct responses	-.67 (1.63)	.10	-.19	.13	.00	.10	.14	.10	.15	.04

*Note: Change in cardiovascular measure (pulse, systolic, diastolic, MAP) calculated as values at the start minus values at the end. Difference in IAT scores calculated as congruent values minus incongruent values. * indicates significance at p< .05, ** indicates significance at p< .01, *** indicates significance at p < .001.*

Discussion

This study explored how ABST can threaten physical performance. It has gone beyond previous research by exploring handgrip using a digital hand dynamometer, using EMG to capture neuromuscular effects, and included an exploratory condition, Threat After MVC (TAM), to test whether prior performance protects against ABST. Although hypotheses were not wholly supported, understanding of how ABST can threaten physical performance is substantially extended by this research.

In line with expectations, participants perceived more threat and were more anxious when stereotype threat was evoked. However, contrary to expectations, there was no direct effect of ABST on either sustained contraction (time to task failure) or strength (peak force), when comparing the TBM and control conditions. Although no direct effect of ABST on physical performance measures was found, the mediation revealed indirect effect of ABST via anxiety on peak force. This effect was close to statistical significance for time to task failure. Significant decrements in peak force and marginally significant decrements in contraction time were evidenced. Notably, this mediation was only significant for people who had ABST evoked before they performed the handgrip strength task. This suggests that prior task performance (as in the TAM condition) may protect subsequent physical efforts from the damaging effects of anxiety evoked through ABST.

This partially supports previous findings that ABST causes underperformance of physical tasks (Swift et al., 2012). It also provides causal pathways for understanding previous mixed results which did not have direct effects of ABST on performance (Horton, Baker, Pearce, & Deakin, 2010; Marquet et al., 2018). Anxiety might fully mediate the effect of ABST on these measures where the researchers previously found no effect, or provide a framework for studying the effect of ABST on other physical tasks such as balance (see Chapter 6).

Additionally, the Integrated Process Model (Schmader et al., 2008) is supported, by demonstrating how anxiety from ABST can impair physical performance. Compared to the control condition, the threatened group experienced greater levels of anxiety. In turn, more anxious individuals demonstrated lower peak forces and shorter contraction times. These findings are also consistent with well-established research demonstrating the effects of anxiety on physical performance (Masters, 1992). Anxiety did not mediate the effect of ABST on handgrip performance when the threat was presented after an initial handgrip trial. This could mean that previous successful experiences of the task provide resilience against the negative effects of psychosocial factors on performance (Bandura, 1988; Beauchamp, Crawford, & Jackson, 2019; Feltz & Payment, 2005). Indeed, Barber et al (2020) demonstrated the importance of resource evaluations in the effect of ABST on physical performance. In this study, participants walked slower, showed increase gait speed variability, and more step errors when threat was invoked. Importantly, these threat effects were more pronounced when participants completed a more difficult, narrow-base gait task compared to walking normally. This means that ABST may reduce individuals' perception of available resources, and this is accompanied by anxiety, which has debilitating effect on performance. This may be through withdrawal of effort, or through reduction in available cognitive resources.

Electromyography

This study explored the effect of ABST on neuromuscular performance. Electromyography showed some evidence that when ABST was evoked (either TAM or TBM), participant's neuromuscular activity was reduced, suggesting lower muscle contraction. These threatened participants demonstrated lower percentage activation of the synergist muscle overall. This is indicative that additional neuromuscular resources are being recruited to meet the target force when individuals are not threatened through age-related stereotypes, and that individuals do not readily implement all available resources under ABST. This corroborates previous findings that effort is withdrawn when participants experience stereotype threat (Stone, 2002). The failure to maintain a target force during sustained contraction is commonly understood to originate from central factors such as motivation, or peripheral factors such as metabolite accumulation (Stokes, Edwards, & Cooper, 1989). Compared to threatened participants (either TAM or TBM) control participants showed greater percentage activation of the synergist, implicating central factors in the reductions in physical performance evidenced in stereotype threat (Gandevia & Gandevia, 2001).

Also, a cross-level interaction revealed that compared to TAM participants, non-threatened participants also showed decreasing agonist mean frequency over time. According to the onion skin principle of motor unit recruitment, which posits that earlier recruited motor units have faster firing rates than later ones, this could be indicative that a more fatigued neuromuscular state had been reached (Contessa & De Luca, 2013). This suggests that strategies for coping with increases in effort are not readily deployed when stereotype threat is presented. However, simpler models were more parsimonious in predicting agonist frequency, and this effect was not present for TBM participants. The lack of effect for TBM participants for this muscle may be because of factors specific to the effect of fatigue under threat given prior task performance, or because for TBM participants the sustained contraction target force was normalised to peak force also performed under threat. This means that a lower initial level of neuromuscular firing would be necessary to match the target force which would generate lower levels of fatigue. Additionally, neuromuscular effects were only identified for the synergist muscle. This could be because of effects of task duration, as the increased synergist activation may have preceded the noticeable fatiguing of the agonist muscle. Ultimately, this speculation highlights the need for further work to elaborate the effect of ABST on neuromuscular performance.

Implicit age attitudes

Previous research showed that stereotype threat could lead to more biased responses on IAT (Frantz et al., 2004). However, implicit age attitudes did not differ by condition. However, the researcher anecdotally noted that all participants were threatened by the requirement to use the computer, regardless of experimental condition. This nullified between group differences. IAT scores were not correlated with anxiety. This is because anxiety was measured immediately following the handgrip task (TTF), in order to capture affective response relating to the physical task under stereotype threat. Therefore, this measure would not have captured anxiety related to the computer task.

Cardiovascular response

Elevated cardiovascular responses (blood pressure, pulse) is a generally accepted correlate of anxiety, and has been previously demonstrated when stereotype threat is evoked (Levy et al., 2008). These findings were not replicated. A key limitation in measuring cardiovascular stress response was that blood pressure were taken on discrete occasions (before the initial MVC and after the sustained contraction). Continual measurement of cardiovascular measures might have enabled more accurate investigation. Other potential explanations for this finding are that handgrip imposes low cardiovascular demand, or that some participants may have been prescribed medication to moderate blood pressure, or that due to the subtle threat then the stress response was statistically undetectable.

Strengths/ limitations

This research extends understanding how ABST can threaten physical underperformance. By limiting sources of bias, robust investigation of the kinetic effects of stereotype threat and assessment of the psychological processes involved in handgrip strength and sustained contraction tasks was enabled. The effect of ABST on physical performance was demonstrated by objectively separating out measurements of strength and sustained contraction time using digital dynamometry, and by using a subtle written manipulation. Given the low effect sizes, it is reasonable to infer that this study was underpowered. Future work should ensure robust sample sizes to detect subtle effects of ABST.

While EMG provided insight to neuromuscular processes, between-subjects analysis typically explained low to moderate variance. To manage individual-level margins of error, every effort was made to ensure reliability of skin preparation and electrode placement according to recognised standards of electromyography. However, the heterogeneity of the physiology and anthropomorphology of this population should not be understated. The ageing process is dependent on many individual factors, and these factors provide a challenge to ensuring accuracy. For example, fatty striates within the muscle and excess skin effectively impede electrical signal (Boccia, Dardanello, Rosso, Pizzigalli, & Rainoldi, 2015), and the range of arthritic issues also complicated electrode placement. While it may be possible to reliably control this in future studies (for example using dual-energy X-ray absorptiometry to measure lean muscle mass), it was not feasible for this study where data collection was carried out on-site in multiple day centres.

Conclusion

The study provides evidence for the mechanistic role of anxiety in the effect of stereotype threat on physical performance. Mediation analysis demonstrated the role of anxiety in reducing peak force and contraction time when stereotype threat is evoked. Markedly, this study is the first experiment the authors are aware of to investigate stereotype threat using EMG, and so enabling and validating a more sensitive measure and analysis of neuropsychological mechanisms of neuromuscular performance under stereotype threat for future research. Electromyography provided limited support for hypotheses that people are more likely to withdraw effort when stereotype threat is evoked, compared to when they perform the task absent of threat. This provides an intriguing prospect for future research.

These findings have important implications for research, clinical decision making, and rehabilitation settings, where premature task failure could result in unreliable conclusions, inaccurate prognosis, or inefficient training progress. Fundamentally, the research highlights the subtle way in which ABST can affect handgrip via anxiety pathways, which may affect validity of grip strength as a research or clinical decision-making metric if not properly controlled. Therefore, further research to disentangle the way in which ABST affects physical performance in research, clinical, and rehabilitation applications is warranted.

Chapter 6 - How does age-based stereotype threat affect older adults' balance performance?

Abstract

Mobility depends on psychological inputs to physiological systems. When these inputs fail then balance may not be regained and a fall is likely. For some older adults, these falls can lead to hospitalisation and can be fatal. Increased cognitive load, such as increased anxiety, can decrease available resources to maintain balance. Study 1 revealed ABST can increase anxiety and this can decrease performance, but the study is restricted to handgrip. This study address this by exploring whether ABST would affect participants' performance on a balance task. It also explores additional aspects of the IPM by including a cognitive load. ABST was expected to negatively impact on balance by increasing postural sway. We expect this effect to be greater with increased cognitive demands.

Participants (n = 47) were recruited from local community groups and randomly assigned either ABST or control group in the single-blind procedure. They performed balance in single-leg and tandem stance position for one minute each. Then, the same positions were held again for 1 minute each while simultaneously counting backwards by 3.

Unlike Study 1, the ABST manipulation instructions failed to increase threat and anxiety. During single-leg and tandem stance positions, postural sway was greater when cognitive and physical tasks were performed together (e.g. reduced time to contact). A condition by task interaction was identified for length of travel ($b = -0.46$, $t(44) = 2.70$, $p = 0.02$), revealing that under threat, participants swayed significantly more during dual task compared to single task whereas controls did not. Additionally, the role of anxiety in effective balance control was highlighted by the reduction in complexity during single leg/ tandem stance when participants were more anxious. Demographic factors including presence of a health condition was controlled. This study makes a valuable contribution in to ABST theory, by extending understanding of the effects of ABST. Factors which may increase protection from ABST underperformance are discussed.

Introduction

Mobility difficulties can lead to falls (Landi et al., 2017) and this risk increases as people age (Peel, 2011). Falls are the most common type of accident to result in emergency hospital admission in people over 65, and can be fatal (Age UK, 2012). Falls therefore bear costs at individual and economic levels. It is crucial to understand the factors which predispose fall risk.

Physiological and psychological systems together control mobility and posture. In terms of physiology, sufficient physical strength to support bodyweight is essential for a person to stand. Therefore, the occurrence of a fall in later life can be predicted from physical measurements such as sit-to-stand and handgrip strength tests prior (Landi et al., 2012; Nowak & Hubbard, 2009). Increased age is associated with reduction in strength (Dodds et al., 2014). Notably, strength declines quicker than the reduction in muscle mass (Frontera et al., 2000). Loss of mass is around 1.3% per year after 60 years, whereas loss of strength is 1.7-2.5% per year. While physical performance and falls risk is associated with age, this relationship may be intensified from sources other than from physiology alone, which could potentially be more modifiable. Therefore, it is necessary to investigate if psychosocial factors could contribute to this trajectory of physical performance decline.

In terms of psychological factors, there is evidence that challenges to cognitive processes can affect balance (Varalta, Fonte, & Munari, 2018). For instance, changes in posture are apparent when attention is divided between tasks. This is commonly demonstrated using a dual-task paradigm. Using this method, a consciously controlled task (e.g. serial subtractions) is performed concurrent with an automatically controlled task (e.g. walking or standing). During walking, such effects as reduced gait speed (Smith, Cusack, & Blake, 2016), decreased stride variability (Wayne et al., 2015), decreased step width (Nordin, Moe-Nilssen, Ramnemark, & Lundin-Olsson, 2010), increased double support time (Taylor, Delbaere, Mikolaizak, Lord, & Close, 2013), and increased percentage of lower limb co-activation (Hallal et al., 2013; Hortobágyi, Finch, Solnik, Rider, & De Vita, 2011; Lo et al., 2017) are evidenced. During quiet standing under dual-task conditions, sway velocity and centre of pressure (COP) length of travel increases (Doumas et al. 2009; Kilby et al. 2014; Manor & Lipsitz 2013). While muscles throughout the body are crucial for postural control, it is asserted that these changes occur due to a conscious attempt to mitigate bodily sway, and from over compensation of sway, by co-contracting muscles around the ankle. Notably, during quiet standing while performing a modified version of the Stroop task, EMG showed that older participants (mean age = 77 years) increased co-contraction (tibilias anterior & soleus muscles, in the lower leg) more than younger (M = 27 years) participants (Melzer, Benjuya, & Kaplanski, 2001). This increased co-contraction was associated with reduced stability as indicated by greater elliptical area and increased medial-lateral sway. While both age groups increased sway during dual task, this effect was more pronounced in the older group. Importantly, co-contraction decreases the number of ways a neuromuscular system can adapt to external demands (Young & Williams, 2015), so has a counter-productive effect on stability and so increases risk of falls. For example, co-contraction of gastrocnemius and tibialis anterior was found to be predictive of falls (Nelson-Wong et al 2012), and ankle stiffness has been associated with increased fall risk (Ho & Bendrups 2002; Nelson-Wong et al. 2012). Therefore, identifying the factors that can increase co-contraction and instability may offer a way to attenuate older adults' fall risk. These measures are considered indicative of reduced postural control and increased fall risk (Kilby et al., 2014; Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996).

Indication of falls risk might manifest in other balance task measures too. As postural control is dependent on multiple sensory, physiological, and neuromuscular inputs, it is inherently complex. The ageing process has a degrading effect on these inputs, and this can be seen in the structural fluctuations of cardiac signal (Mccraty & Shaffer, 2015) and isometric force production (Vaillancourt & Newell, 2003). These structural fluctuations reflect the biological systems' complexity. Similar degradations are apparent in postural control complexity (Duarte & Sternad, 2008). Signal complexity is regarded to reflect the capacity for a biological system to adapt (Goldberger et al., 2002; Peng, Costa, & Goldberger, 2009). For example, frail older adults' anterior-posterior COP (centre of pressure) complexity was significantly reduced compared to non-frail counterparts (Kang et al., 2009). Additionally, these differences in anterior-posterior COP complexity were more apparent when a serial subtraction task was concurrently performed. Therefore, age related reductions in complexity may be indicative of reduced postural control (Wayne et al., 2014).

Indeed, lower postural sway complexity predicts future falls (Zhou, Habtemariam, Iloputaife, Lipsitz, & Manor, 2017). Ultimately, complexity, and the adaptability of postural systems, is reduced when people were older, frailer, and occupied with additional cognitive demands, and this reduction is associated with increased fall risk.

Psychosocial factors might also impose this sort of cognitive burden. One such potential source appears to be from stereotype threat (Schmader & Johns, 2003; Schmader, Johns, & Forbes, 2008, also see Chapter 4). This decrement in cognitive performance under ABST mirrors the decline in function with age, and there is some evidence that this might extend to physical task performance too. For instance, when ABST was evoked then older adults' hand grip strength was nearly half that of control participants (Swift et al., 2012), Study 1 partially support this finding revealing that ABST indirectly impacted on handgrip via heightened anxiety. However, as noted in Chapter 4, empirical support for ABST on physical performance is not univocal (Horton, Baker, Pearce, & Deakin, 2010; Marquet, Boutaayamou, et al., 2018). Moreover, research is limited to a narrow set of physical performance measures (e.g. handgrip, sit-to-stand). Therefore, our knowledge of how ABST affects physical tasks, and specifically balance, is currently limited. This constricts understanding of ABST, and inhibits the ability to inform effective falls prevention and rehabilitation strategies.

The IPM proposes that stereotype threat imposes a load on cognitive processes through feelings of anxiety (Schmader & Johns, 2003; Schmader, Johns, & Forbes, 2008). Anxiety is recognised to invoke a cycle of cognitive effects such as negative thoughts and thought suppression, which can counter productively provoke more anxiety. Ultimately, this absorbs limited cognitive resources (Derakshan & Eysenck, 2009; Eysenck et al., 2007; Johns et al., 2008; Logel et al., 2009). This describes how ABST can affect cognitive processes. Chapter 5 showed that ABST increased anxiety and that this lead to under-performance in a handgrip task. However, there is currently no empirical evidence examining how ABST-induced cognitive challenges might derail postural control.

It is asserted that physical performance may be perturbed by an individuals' affective response to stereotype threat (Schmader et al., 2008). The pathways between anxiety and physical performance is well-supported (Masters & Maxwell, 2008; Masters, 1992). For example when fear of falling is greater, co-contraction between muscle pairs is also greater. Increases in soleus and tibialis anterior co-contraction results in increased sway velocity (Benjuya, Melzer, & Kaplanski, 2004), which is indicative of increased fall risk (Piirtola & Era, 2006). Further, increased cognitive anxiety from ABST may increase cognitive load and enact similar effects on balance as performing a concurrent task (Chalabaev, Palluel, & Ruchaud, 2020). When performing a walking task and a concurrent Stroop task then cognitive performance was worse when ABST was evoked. This highlights, among other things, that ABST can increase cognitive load and therefore has potential to disrupt postural control. However, this study did not look at the effect of ABST on a range of the biomechanical aspects of balance that might increase falls risk. It is important to understand how ABST might lead older adults to be more susceptible to falls, and this can be addressed by exploring the impact on static balance.

The aim of this research therefore is to address the gap in understanding how ABST acts on older adults' balance. Gaining a greater understanding of attentional and neuromuscular mechanisms involved in balance has clinical and social application in informing diagnostic and rehabilitative procedures for older adults, such as falls prevention and frailty assessment. With a mixed design with 2 between subjects factors (threat, no threat) and 2 within subject factors (single/ dual task) this study aims to explore the relationship between threat and single leg stance or tandem stance task balance when a concurrent cognitive task is performed.

Hypotheses

It is hypothesised that:

1) Anxiety will be invoked by the ABST manipulation. In line with Study 1 (Chapter 5), anxiety is expected to mediate the relationship of ABST on balance performance,
2) Sway is expected to increase for all participants in dual task conditions,
3) The dual task effect will be exacerbated when ABST is elicited. Under threat, sway is expected to be lower during single task compared to control participants' sway. This is expected as balance will be more

tightly controlled, and this will be shown by increased mean EMG amplitude.

Method

The study employed a mixed design with 2 between-subjects factor (threat vs control condition) and 2 within-subjects factor (single and dual task). These tasks were performed in single leg stance and tandem stance on a force plate. To test between subjects effects, participants were assigned to threat or control condition to perform these balance tasks. To test the within-subjects effect of performing a concurrent cognitive task, these balance tasks were then repeated while counting backwards in 3s. EMG sensors were attached to participants' lower leg to measure neuromuscular activity across the physical tasks. Following the physical tasks, anxiety and potential confounding variables were measured via questionnaire. Research ethics were approved by the University of Kent Research Ethics Advisory Group (Prop 96_2017_18).

Participants

Based on a priori estimates for a main effect size of $d = 0.58$ (Swift et al., 2012), 47 socially active participants over age 55 years (N = 47, Age $M = 70$ years, $SD = 6.25$ years) were recruited from community-based older adults' groups. All participants were able to ambulate unassisted, free from cardiac, neurological, lower extremity or vestibular pathology, and without joint or muscle injury or illness that would inhibit safe performance. Comparing across conditions, T-tests found no significant differences for age ($p > .05$), or sway velocity (medial-lateral (ML) $p > .05$, anterior-posterior (AP) $p = .05$) or total sway range (ML $p > .05$, AP $p > .05$) at baseline.

Procedure

Three rounds of two trials each were completed in total. EMG sensors were attached to lower leg for all trials. Each trial required participants to stand with eyes open on a force plate (Kistler: London, UK) for one minute, first in tandem stance with one foot directly in front of the other. Then after 30 seconds rest, the second trial consisted of standing with their preferred leg on the force plate, whilst the other leg was flexed at approximately 90 degrees. After these baseline measurements, the next round was repeated after either the stereotype threat manipulation or the neutral statement had been read by participants, according to the condition they had been randomly allocated to. Bolstering the subtle threat instructions used in Chapter 5 to induce ABST, age was made salient by an age identity questionnaire consisting of age, subjective age and questions of age identification from the European Social Survey (Concept 1, European Social Survey (ESS), 2005), and negative age-stereotype was made salient by administration of the Falls Efficacy Scale-International questionnaire (Yardley et al., 2005) before the manipulation instructions. Control participants received neutral instructions only. For the third round, participants counted backwards from 500 in 3s whilst performing the balance trials and this number was not reset between balance trials. Following the final trial, all participants completed the age self-categorisation questionnaire from the ESS (2005). They also completed an anxiety questionnaire, which included a threat manipulation check. To account for individual differences in physical abilities, the International Physical Activity Questionnaire (IPAQ; Booth, 2000) was also completed. Finally, participants in the control condition completed the age identity questionnaire and falls efficacy scale.

Figure 6.1: Experimental protocol

Order	Item
1.Consent	Consent. Health Questionnaire.
2. EMG	EMG set up- Shave, swab, place electrodes bilaterally. EMG set to Biopolar input and 1000Hz gain. Tibialis Anterior, Gastrocnemius Lateralis, Peroneus longus. Maximal contractions: seated. toe up, into floor and everted
3. Single task baseline	Record base of support. All conditions: 1. Tandem ; 2. Single-leg Ensure to run both Bioware and BioLab (10sec lead in time on Biolab for EMG then start Bioware at the start of acquisition trial for force)
4.Study Info	ABST condition: Statement + age identity + fall efficacy questionnaire Control condition: Instructional statement only
5. Second Single Task	**Single task balance:** 1. Tandem; 2. Single-leg
6. Dual Task	**Dual task** – Standing & counting back in 3s from 500 (each trial starts from where the previous trial ended). 1. Tandem; 2. Single-leg
6. Post-Task Questions	**Control Group only**: Age Identity + falls efficacy questionnaire **All conditions**: 1) Threat manipulation check and Anxiety Questionnaire. 2) Physical Activity questionnaire 3) Self-categorisation
7. Debrief	Debrief

Measurements

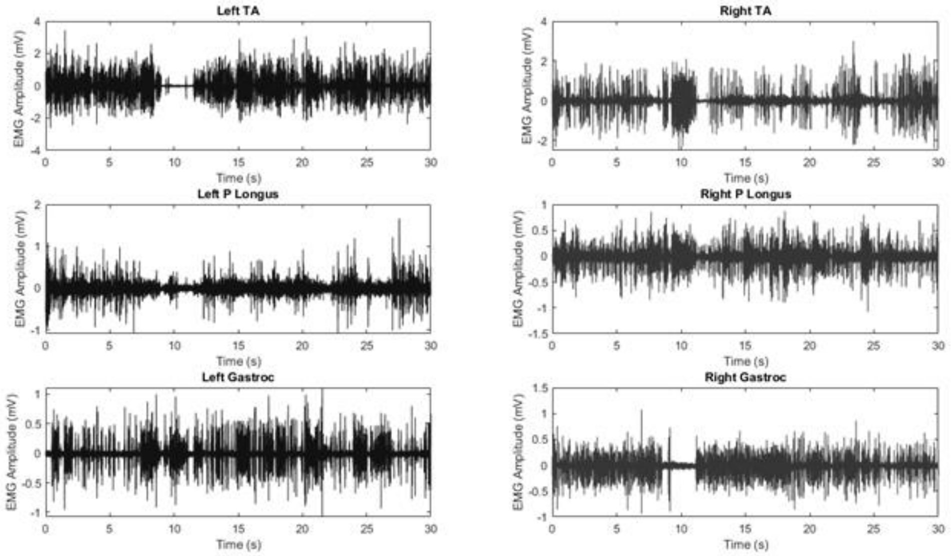
To record surface electromyographic (EMG) signal, 2cm bipolar silver chloride self-adhesive electrodes were affixed to tibialis anterior (TA), peroneus longus (PL) and gastrocnemius medialis (GM) according to SENIAM standards (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles; Stegeman & Hermens, 2007), following hair removal and alcohol cleansing of the electrode sites. EMG signal was passed through the pre-amplifier to the EMG amplifier (OT Bioelettronica, Turin: Italy) and recorded on OT BioLab software. Muscle co-contraction was calculated based on mean amplitude for the trial, for TA relative to PL (TA/PL), GM relative to PL (GM/ PL), and TA relative to GM (TA/GM).

The force plate signal was passed through a separate amplifier to Kistler Bioware software, so that anterior-posterior (AP), medial-lateral (AP), and vertical (Z) ground reaction force could be recorded. To synchronise the EMG and force plate data, participants made a dorsi-flexion to plantar flexion foot strike to indicate the start of each trial. Data processing

Force and EMG data were processed using custom written MATLAB (MathWorks, Natwick, MA: USA).

Electromyography - For each muscle, root mean square (RMS) amplitude and frequency (hertz, Hz) of EMG signal from the initial and final 10 second epochs for each trial were extracted for comparison within and between trials, and between groups. Co-activation was calculated as the proportion in EMG RMS amplitude of one muscle as a proportion of the second muscle (TA / PL; PL / GM; TA / GM). See Figure 6.2 for an example of electromyography output signal before processing. Greater signal amplitude reflects greater neuromuscular activity.

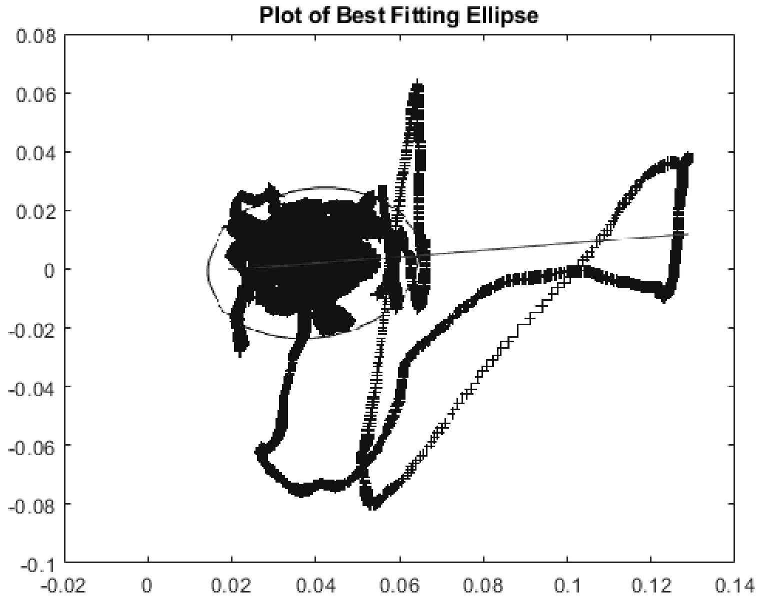
Figure 6.2: Example of initial 30 seconds EMG signal during tandem stance



Note: The full experimental trial lasted 60 seconds.

Kinetic measurements - From across each trial, average time that centre of pressure (COP) met the base of support boundary (time to contact, TTC, minutes), ellipse of 95% COP area (meters squared, m^2), total length of COP path (length of travel, meters), sway standard deviation (meters), and sway complexity (approximate entropy, ApEn) was calculated (Pethick, Winter, & Burnley, 2015). Figure 6.3 shows an example of COP profile for a trial, showing sway 95% ellipse for sway area. Reduced TTC indicated worse performance as it meant that participants were unable to maintain balance. Greater sway area, sway frequency or length of travel indicated greater sway. Reductions in ApEn or sway standard deviation may demonstrate reduced anatomical degrees of freedom, and so indicate reduced ability to adapt to changes in the environment (Toledo & Barela, 2014).

Figure 6.3: Example COP profile showing ellipse of 95% sway area



Statistical analysis

Multivariate outliers were detected using Mahalanobis Distances and excluded from subsequent analysis. Shapiro-Wilk's test was used to test assumptions of normal distribution. Cronbach's alpha was used to check scale reliability. Tests for demographic differences between control and stereotype threat groups were carried out with chi square test for categorical variables, and T-tests for continuous variables unless assumptions were not met, in which case Mann-Whitney U test were used. For mixed effects models, residuals and random effects were plotted to test assumptions (linearity, random distribution of residuals, homoscedasticity, normally distributed errors and random effects). T-tests were used to check whether the ABST manipulation had evoked threat, and to see if anxiety had been evoked.

To assess between subjects differences at baseline (threat and control conditions), differences in pre-instruction trials across conditions was compared. Then, to test the interaction of condition (threat vs control) and task (single/ dual task) on balance performance (observations that happened after the threat or control instructions) multivariate analyses were used. For clarity of interpretation and to maximise statistical power, single leg and tandem stance observations were analysed separately. Where dependent variables were correlated and logically related, MANCOVA was conducted to minimise the risk of Type 2 error. This tested the effect of condition and task on dependent variables together (1 - AP and ML sway frequency; 2 - AP and ML sway variability; 3 - EMG co-activation; AP and ML Complexity), controlling for demographic variables (age, sex, presence of a health condition, physical activity levels). For significant variables in MANCOVA as indicated by Pillai's Trace, post-hoc linear mixed models were conducted with participant at random intercept.

Where dependent variables were not correlated and had discrete experimental hypotheses (TTC, length of travel and sway area), linear mixed models with participant at random intercept were sequentially modelled. The full model predictors consisted of interactions between condition and task, plus demographic covariates. Exploratory analysis with mixed models additionally examined the contribution of other factors (falls efficacy, anxiety, age identification, and self-categorisation) on balance measures. Models were compared for fit with AIC to identify the most parsimonious model.

Anxiety items were strongly correlated. Consistent with methodology of Chapter 5, factor analysis was run with promax rotation to aid interpretation. Factor loadings were saved (alpha reliability= 0.92). The unidimensional solution explained 67% variance and factor loadings > .68. All analyses involving anxiety used these scores. With the same approach, IPAQ items were also reduced to a single factor (alpha reliability = 0.73; 82% explained variance; factor loadings >.63). All tests were conducted with R (R Core Team: Vienna, 2019).

Results

In total, 47 participants were included in analyses. There were 24 participants (51%) in the Threat condition (control N = 23, 49%). Overall, the average age was 70.1 years, and there were 29 (73%) females (males N = 17, 27%). Outlier checks identified 6 observations from 6 different participants, which were excluded from subsequent analysis. These were because of extreme values from force plate (from 4 participants) or from EMG (from 2 participants) measurements. This did not affect the overall number of participants included in analyses.

Preliminary analysis

Testing the between subjects effects, there was no significant difference between the conditions (threat vs control) for any demographic or performance measures ($p > .05$) as described in Table 6.1 and Table 6.2 respectively.

Correlations between demographic and psychological measures are shown in Table 6.3. These showed positive associations of age and subjective age ($r(45) = .43$, $p = .003$), subjective age and age identity ($r(45) = .34$, $p = .02$), and a marginally significant positive correlation of anxiety and threat ($r(45) = .39$, $p = .008$).

Condition

T-tests were conducted to explore the effect of threat vs control on perceived threat and anxiety. Contrary to hypothesis 1, that ABST should increase perceptions of threat and anxiety, the analyses revealed no differences in participants' perceived threat ($t(46) = 0.31$, $p = 0.8$; Control $M = 2.97$, $SD = 1.37$; Threat $M = 3.12$, $SD = 1.8$), or anxiety ($t(46) = 1.15$, $p = 0.3$; Threat $M = 0.06$, SD = 0.9; Control $M = -0.08$, $SD = 1.1$).

Contrary to hypothesis 3, there was no main effect of condition (threat vs control) for any performance measures during either single or dual task, as presented in Table 5.4 (single leg stance) and Table 6.5 (tandem stance). These tables show the performance measures for single and dual task by condition.

Table 6.1: Participants demographics

Measure	*Control*, ***N = 23***	*Threat*, ***N = 24***
Actual Age	72 (7)	69 (5)
Physical Activity (IPAQ, factor)	0.14 (1.07)	-0.12 (0.90)
Sex (female)	N = 14	N=15

Note: Mean (SD)

Table 6.2: Baseline performance measures

Measure	Single Leg		Tandem Stance	
	Control, N = 23	**Threat, N = 24**	**Control, N = 23**	**Threat, N = 24**
Area (m2)	0.0018 (0.0022)	0.0020 (0.0016)	0.0010 (0.0008)	0.0013 (0.0015)
AP sway frequency (Hz)	2.48 (0.76)	2.50 (0.47)	2.87 (0.73)	2.75 (0.47)
ML sway frequency (Hz)	2.57 (0.80)	2.72 (0.39)	2.30 (0.76)	2.65 (0.45)
TTC (minute)	0.29 (0.04)	0.29 (0.05)	0.42 (0.15)	0.47 (0.17)
AP variability (SD)	0.011 (0.007)	0.013 (0.007)	0.0084 (0.0026)	0.0088 (0.0030)
ML variability (SD)	0.011 (0.005)	0.012 (0.004)	0.009 (0.005)	0.011 (0.008)
Length of Travel (m)	3.45 (1.41)	3.55 (1.13)	2.61 (1.02)	2.46 (0.83)
AP Complexity (ApEn)	0.032 (0.007)	0.030 (0.011)	0.033 (0.010)	0.029 (0.012)
ML Complexity (ApEn)	0.034 (0.010)	0.029 (0.010)	0.031 (0.006)	0.027 (0.005)
Co-contraction (GM-PL)	2.10 (1.56)	1.83 (1.14)	2.39 (2.52)	1.97 (1.59)
Co-contraction (TA-PL)	1.05 (0.67)	0.90 (0.56)	1.20 (1.12)	0.78 (0.46)
Co-contraction (TA-GM)	1.56 (0.65)	2.09 (0.98)	1.40 (0.70)	1.52 (0.57)

Note: Mean (SD). There was no significant difference between control and threat conditions for any measures.

Table 6.3: Correlation of demographic and psychological variables

	M (SD)	1	2	3	4	5	6	7
1. Age	70 (6)							
2. Subjective Age	58 (10)	.43 **						
3. Physical Activity (IPAQ)	-0.01 (1.02)	.03	-.28					
4. Anxiety (factor)	-0.01 (1.00)	-.06	.06	.16				
5. Threat	3.05 (1.61)	-.1	.07	.03	.39 **			
6. Falls Efficacy	1.25 (0.27)	.04	.001	-.15	-.21	-.29		
7. Age Identity	5.2 (2.3)	.1	.34 *	-.04	-.14	.11	.14	
8. Self-Categorisation	6.8 (0.8)	-.08	.08	-.06	.03	-.04	-.08	-.23

Task

Mixed models were conducted to explore the main effect of task (single vs dual), on single and tandem stance balance. These models showed that there were significant effects for task as shown in Table 6.8, supporting hypothesis 2.

In tandem stance, sway was greater in dual task compared to single task as shown by increased length of travel (b = 0.56, t(46) = 5.42, p <.001), reduced time to contact (b = -0.04, t(44) = 4.60, p < .001), and increased AP (b = 0.006, t(46) = 2.62, p= .01) and ML (b = 0.004, t(46) = 2.24, p <.001) complexity, as shown in Figure 5.5. Dual task compared to single task also resulted in reduced ML sway frequency (b = -0.09, t(44) = 2.17, p = .03).

For single leg stance, these regressions showed that dual task compared to single task resulted in quicker time to contact (*b* = -0.20, *t*(45) =2.38, *p* = .02), and increased length of travel (*b* = 0.42, *t*(43) = 3.55 , *p* < .001), indicating greater postural sway and worse performance. Notably, people with greater levels of physical activity performed better. They had longer time to contact (*b* = 0.02, *t*(45) = 3.00, *p* = .03) and decreased length of travel (*b* = -0.38, *t*(43) = 2.45, *p* = .01). When falls efficacy was higher then people performed better showed shorter length of travel ($b = -1.23$, $t(41) = 2.15$, $p = .03$) and time to contact was longer ($b = 0.06$, $t(42) = 2.40$, $p = .02$). Stronger age identification was associated with increased ML sway variability ($b = 0.003$, $t(44) = 2.45$, $p = .01$). Table 6.9 shows regression output for all predictors for significant single leg stance models.

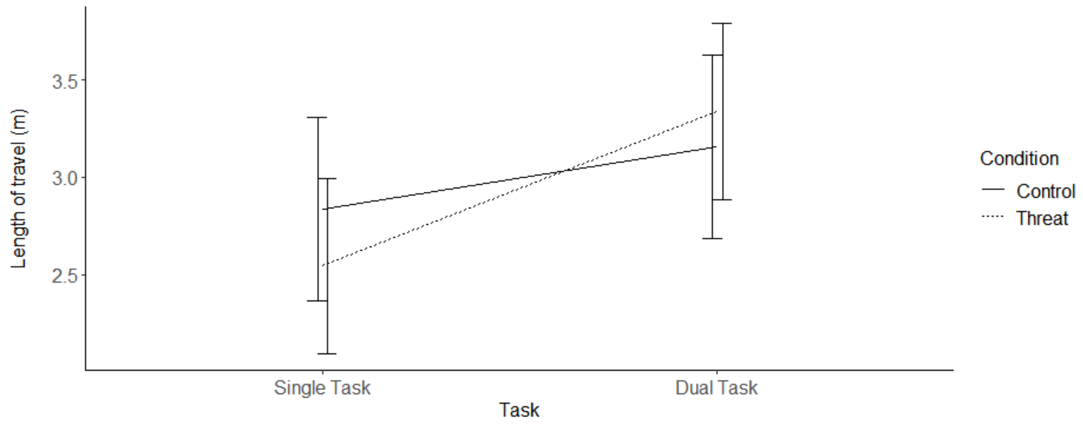
In summary, dual task resulted in less stability, shown by increased sway and decreased time to contact, as shown in Table 6.4. These findings suggest that participants found the dual task more challenging.

Task by condition interaction

Hypothesis 3, was that ABST would exacerbate dual task effects. For tandem stance, a significant task by condition interaction was identified, supporting this hypothesis. This interaction showed that compared to single task, dual task increased length of travel more for participants in the threat condition compared to controls (b = -0.46, t(44) =2.70, p = .02), as shown in Figure 6.4*: Interaction between condition and task for COP length of travel*

Post-hoc, Tukey HSD showed that threat participants swayed significantly more during dual task (M = 3.34m, SD = 1.6) compared to single task (M = 2.55m, SD = 1.6), whereas controls did not (single task M = 2.84m, SD = 1.7; dual task M = 3.16, SD = 1.7). There were no equivalent findings for single leg stance. Also, models with predictors failed to predict EMG co-activation significantly better than models with intercept only (p> .05).

Figure 6.4: Interaction between condition and task for COP length of travel



Compared to controls, Threat group participants swayed more during dual task vs single task

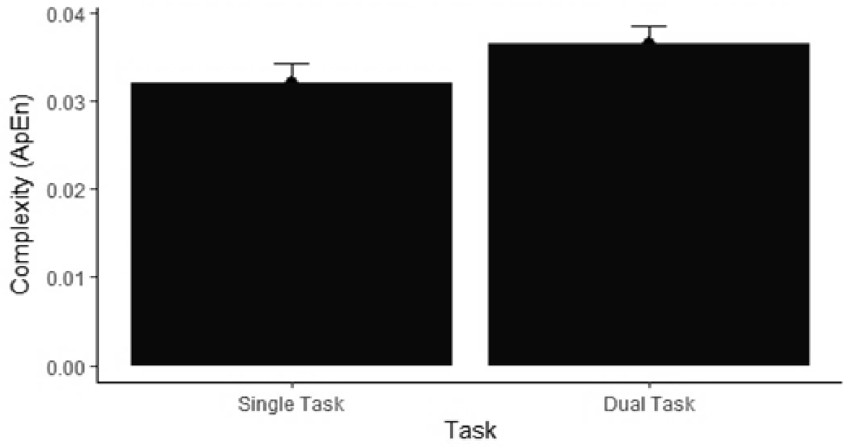
Anxiety decreases stability in dual task compared to single task

Despite the absence effect of ABST on anxiety, the effect of anxiety on performance was of interest and was investigated. Exploring the interaction of anxiety with task during single leg stance showed that dual task compared to single task resulted in poorer performance as sway area was greater (b = 0.001, $t(44)$ = 2.94, p = 0.003). Also, as shown in Figure 6.6, when anxiety was higher then dual task caused increase in variability in AP (b = 0.006, $t(44)$ = 2.66, p = .001) and ML directions (b = 0.006, $t(44)$ = 2.07, p = .004), as well as reduction in AP sway complexity (b = -0.005, $t(44)$ = 3.34, p = .001) and reduction in ML sway complexity (b = - 0.004, $t(44)$ = 2.84, p = .004). This shows that when anxious during dual task, participants swayed across a greater area and in a less complex fashion which is indicative of decreased stability. These effects were not apparent during tandem stance.

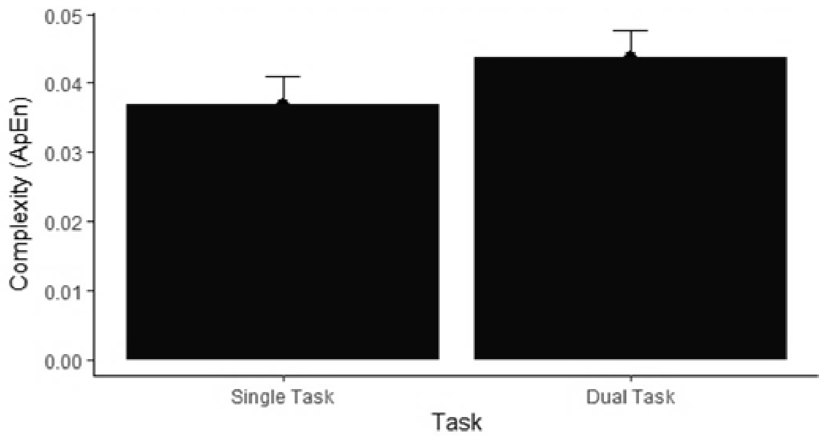
Regression output for all variables in significant final tandem stance models are shown in Table 6.9 and Table 6.10.

Figure 6.5: Centre of pressure complexity (ApEn) by task

A - Medial Lateral COP complexity



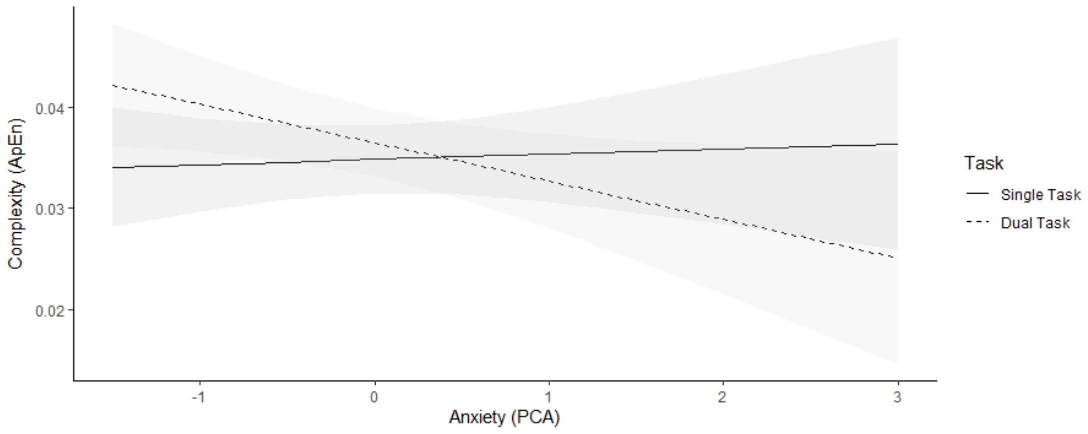
B - Anterior Posterior COP complexity



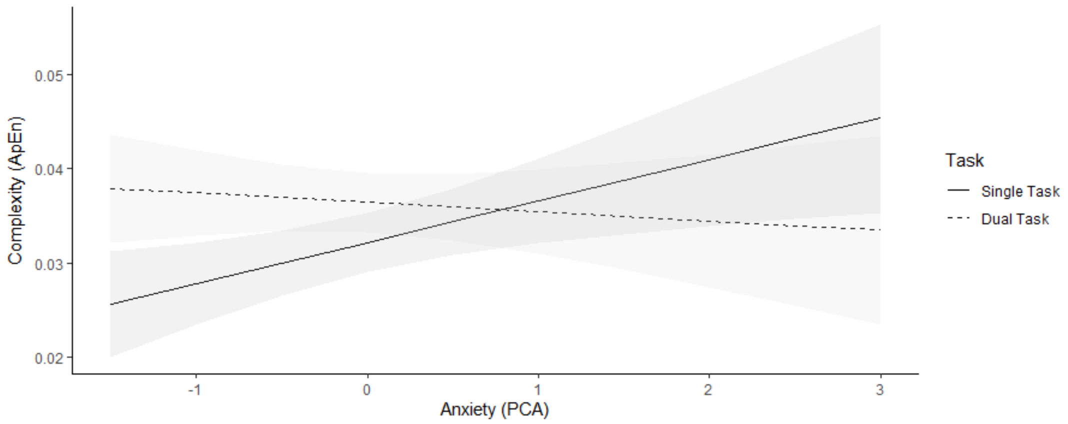
When performing tandem balance, COP complexity was greater under dual task conditions

Figure 6.6: Anxiety affects COP complexity (ApEn)

A- Medial Lateral COP complexity



B - Anterior Posterior COP complexity



During single leg balance, COP complexity was lower under dual task conditions only when anxiety was higher.

Table 6.4: Single leg stance performance by task then condition

Measure	Single Task		Dual Task	
	Control	**Threat**	**Control**	**Threat**
Area (m^2)	0.0013 (0.0010)	0.0016 (0.0014)	0.0017 (0.0014)	0.0017 (0.0015)
AP sway frequency (Hz)	2.55 (0.68)	2.62 (0.52)	2.61 (0.45)	2.61 (0.48)
ML sway frequency (Hz)	2.58 (0.68)	2.77 (0.25)	2.61 (0.45)	2.68 (0.31)
TTC (minute)	0.29 (0.05)	0.29 (0.07)	0.27 (0.05)	0.26 (0.05)
AP variability (SD)	0.010 (0.004)	0.011 (0.006)	0.012 (0.007)	0.011 (0.006)
ML variability (SD)	0.010 (0.004)	0.011 (0.005)	0.011 (0.004)	0.012 (0.005)
Length of Travel (m)	3.30 (1.18)	3.49 (0.90)	3.86 (1.06)	4.02 (1.39)
AP Complexity (ApEn)	0.032 (0.009)	0.032 (0.011)	0.036 (0.012)	0.037 (0.012)
ML Complexity (ApEn)	0.037 (0.010)	0.033 (0.011)	0.036 (0.015)	0.036 (0.010)
Co-contraction (GM-PL)	2.34 (1.29)	2.30 (1.12)	2.46 (1.83)	2.42 (1.75)
Co-contraction (TA-PL)	2.14 (1.88)	1.61 (1.10)	2.52 (2.54)	1.45 (0.71)
Co-contraction (TA-GM)	0.99 (0.60)	0.82 (0.62)	1.08 (0.77)	0.77 (0.47)

Note: Mean (SD). No main effects of condition (threat vs control) for single leg stance

Table 6.5: Tandem stance balance by task then condition

Measure	Single Task		Dual Task	
	Control	**Threat**	**Control**	**Threat**
Area (m^2)	0.0010 (0.0008)	0.0008 (0.0006)	0.0010 (0.0006)	0.0010 (0.0009)
AP sway frequency (Hz)	2.85 (0.74)	2.94 (0.34)	2.85 (0.73)	2.96 (0.32)
ML sway frequency (Hz)	2.30 (0.72)	2.66 (0.41)	2.25 (0.74)	2.53 (0.38)
TTC (minute)	0.40 (0.16)	0.45 (0.17)	0.38 (0.15)	0.39 (0.13)
AP variability (SD)	0.0087 (0.0028)	0.0078 (0.0017)	0.0087 (0.0024)	0.0087 (0.0024)
ML variability (SD)	0.008 (0.005)	0.008 (0.004)	0.009 (0.004)	0.008 (0.005)
Length of Travel (m)	2.84 (1.25)	2.55 (0.98)	3.16 (1.12)	3.34 (1.05)
AP Complexity (ApEn)	0.039 (0.014)	0.035 (0.012)	0.042 (0.016)	0.045 (0.014)
ML Complexity (ApEn)	0.032 (0.009)	0.032 (0.007)	0.037 (0.008)	0.036 (0.007)
Co-contraction (GM-PL)	2.64 (1.48)	2.65 (1.72)	2.49 (1.45)	2.53 (1.95)
Co-contraction (TA-PL)	2.55 (2.85)	1.75 (1.23)	2.48 (2.24)	1.75 (1.36)
Co-contraction (TA-GM)	1.15 (0.97)	0.81 (0.48)	1.25 (1.12)	0.83 (0.50)

Note: Mean (SD). No main effects of condition (threat vs control) for tandem stance.

Table 6.6: Single leg stance balance by condition then task

Measure	Control		Threat	
	Single Task	Dual Task	Single Task	Dual Task
Area (m^2)	0.0013 (0.0010)	0.0017 (0.0014)	0.0016 (0.0014)	0.0017 (0.0015)
AP sway frequency (Hz)	2.55 (0.68)	2.61 (0.45)	2.62 (0.52)	2.61 (0.48)
ML sway frequency (Hz)	2.58 (0.68)	2.61 (0.45)	2.77 (0.25)	2.68 (0.31)
TTC (minute)	0.29 (0.05)	0.27 (0.05)	0.29 (0.07)	0.26 (0.05)
AP variability (SD)	0.010 (0.004)	0.012 (0.007)	0.011 (0.006)	0.011 (0.006)
ML variability (SD)	0.010 (0.004)	0.011 (0.004)	0.011 (0.005)	0.012 (0.005)
Length of Travel (m)	3.30 (1.18)	3.86 (1.06)	3.49 (0.90)	4.02 (1.39)
AP Complexity (ApEn)	0.032 (0.009)	0.036 (0.012)	0.032 (0.011)	0.037 (0.012)
ML Complexity (ApEn)	0.037 (0.010)	0.036 (0.015)	0.033 (0.011)	0.036 (0.010)
Co-contraction (GM-PL)	2.34 (1.29)	2.46 (1.83)	2.30 (1.12)	2.42 (1.75)
Co-contraction (TA-PL)	2.14 (1.88)	2.52 (2.54)	1.61 (1.10)	1.45 (0.71)
Co-contraction (TA-GM)	0.99 (0.60)	1.08 (0.77)	0.82 (0.62)	0.77 (0.47)

Note: Mean (SD). No main effects of task (singe vs dual task) for single leg stance.

Table 6.7: Tandem stance balance performance by condition then task

Measure	Control		Threat	
	Single Task	Dual Task	Single Task	Dual Task
Area (m^2)	0.0010 (0.0008)	0.0010 (0.0006)	0.0008 (0.0006)	0.0010 (0.0009)
AP sway frequency (Hz)	2.85 (0.74)	2.85 (0.73)	2.94 (0.34)	2.96 (0.32)
ML sway frequency (Hz)	2.30 (0.72)	2.25 (0.74)	2.66 (0.41)	2.53 (0.38)
TTC (minute)	0.40 (0.16)	0.38 (0.15)	0.45 (0.17)	0.39 (0.13)
AP variability (SD)	0.0087 (0.0028)	0.0087 (0.0024)	0.0078 (0.0017)	0.0087 (0.0024)
ML variability (SD)	0.008 (0.005)	0.009 (0.004)	0.008 (0.004)	0.008 (0.005)
Length of Travel (m)	2.84 (1.25)	3.16 (1.12)	2.55 (0.98)	3.34 (1.05) *
AP Complexity (ApEn)	0.039 (0.014)	0.042 (0.016)	0.035 (0.012)	0.045 (0.014) *
ML Complexity (ApEn)	0.032 (0.009)	0.037 (0.008)	0.032 (0.007)	0.036 (0.007) *
Co-contraction (GM-PL)	2.64 (1.48)	2.49 (1.45)	2.65 (1.72)	2.53 (1.95)
Co-contraction (TA-PL)	2.55 (2.85)	2.48 (2.24)	1.75 (1.23)	1.75 (1.36)
Co-contraction (TA-GM)	1.15 (0.97)	1.25 (1.12)	0.81 (0.48)	0.83 (0.50)

*Note: Mean (SD). * indicates p<.05 for differences between single and dual task under Threat condition. Differences between single and dual task for threat condition only. This is not qualified with task by condition interaction in regression models.*

Table 6.8: Single vs dual task balance performance

Measure	Single Leg		Tandem Stance	
	Single Task	**Dual Task**	**Single Task**	**Dual Task**
Area (m^2)	0.0015 (0.0012)	0.0017 (0.0014)	0.0009 (0.0007)	0.0010 (0.0007)
AP sway frequency (Hz)	2.59 (0.60)	2.61 (0.46)	2.90 (0.56)	2.90 (0.56)
ML sway frequency (Hz)	2.67 (0.52)	2.65 (0.38)	2.49 (0.60)	2.40 (0.60)
TTC (minute)	0.29 (0.06)	0.27 (0.05)	0.42 (0.17)	0.38 (0.14)
AP variability (SD)	0.011 (0.005)	0.012 (0.007)	0.0082 (0.0023)	0.0087 (0.0024)
ML variability (SD)	0.011 (0.004)	0.011 (0.004)	0.008 (0.004)	0.008 (0.004)
Length of Travel (m)	3.40 (1.04)	3.94 (1.24) *	2.68 (1.12)	3.25 (1.08) *
AP Complexity (ApEn)	0.032 (0.010)	0.036 (0.012)	0.037 (0.013)	0.044 (0.015) *
ML Complexity (ApEn)	0.035 (0.011)	0.036 (0.012)	0.032 (0.008)	0.037 (0.007) *
Co-contraction (GM-PL)	2.32 (1.19)	2.44 (1.77)	2.65 (1.59)	2.51 (1.70)
Co-contraction (TA-PL)	1.87 (1.55)	1.95 (1.87)	2.13 (2.18)	2.11 (1.86)
Co-contraction (TA-GM)	0.91 (0.61)	0.91 (0.64)	0.97 (0.77)	1.04 (0.88)

*Note: Task performance pooled across conditions. * indicates p <0.05*

Table 6.9: Single leg balance final model fixed effects

		Intercept	Dual Task	Anxiety	Age Ident.	Falls Efficacy	Physical Activity (IPAQ)	Dual Task * Anxiety
Length of travel (m)	b	5.01	0.42			-1.23	-0.38	
	se	0.73	0.12			0.57	0.16	
	t	6.83	3.55			-2.15	-2.45	
	p	p <.001	p <.001			.03	.01	
Area (m2)	b	0.002	0.0002	-0.0001				0.001
	se	0.0002	0.0002	0.0002				0.0002
	t	8.01	0.70	-0.54				2.94
	p	p <.001	.49	.59				.003
AP complexity (ApEn)	b	0.03	0.004	0.004				-0.005
	se	0.002	0.002	0.002				0.002
	t	20.2	2.66	2.74				-3.34
	p	p <.001	.008	.006				.001
ML complexity (ApEn)	b	0.04	0.002	0.001				-0.004
	se	0.002	0.002	0.002				0.002
	t	20.8	1.11	0.30				-2.84
	p	p <.001	.27	.76				.004
AP frequency (Hz)	b	2.58	-0.02					
	se	0.09	0.049					
	t	30.2	-0.45					
	p	p<.001	.65					
ML frequency (Hz)	b	2.66	-0.05					
	se	0.07	0.06					
	t	36.5	-0.86					
	p	p<.001	.39					
AP variability (SD)	b	0.007	0.0004	0.0002	0.001			
	se	0.001	0.001	0.001	0.0002			
	t	4.98	0.55	0.42	2.66			
	p	p<.001	.58	.68	.008			
ML variability (SD)	b	0.007	0.001	0.002	0.001			
	se	0.002	0.001	0.001	0.001			
	t	3.80	0.81	2.27	2.08			
	p	p<.001	.420	.02	.04			
TTC (minutes)	b	0.21	-0.02			0.06	0.02	
	se	0.03	0.008			0.024	0.007	
	t	6.86	-2.38			2.40	2.30	
	p	p<.001	.02			.02	.003	

Note: predictors not in the final model are not shown

Table 6.10: Tandem stance final model fixed effects

Model		Intercept	Threat	Dual Task	Age Ident.	Dual Task * Threat
Length of Travel (m)	b	2.84	-0.29	0.32		0.46
	se	0.24	0.32	0.14		0.19
	t	12.1	-0.89	2.28		2.36
	p	p<.001	.38	.02		.02
AP Complexity (ApEn)	b	0.04		0.007		
	se	0.002		0.003		
	t	17.9		2.62		
	p	p<.001		.009		
ML Complexity (ApEn)	b	0.03		0.004		
	se	0.001		0.001		
	t	29.001		4.24		
	p	p<.001		p<.001		
ML frequency	b	2.49		-0.09		
	se	0.09		0.04		
	t	28.3		-2.17		
	p	p<.001		.03		
AP variability (SD)	b	0.007			0.0003	
	se	0.002			0.0003	
	t	4.22			1.16	
	p	p<.001			.25	
ML Variability (SD)	b	0.007			0.0003	
	se	0.0008			0.0001	
	t	8.76			2.45	
	p	p<.001			.01	
TTC (minutes)	b	0.42		-0.04		
	se	0.02		0.009		
	t	18.6		-4.60		
	p	p<.001		p<.001		

Note: Predictors not in the final model are not shown. Models for AP frequency and area were not significant and not included in the table.

Discussion

The aim of this study was to investigate how ABST affects older adults' balance. This is crucial to understand because ABST has been shown to affect older adults' physical performance, such as handgrip (Swift et al., 2012; Also Chapter 5). Evoking ABST was expected to reduce stability as shown by increased postural sway and reduced time to contact. Muscle co-contraction was expected to cause this. Anxiety was expected to mediate the pathway of threat on performance, as in Chapter 5. The dual task was expected to exacerbate the effect of increased sway under ABST. This study demonstrates for the first time the effect of ABST on static balance. An interaction of condition (threat/ control) and task (single/ dual task) was found on length of travel, suggesting different postural strategies during single and dual task under ABST compared to unthreatened controls. Specifically, compared to the control group, length of travel was greater for dual task and lower for single task when ABST was present. Unlike in Chapter 5, anxiety was not evoked for participants presented the ABST manipulation. The expected within-groups differences were identified for dual task. Under dual task, participants swayed more than during single task. Unexpectedly, no differences of condition or task were found for EMG measures. Exploring this area extends ABST theory by revealing the potential effects of ABST. Practically, if ABST affects older adults' balance, it could offer potential for public health campaigns and more effective rehabilitation strategies.

Effect of task within threat and control conditions

Crucially, these findings demonstrate the effect of ABST on postural control. Balance performance was worse during dual task relative to single task when ABST was present, compared to when it was not. During single task balance, ABST participants swayed less than controls, and during dual task balance, ABST participants swayed more than controls. This suggests that different balance strategies may be at play when people are threatened by stereotypes. As length of sway increased but sway area did not change, this suggests that participants under threat wobbled in the same area more than controls during dual task. Particularly, the finding suggests that under threat during single task, conscious control of balance is increased, causing less sway. Whereas, when threatened during dual task, then the additional attentional demands result in less capacity for control of balance and more sway. This suggests different postural strategies during single and dual task when ABST is presented.

Consistent with previous research, when threatened, participants swayed less during the single task, indicating a tightening of postural control. This may be because under ABST there is greater vigilance to risks (Forbes, Schmader, & Allen, 2008; Johns et al., 2008), and postural control increases in order to avoid perceived hazards (Yogev-Seligmann, Hausdorff, & Giladi, 2012). Increased postural control under threat is highlighted by the finding in another study that postural sway decreased when participants stood on a raised platform, inducing postural threat, when compared to sway while standing on the floor only (Cleworth & Carpenter, 2016). In terms of performance during dual task, the interpretation that ABST increases task demands is consistent with the observation that older adults with greater fall risk are likely to 'stop walking when talking' (Lundin-olsson et al., 1997). The findings suggest different postural strategies are used during single and dual task when ABST is present. However, main effects of condition were not seen on single task or dual task individually, and it is important that this effect was only revealed when the interaction of condition and task was considered. Still, with greater statistical power then more marginal effect sizes might also be detected. Therefore, it is essential that future work seeks to elucidate the effects of ABST on postural control, as fundamentally different mechanisms appear to be involved when cognitive demands are greater.

These findings are consistent with the Integrated Process Model of Stereotype Threat (IPM). The IPM follows Steele and Aronson's (1995) proposal of the mediating role of working memory and anxiety in stereotype threat effects. The Integrated Process Model of Stereotype Threat asserts a pathway by which stereotype threat leads to physical task underperformance by causing an emotional response, and the response interferes with working memory (Schmader et al., 2008). The model has received considerable attention, although much of the empirical support for the model is from cognitive performance (Jamieson & Harkins, 2007). This finding that dual task impairs postural control under ABST therefore contributes to the understanding of how additional task demands can affect physical performance when ABST is presented. Other studies demonstrate that ABST affects physical tasks when task demands are higher too. For example, Barber et al. (2020) showed that ABST only affected participants' walking performance (gait speed, step errors) when the task was more difficult. The difference in walking performance under threat was also only found when participants perceived the task to be difficult. This further highlights the need to understand the individual differences involved in older adults' postural control, such as susceptibility to stereotype threat.

Additionally, the IPM asserts that working memory may affect automatic processes and controlled processes differently. Specifically, additional load on working memory under ABST is posited to affect tasks with controlled processing, but tasks processed automatically may be affected more directly by threat related monitoring processes, as described in Chapter 4 (and particularly see Figure 4.3, page 51). In a recent study (Chalabaev et al., 2020), showed that stereotype condition did not affect older adults' walking performance (cadence, velocity, step length). Crucially, when the participants concurrently performed a Stroop task, then their cognitive performance was impaired, but walking performance was unaffected. This suggests that ABST generated cognitive load through cognitive anxiety (worrying thoughts) causing distraction from the cognitive task (e.g. thought suppression), while the automatically processed walking task was unaffected. Potentially at odds with the finding of increased length of travel during dual task when ABST is present, such an assertion might otherwise explain why on the whole measures of balance performance were not affected in this study. Else, it is equally plausible that length of travel was the most sensitive to performance under threat, and so exhibited greatest effect. Given the findings of Chalabaev et al (2020) and in light of the IPM, perhaps this could be because length of sway was somehow more consciously controlled than the other measures of balance, whereas these more automatically controlled performance measures could be less affected by the dual task. However, empirical founding is required to underpin this supposition.

As there was no main effect of condition on anxiety, it was not feasible to test the possible mediating effect ABST may have had on balance performance. However, the finding that ABST led to greater sway during dual task supports the pathway by which controlled task underperformance can be caused by reduced working memory efficiency under ABST. Given the theoretical and applied importance of the finding that ABST caused greater postural sway during dual task, future research may seek to test the causal relationships between anxiety, working memory, and balance under threat, crucially differentiating automatic process and controlled process tasks.

Anxiety

The lack of affective response to the stereotype threat stimuli was surprising. Previous research has demonstrated that stereotype threat effects are elicited when the stimulus is subtle and implicit (Lamont et al., 2015; Shih, Ambady, Richeson, & Gray, 2002). The potential effectiveness of the ABST manipulation was demonstrated in Chapter 5, showing that threat and anxiety increased when the ABST manipulation was presented using written instructions. The response was not repeated in this study. There are some key differences between these studies that may have limited the effect of this subtle manipulation.

A key factor in understanding the effect ABST had on anxiety in this study is the point in the procedure at which anxiety was measured. For all participants, the anxiety measurements occurred following the dual task (serial subtractions and balance). It was recorded at this point only to avoid priming or demand characteristics being evoked by repeated questioning. However, this may have introduced extraneous effects. For instance, the serial subtractions may have evoked an affective response across all participants, similar to observations in Chapter 5 whereby the computer task seemed to evoke threat. In this case, maths anxiety (Baloglu & Kocak, 2006; Lyons & Beilock, 2012) may have caused a levelling of measurements across conditions. Alternatively, the presence of the cognitive task may have evoked ABST to some degree for all participants, as the balance task may have made age and performance salient. However, the difference in length of travel under threat during single and dual task suggests the manipulation was not futile. In this case, it is plausible that the anxiety questionnaire was not sensitive enough to detect the effects of the subtle manipulation, despite the effect on length of sway. The lack of affective response could indicate that effects of condition were because of stereotype priming (Jamieson & Harkins, 2012). However, in that case, the sway of participants under threat would be expected in be greater during single task

Therefore, such a position is not tenable given the relative tightening of postural control under single task compared to relative instability seen during dual task. Essentially, as anxiety was recorded after the dual task only, it is not possible to conclude whether the unexpected lack of effect of affective response was artificial because of interference introduced from the dual task, or whether it was a true finding based on some other factors.

For instance, in this study, participants were recruited from community groups, whereas in Chapter 5, participants were recruited from older adult day centres. The absence of threat effect from the manipulation is therefore attributable to a less frail and more physically active sample of participants. Stereotype threat theory asserts that in order for the threat to be salient, it must be self-relevant (Shih et al., 2002). Supporting this assertion, greater age-identification was found to be associated with greater sway variability. This is demonstrated in previous research. For example, when Levy (1996) presented age-based stereotype threat stimuli to older and younger participants, only the older group's memory performance was impaired. However, invoking negative self-relevant stereotypes can lead to resilience as internal conflict is resolved, for example through downward social comparison (Colton, Leshikar, & Gutchess, 2013). For example, the attitude that 'Older adults are less physically able' and 'I am an older adult' is resolved with the attitude that 'I am unlike other older adults because I am better than them at physical tasks'. Indeed, when older adults were recruited from a community group for older adults academics (U3A) then ABST failed to elicit differences even in the hitherto well supported cognitive domain (Salhi & Bergström, 2020). Therefore weaker identification with age and stronger identification with a non-stigmatized identity (e.g. walking group, U3A) avoids such threat, although not all older adults have a non-stigmatized identity within grasp to identify with. Identification of these individuals to understand potential mitigations of threat is worthwhile, although recruiting them is likely to be inherently challenging.

Further research would be well placed to compare balance performance under ABST conditions for frail compared to non-frail older adults. This would help explain why ABST affected participants in Chapter 5 but that there was no affective response in this study. While ABST effects have been demonstrated when older adults are recruited from a range of settings, these are generally in cognitive task performance. There is much greater disparity in findings from ABST elicited prior to physical task performance. For example, recruiting from community dwelling older adults responding to a newspaper advertisement, Horton et al. (2010) found no effect of ABST on hand grip strength, walking speed, or flexibility. Conversely, when recruiting from an older adult day care centre, Swift et al. (2012) found handgrip strength to be lower when ABST was invoked. The findings of Barber et al (2020) demonstrate that these differences in performance may be attributable to resource appraisal. ABST effects were only identified in gait measures when subjective resource evaluations were poor. This might explain why there was no effect in balance performance between conditions as participants may have had more positive resource evaluations in this study compared to Chapter 5. Further, this highlights the need to further understand ways in which some older adults may be protected from ABST.

In this study, it is plausible that the threat was more easily rebutted by the socially active and physically abled older adult sample. For instance there are characteristics of being healthy which may mitigate concern about the task and therefore attenuate ABST. For example, being in better physical and mental health is associated with higher physical self-efficacy (Parkatti, Deeg, Bosscher, & Launer, 1998). In turn, higher physical self-efficacy is associated with higher levels of daily physical activity (McAuley, Szabo, Gothe, & Olson, 2013) and better physical performance (Bosscher, Van Der, Van Dasler, Deeg, & Smit, 1995). This means that when self-efficacy is greater then available resources are likely to be evaluated as sufficient to successfully complete the physical task, as so the threat from negative age-stereotypes is attenuated. While previous studies have investigated the effect of ABST on self-efficacy for job search (Weiss & Perry, 2020) and memory performance (Desrichard & Kopetz, 2005), more investigation is required to assess how ABST affects physical task self-efficacy.

It is plausible that the written instructions were too subtle to invoke threat. In previous research (Abrams et al., 2009; Swift et al., 2012) participants were verbally instructed to invoke threat. This may have caused a stronger effect whilst retaining ecological validity. It is also possible that this invoked ‘white coat’ anxiety, rather than ABST alone, or inadvertently evoked experimenter desirability effects. In Swift et al (2012) and in Chapter 5, the experiment took place at older adult care centre. In this study and in Horton et al (2010) the experiment took place in laboratory setting. It is possible that the care centre setting made negative stereotypes of ageing even more salient. Alternatively, that participants were required to travel and turn up to an unknown location may have self-selected participants resistant to ABST. These findings are not unprecedented given the subtlety of the manipulation. In Barber (2020), ABST was evoked by participants reading and listening to instructions. As a result, condition had an effect on walking performance (slower walking, step errors) only when task difficulty was high (narrow base of support) and participants were not confident in their ability to succeed at the task. On the other hand, Horton et al (2010), used a fake news article 'Bad news for seniors', and showed them a video clip of an experimenter reading the article. There was no difference between groups in this case. Clearly, there is scope for future research to identify effective methods to invoke and measure threat whilst retaining methodological rigour.

Dual task

Previous research shows that when participants are presented with a balance task which requires attention to successfully complete (i.e. when the balance task is not automatically processed), then a concurrent attentional demand increases postural sway (Ruffieux, Keller, Lauber, & Taube, 2015). It is reasoned that this is because attentional resources are limited, and performing the additional task leaves less resources available to control posture (Melzer et al., 2001; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003). This dual task cost in sway is predictive of falls in older adults (Swanenburg, De Bruin, Favero, Uebelhart, & Mulder, 2008). The expected within-participants differences on postural sway between single and dual task balance were elicited, largely consistent with existing research (Doumas et al., 2009; Kang et al., 2009; Kilby et al., 2014; Manor & Lipsitz, 2013). This was evidenced in increased length of travel, and reduced sway frequency. At first, reduced sway frequency might seem as though sway decreased under dual task. This is not the case because length of travel also increased. This means that dual task performance resulted in greater sway range per second than single task performance. This is indicative of poorer stability. Consistent with this, and with previous research (Manor et al., 2010; Anne Shumway-Cook, Woollacott, Kerns, & Baldwin, 1997), time to contact also reduced when the dual task was performed. Additionally, during single leg balance, a significant interaction of task and anxiety on complexity was identified, such that complexity was only reduced under dual task when participants were more anxious. Conversely, this effect was not found with tandem stance. Although sway increased and time to contact reduced under dual task, there was an increase in complexity under dual task during tandem stance. This could suggest that focus of attention is relatively less internal during tandem stance dual tasking. Although some previous research shows that a simple cognitive task can increase stability compared to internal or external focus of attention (Polskaia & Lajoie, 2016), given the reduced time to contact in both single and tandem stance then this is unlikely to be the case. Instead, the difference between a more difficult task (single leg balance) and a relatively easier task (tandem stance) might suggest that the tandem balance task was not perceived to be as challenging and was therefore processed differently (automatically) to the single leg stance when the dual task was imposed. Nevertheless, these results are not conclusive and differences between stance types during dual task warrants further investigation.

Reductions in stability can occur because of muscle co-contraction (Melzer et al., 2001). This co-contraction reduces the ways in which an anatomical system can adapt to changing demands (Young & Williams, 2015). This heightens the risk of falls (Nelson-Wong et al., 2012). As greater attentional loads increase co-contraction (Melzer et al., 2001), this means the risk of falls can be higher in these situations. Indeed, older people tend to co-contract muscles around the ankle more than younger people, and co-contract more when balance tasks are more difficult (Donath, Kurz, Roth, Zahner, & Faude, 2016). The current study did not replicate these results. However, in Donath et al (2016), younger people tended towards higher trunk muscle contribution during balance tasks. It is possible that participants may have used different strategies to maintain balance, accounting for these differences between studies. Without further research, it not completely clear why differences in postural sway were observed, without differences in the causal electromyography.

Conclusion

These results demonstrate for the first time ABST effects on balance performance as measured by COP length of travel, highlighting the additional burden that ABST can exert on postural stability. This finding means that when threatened by age stereotypes and when cognitive demands are greater, then fall risk may also be heightened. Despite no differences of condition on affective response, anxiety was a significant predictor of balance performance. Then, these results also re-emphasise the effect of anxiety and attention on postural control.

This study has important practical implications. Differing postural strategies under threat during dual task means that falls risk could be higher for people who experience ABST when working memory demands are greater. Everyday tasks often divide attention between postural stability and another task (e.g. cooking, house cleaning). This means that to reduce fall risk in these circumstances then mitigating ABST, or reducing task demands is essential. Crucially, experiencing a fall further exacerbates a cycle of anxiety. This means that people may disengage from physical activity, and this in turn can exacerbate the age-related deterioration of physiological systems. Consequently, individuals are more susceptible to experiencing a fall, so a self-fulfilling prophesy is perpetuated (Yardley & Smith, 2002). Because of this cyclical risk, it is essential for further research to explore how ABST might affect neuromuscular processes involved in postural control.

This is relevant to public health policy, as impaired balance performance increases fall risk in older adult populations. Specifically, when people under threat completed a challenging concurrent task, then stability reduced. When participants were more anxious, then sway complexity reduced. Sway complexity is reflective of reduced adaptive ability, and so indicates likelihood of recovering from environmental perturbation like a slip or trip. Together, these results demonstrate the risks to postural stability presented by performing two tasks simultaneously, and when these tasks are performed under threat. Yet, there is stark need for further research. These investigations should seek identify individuals who are susceptible to physical task underperformance when age-based stereotype threat is salient.

Chapter 7 - Self-perceptions of ageing associated with older adults' grip strength, walking speed, physical activity, and risk of falls

Abstract

Frailty is a common clinical syndrome associated with older age, characterised by weakness, fatigue, and significant decreases in muscle mass. It carries increased risk of poor health outcomes and falls. Self-perceptions of ageing (SPA), an individual's personal evaluation of their own ageing, are associated with development of frailty (Gale & Cooper, 2017). Separate research has linked SPA to older adults' physical performance, healthy behaviours, and health outcomes (Levy, Pilver, Chung, & Slade, 2014; Levy & Myers, 2004). Wave 8 of The English Longitudinal Study of Ageing (ELSA) provides an opportunity to explore the relationship between SPA on physical activity and performance measures taken in the same wave. Data from 2322 respondents (aged 60 to 89 years, mean age 71 years) were explored. A series of stepwise linear or logistic regressions revealed that positive SPA are associated with increased physical activity (OR = 1.12, LCI = 1.01, UCI = 01.24, p = .04), handgrip strength (*b* = 0.47, p = .002), faster timed walk (*b* = -0.031, p < .001), and importantly, decreased falls risk (OR = 0.83, LCI = 0.75, UCI = 0.91, p< .001). This study provides important evidence for the association between SPA with physical performance, health behaviours, and falls in the ELSA survey data for one wave. Theoretical implications are discussed in relation to wider theories of age stereotypes, and practical implications are discussed in relation to falls prevention. The research highlights the importance of exploring these effects longitudinally using later waves.

Introduction

Prevalence of frailty is estimated to be around 10% of people over 65 years and 50% over age 85 years (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013). A phenotype is proposed that characterises frailty as a state of cumulative physiological deficits that result in unintentional weight loss, low energy, slow walking speed, and loss of strength (Fried et al., 2001). Frailty decreases mobility and increases the risk of falls (Ambrose, Paul, & Hausdorff, 2013). In turn, this leads to an increased risk of morbidity and mortality (Wilkinson et al., 2018). As such, physical performance measures are routinely administered for clinical diagnosis and prognosis of frailty, with the intention of reducing risk of falls (Makary et al., 2010; Syddall, Cooper, Martin, Briggs, & Sayer, 2003).

Falls are the most common accident in people aged 65 and over, and these accidents can detrimental to wellbeing, independence and can even be fatal (World Health Organisation, 2018). The economic and social costs of falls are also dramatic: they are estimated to cost UK public services £6m per day (Age UK, 2012). This is a global concern as the worldwide population of adults aged 65 years and over is expected to more than double by 2050 (United Nations, 2017). Health care needs are expected to rise in line with this rapid population increase. Therefore, identifying modifiable risk factors for adverse health outcomes is essential to promote older adult health and to manage economic pressures. This emphasises the need to understand how frailty measures relate to potentially modifiable determinants, such as physical activity and our attitudes.

Physical activity

The attenuation of adverse health outcome risk through effortful physical exercise is well-documented (Garatachea et al., 2015). Physical activity can offset sarcopenia, frailty and falls (Marzetti et al., 2017; Steffl et al., 2017). The World Health Organisation advises older adults to take regular physical activity: at least 150 minutes of moderate intensity or 75 minutes of vigorous intensity per week (WHO, 2015). However, despite these guidelines and the well documented health benefits associated with physical activity, engagement in physical activity in later life is relatively low compared to younger age group. Fewer than 35% of adults aged 65-75 meet the age-appropriate physical activity guidelines, and fewer than 18% of older adults aged 75 and older do so (U.S. Department of Health and Human Services, 2019). Some of barriers to physical activity could be due to physical impairment, but for those without physical impairment to exercise, the barriers may be psychological.

Self-Perceptions of Ageing

Previous research has shown that this reduced engagement in physical activity in later life is associated with a host of physical, personal and psychological factors (Schutzer & Graves, 2004). An important psychological factor that has been established for older adults is the individual's self-perceptions of ageing (SPA). The Risks of Ageism Model (RAM; Swift, Abrams, Lamont, & Drury, 2017) argues that SPA should be associated with engagement with physical activity via two psychological pathways, stereotype embodiment and stereotype threat.

Stereotype embodiment impacts on activity by embodiment of negative stereotypes that denote inevitable decline in health and cognitive functioning (Levy, Pilver, Chung, & Slade, 2014). This leads to a self-fulling prophecy through the application of stereotypes to the self. Evidence for this comes from research using implicit priming techniques (Levy, 1996) and survey data (Wurm, Diehl, Kornadt, Westerhof, & Wahl, 2017). Stereotype embodiment could lead to lower physical activity by reducing self-esteem or diminished self-efficacy, which have been associated with lower physical activity (White et al. 2012). Research has also shown that negative SPA is associated with increased risk of mortality, with people who had more positive SPA were likely to live, on average, 7.5 years longer than those with more negative SPA (Levy, Slade, Kunkel, & Kasl, 2002). However, this research does not elucidate the relationship of self-relevant age stereotypes on falls risk.

Stereotype threat is an additional psychological pathway through which negative stereotypes can impact on behaviour. The negative effect of ABST on physical performance was also demonstrated in Chapter 5 and Chapter 6. In Chapter 5, anxiety was found to mediate the effect of ABST on handgrip strength. In Chapter 6, ABST increased postural sway (total sway length) during dual task relative to single task, more than it did for control participants. The wider stereotype threat literature has shown that negative expectations about performance on stereotype related tasks can lead to disengagement and avoidance of tasks, due to the fear of being judged negatively by others (Pennington et al., 2016; Smith, Sansone, & White, 2007). It is theorised that older adults could disengage from physical activity due to negative expectations about performance conveyed by age stereotypes. This research explores part of this pathway by exploring the relationship between self-perceptions of ageing and physical activity, but extends the literature by exploring these links with risk of falls.

Some indications of a link between positive self-perceptions of ageing and greater levels of physical activity and better health exist in the literature. For example, the Attitude Toward Own Ageing scale (Lawton, 1975; Liang & Bollen, 1983) was found to be predictive of self-reports of health and physical activity levels in follow up 2.5 years later (Beyer, Wolff, Warner, Schüz, & Wurm, 2015). However, an individual's self-relevant view of ageing does not seem to be consistently predictive of health or activity. For example, Gale et al (2018) found no evidence to support the association of the Attitudes to Ageing Questionnaire with either time spent sedentary or physical performance in seven-year follow up. There are crucial differences between these studies which may have caused the difference in findings. For example, the way that perceptions of age and ageing were measured is fundamental. While both scales are well validated in terms of internal consistency, they could differ in their sensitivity to specific health or physical performance outcomes. This is particularly important because Gale et al (2018) used physical performance outcomes using a sit-to-stand task, and did not rely solely on questionnaire based measurements. Although more objective, the sit-to-stand performance measure is also more specific than the broad single subjective measure about health in Beyer et al. (2015). Additionally, the longer follow-up period in Gale et al (2018), could have allowed the introduction of confounding factors, such as qualitative changes to health or lifestyle. Given the mixed evidence, there remains a need to establish whether SPA is associated with physical activity levels, and how this relates to health outcomes, such as falls risk.

Negative age-stereotypes can affect not only older adults' cognitive (Beilock et al., 2007) and physical (Swift et al., 2012) task performance, and they can also affect health behaviours and outcomes too (Levy, 1996; Levy, Hausdorff, Hencke, &

Wei, 2000; Sargent-Cox, 2017; Sargent-Cox & Anstey, 2015). Investigating self-perceptions of ageing on physical activity, physical performance, and falls risk is crucial given the detrimental effects of falls in later life.

In sum, the frailty phenotype is typically characterised by biological factors and physical performance. However, there is reason to believe that psychological factors may also comprise this phenotype. Indeed, there is a need to better understand the modifiable determinants of frailty. This will help inform effective diagnostic methods and clinical interventions for the benefit of older adults' health and wellbeing. The latest ELSA data allows for an examination of the relationship of various physical performance measures with SPA, and to investigate how sociodemographic factors contribute to this relationship, such as age, sex, and education (Gale et al., 2018). Compared to laboratory studies, additional benefits can be achieved, such as testing that these relationships with greater statistical power, avoiding the potential selection bias of people travelling to laboratories, and including a wider cross section of the population. Specifically, following previous research demonstrating association of SPA with physical activity and frailty (Gale & Cooper, 2017; Levy & Myers, 2004), the purpose of this study is to identify the relationship of SPA on physical activity, physical performance (grip strength and timed walk), and the relationship of these measures with falls risk. More positive SPA is expected to be associated with greater levels of physical activity, greater handgrip strength, faster timed walk, and having experienced a fall within the previous two years. SPA is expected to act indirectly along these pathways too, consequently affecting fall risk.

Specifically it is hypothesised that:

1) More positive SPA is expected to be associated with greater levels of physical activity, greater handgrip strength, faster timed walk, and having experienced a fall within the previous two years.

2) SPA is expected to act indirectly along these pathways too, consequently reducing fall risk.

Method

ELSA is an ongoing prospective cohort study of individuals aged 50 years and over living in private households in England. Data is collected biennially through computer assisted personal interviews and self-completion questionnaires. Biomedical data is collected every four years in a nurse visit. Sampling is stratified by postcode sector, health authority, and socioeconomic group. Wave 8 is the first to include self-perceptions of ageing. The cross-sectional relationship of Self-Perceptions of Ageing (SPA) with moderate-vigorous physical activity (MVPA), physical performance (timed walk, handgrip strength), and falls was investigated via regression analyses and structural equation modelling.

Participants

Wave 8 of ELSA had 8445 respondents. 6172 observations had missing data for at least one analysis-critical variable. In total, there were 1558 non-respondents for the self-completion questionnaire, and 4920 cases did not have dominant hand maximal grip strength or timed walk. This missing physical performance data is attributable to the limited number of respondents who received a nurse visit for Wave 8. Listwise deletion was applied for compete case analysis. Multivariate outliers were identified by Mahalanobis distances and excluded from analyses (n= 48). Analysis was performed for 2219 people, mean age = 71.3 years. Demographic descriptive statistics are shown in

Table 7.1: Correlations between predictors included in initial model

Variable	*M*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1.SPA	0.06	0.97											
2. MVPA	4.7	1.89	-.12 ***										
3. Grip	29.7	10.6	0.01	-.26 **									
4. Timed Walk (s)	3.11	1.31	-.13 **	.41 **	-.24 ***								
5. Sex	1.54	0.5	.08 **	.08 ***	-.71 ***	.07 ***							
6. Education	5.36	1.75	-0	-.25 **	.14 ***	-.22 ***	-0						
7. Chronic Condition	0.25	0.43	-.06 ***	.05*	-.07 **	.06 **	0	0					
8. Smokes	0.07	0.25	0	.06 **	0.01	0.02	0	-.07 **	-0				
9. Weight	77.4	16	-.07 ***	.11 **	.42 **	.10 ***	-.41 ***	-.04 *	0.02	-.10 ***			
10. Age	71.3	7.29	-0	.27 **	-.29 **	.29 ***	-0	-.22 **	.06 **	-.10 ***	-.14 **		
11. Socio-economic status	3.72	1.96	0	.19 **	-.14 ***	.16 ***	.09 ***	-.41 **	0.01	.06 **	0.03	.06 **	
12. Falls	0.25	0.43	-.08 ***	0.03	-.12 ***	.07 ***	.07 ***	0	.05 *	0	0	.09 **	0

*Note: * indicates significance at p<0.05, ** indicates significance at p < 0.01. SPA – Self-perceptions of ageing. MVPA – Moderate-vigorous physical activity*

Table 7.2.

Measures

Self-Perceptions of Ageing (SPA) – In ELSA Wave 2, qualitative data was gathered about respondents' perceptions of ageing. These responses were used to construct the 12 statements used in Wave 8, such as "Old age is a time of loneliness", "As I get older, I expect to be able to do the things I've always done" (reverse scored), "Old age is a time of ill health". Respondents rated their agreement for the statements against a 5-point Likert-type scale (higher score = more positive SPA). A scree plot was used to assess the number of factors to extract, and the point of inflection showed that one factor should be used. Reliability statistics were used to support the single construct scale (Cronbach's Alpha= 0.66) which adhered to conceptual premises of age attitudes as a single construct. Therefore, a z-score from the single factor mean was calculated.

Physical Activity – Respondents reported physical activity frequency and these were reverse scored (never, three times a month or less, once a week, more than once a week, scored 1-4 respectively) at each of three intensities (vigorous, moderate, mild). As moderate or vigorous intensity physical activity (MVPA) is recommended by public health guidance (NHS, 2018), these variables were reduced to a single factor for all analyses. Therefore, physical activity variable reflects the frequency of engagement in moderate and vigorous activity only.

Grip Strength – Respondents performed isometric hand grip strength three times on their self-selected dominant hand. Maximum grip strength (kg) was used for analysis.

Timed Walk – Respondents' time (seconds) to walk a distance of 8 feet (144cm) was timed using stopwatch. Only those that completed the walk without aid were included in analysis.

Falls – A binary variable determined by at least one self-reported fall in the previous two years.

Covariates

Based on previous research (Gale et al., 2018; Sayer et al., 2006) age, sex, socioeconomic status, presence of a chronic health condition, body weight (Kg), education level, and current smoking status were included in analyses as covariates. Physical activity, timed walk, and grip strength were also included as covariates in analyses where they were not the outcome of interest. Assistive mobility aids may serve to prevent an individual falling, therefore, these were additionally included as predictors in the initial model.

Statistical analysis

Backward stepwise regression models of Wave 8 ELSA cross-sectional data enabled analysis of the four response variables: physical activity, handgrip strength, timed walk, and falls. This allowed removal of the least significant variables as determined by p-value to explore whether remaining variables retained or increased their effect. This method ensures that the most parsimonious model identifies only the most significant predictors of the outcome variable. Models were compared using Akaike information criterion (AIC), which penalises reductions in deviance by the number of predictors. The relationship between SPA and handgrip strength, timed walk, and MVPA was investigated with linear regression. When modelling MVPA, timed walk and grip were not included in the initial model so that potentially causal relationships could be investigated. For instance, handgrip strength was expected to be a predictor for timed walk, but walking speed was not expected to cause handgrip strength. The relationship between SPA with history of a fall within previous two years was investigated using logistic models. Model fit statistics are given for continuous (R^2) and binary (X^2) outcomes. All statistical analysis was conducted in R v3.2.2 (R Core Team, R Foundation for Statistical Computing: Vienna, Austria).

Once parsimonious linear regression models were established, then these predictors were entered into a serial mediation structural equation model (SEM) following established methods of analyses (Baron & Kenny, 1986). This enabled the whole model pathways of SPA on MVPA behaviour, physical performance, and falls to be tested. By modelling direct and indirect pathways, this fully accounts for the overall direct and indirect impact of SPA on falls, via MVPA behaviours and physical performance.

Results

Overall, self-perceptions of ageing were generally positive slightly above the mid-point of the scale (SPA M =3.28, SD = 0.5). Participants were more likely to engage in at least some mild physical activity (95%) than moderate (88%) or vigorous (43%). Mean handgrip strength matched previously identified averages for community-dwelling older adults, and were outside frailty thresholds (Sallinen et al., 2010). The proportion of people who experienced a fall (N = 591, 25%) were in line with norms for this age range (Age UK, 2012). Demographic and descriptive information is presented in Table 7.2, and correlations are shown in Table 7.1. The resulting stepwise models showed that SPA was a significant predictor of outcomes in all models, even when controlling for socio-demographic factors in the initial model. Age attitudes in relation to the main outcome measures are described below. Regression tables for final models are presented in Table 7.3 to Table 7.6.

Table 7.1: Correlations between predictors included in initial model

Variable	***M***	***SD***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***
1.SPA	0.06	0.97											
2. MVPA	4.7	1.89	-.12***										
3. Grip	29.7	10.6	0.01	-.26**									
4. Timed Walk (s)	3.11	1.31	-.13**	.41**	-.24***								
5. Sex	1.54	0.5	.08**	.08***	-.71***	.07***							
6. Education	5.36	1.75	-0	-.25**	.14***	-.22***	-0						
7. Chronic Condition	0.25	0.43	-.06***	.05*	-.07**	.06**	0	0					
8. Smokes	0.07	0.25	0	.06**	0.01	0.02	0	-.07**	-0				
9. Weight	77.4	16	-.07***	.11**	.42**	.10***	-.41***	-.04*	0.02	-.10***			
10. Age	71.3	7.29	-0	.27**	-.29**	.29***	-0	-.22**	.06**	-.10***	-.14**		
11. Socio-economic status	3.72	1.96	0	.19**	-.14***	.16***	.09***	-.41**	0.01	.06**	0.03	.06**	
12. Falls	0.25	0.43	-.08***	0.03	-.12***	.07***	.07***	0	.05*	0	0	.09**	0

*Note: * indicates significance at p<0.05, ** indicates significance at p < 0.01. SPA – Self-perceptions of ageing. MVPA – Moderate-vigorous physical activity*

Table 7.2: Summary of participant demographics

Variable	
Sex (n)	Female = 1204, 54.3% Male = 1015, 45.7%
Age (years)	Mean = 71.3; SD = 7.3
Age Attitudes mean (max 5)	Mean = 3.28; SD = 0.5
Grip Strength (kg)	Female = 22.8, SD = 5.9 Male = 37.9, SD = 8.8
History of falls in last 2 years	562 people (25.3%)
Socioeconomic group (n)	Higher managerial and professional occupations: 258 Lower managerial and professional occupations: 570 Intermediate occupations (clerical, sales, service): 320 Small employers and own account workers: 284 Lower supervisory and technical occupations: 194 Semi-routine occupations: 367 Routine occupations: 218 Never worked or long-term unemployed: 8
Chronic health condition (n)	Yes = 557 (25.1%)
Vigorous Physical Activity	More than once a week: 483 Once a week: 223 3 times per month or less: 193 Never: 1320
Moderate Physical Activity	More than once a week: 1498 Once a week: 308 3 times per month or less: 125 Never: 288
Mild Physical Activity	More than once a week: 1840 Once a week: 202 3 times per month or less: 62 Never: 115
Current Smoking Status	Smoker: 145 (6.5%)
Education	Never went to school: 7 14 or under: 124 At 15: 706 At 16: 494 At 17: 203 At 18: 175 19 or over: 175 Not yet finished: 45
Weight (Kg)	Female = 71.4, SD = 14.7 Male = 84.6, SD = 14.4

Physical activity

In line with the hypothesis 1, the final regression model ($F(7, 2211) = 70.1$, $p<.001$) showed that more positive SPA was significantly and positively associated with being more physically active ($b = 0.09$, $p < 0.01$, $R^2 = 0.27$). Lower age, more years of education, being a non-smoker, stronger handgrip, faster walk speed, more profession and skilled socio-economic classification, and lower body weight predicted greater physical activity, see Table 7.3.

Table 7.3: Moderate-Vigorous Physical Activity (MVPA)

	b	***SE***	***t***	***p***
Intercept	2.28	0.19	12.00	p<.001
SPA	0.09	0.01	6.26	p<.001
Age	-0.03	0.00	-13.40	p<.001
Sex	0.24	0.03	7.77	p<.001
Smokes	-0.25	0.06	-4.49	p0.001
Socio-Economic Status	-0.03	0.01	-3.99	p<.001
Weight (Kg)	-0.01	0.00	-9.47	p<.001
Education	0.06	0.01	6.69	p<.001

Handgrip strength

Stronger handgrip was predicted by lower age, absence of chronic health conditions, more years of education, more frequent physical activity, faster walking, more professional and skilled socio-economic classification, and heavier body weight ($F(9, 2209) = 437.4$, $p< .001$). Importantly, and in line with the hypothesis 1, more positive SPA also remained a significant predictor of handgrip strength. An increase of 1SD age attitude predicted 0.40kg increase grip strength ($b = 0.40$, $p=0.01$; $R^2 = 0.64$).

Table 7.4: Handgrip strength

	b	***SE***	***t***	***p***
Intercept	39.30	1.90	20.63	p<.001
SPA	0.40	0.14	2.81	.01
MVPA	1.67	0.22	7.61	p<.001
Chronic health condition	-1.10	0.31	-3.52	p<.001
Age	-0.30	0.02	-14.69	p<.001
Sex	13.53	0.30	44.36	p<.001
Socio-Economic Status	-0.11	0.08	-1.48	.14
Weight (Kg)	0.10	0.01	10.26	p<.001
Education	0.16	0.09	1.83	.07

Timed walk

To minimise standard errors, the skewed timed walk data were log transformed. Importantly, and in line with hypothesis 1, more positive SPA also remained a significant predictor of walk speed ($F(7,2211) = 104.1$, $p < .001$). People with more positive age attitudes were faster walkers, a 1-SD more positive age attitude was associated with faster walk speeds ($b = -0.03$, $p < 0.001$, $R^2 = 0.28$). Additionally, faster walk speeds were associated with lower age, more years of education, more frequent physical activity, being a non-smoker, stronger grip, more professional and skilled socio-economic classification, and lower body weight.

Table 7.5: Timed walk

	b	***SE***	***t***	***p***
Intercept	0.38	0.09	4.36	p<.001
SPA	-0.03	0.01	-4.51	p<.001
MVPA	-0.13	0.01	-14.12	p<.001
Grip (Kg)	-0.01	0.001	-8.98	p<.001
Age	0.01	0.001	10.00	p<.001
Smokes	0.06	0.02	2.44	.01
Socio-Economic Status	0.01	0.003	2.54	.01
Weight (Kg)	0.004	0.0001	8.46	p<.001
Education	-0.02	0.004	-3.92	p<.001

Fall risk

Importantly, people with more positive SPA were less likely to have experienced a fall (χ (8) = 62.4, p < .001), and this finding supports hypothesis 1. Age, grip strength, presence of a chronic health condition, socio-economic status and weight also significantly predicted falls risk. People with 1-SD lower SPA were 3% more likely to have experienced a fall (*OR* = 0.97, *p* <.001, R^2= 0.28). Surprisingly, neither MVPA nor timed walk were part of the final model. That is, when grip strength was included in the initial model, model fit was not significantly better when MVPA and timed walk were included.

Table 7.6: Fall risk

	b	***SE***	***t***	***p***	***OR***	***95% CI OR***
Intercept	0.04	0.11	0.34	.73	1.04	[0.83-1.3]
SPA	-0.03	0.01	-3.31	p<.001	0.97	[0.95-0.99]
Grip (Kg)	-0.01	0.001	-5.18	p<.001	1.03	[1 -1.07]
Chronic health condition	0.03	0.02	1.45	.15	1	[1-1]
Age	0.004	0.001	2.83	p<.001	1	[1-1.01]
Socio-Economic Status	-0.01	0.005	-1.81	.07	0.99	[0.98-1]
Weight (Kg)	0.002	0.001	2.64	.01	0.99	[0.99-1]

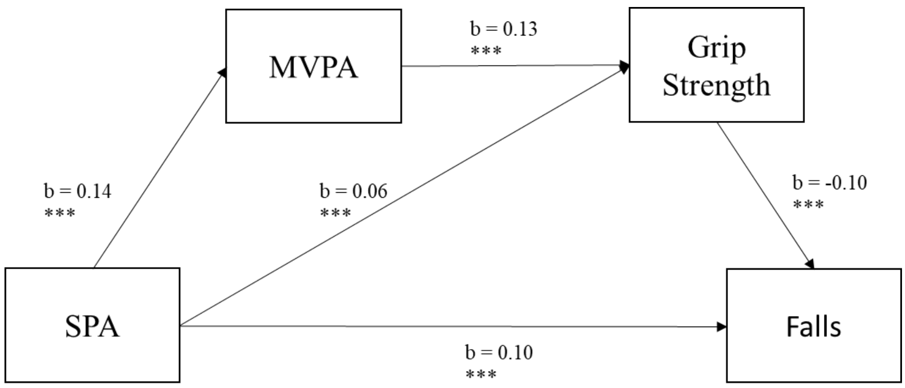
Can SPA protect against falls via increased activity and handgrip strength?

In order to test the hypothesis (hypothesis 2) that more positive SPA might act as a source of potential protection from falls, serial mediation models were run with predictors supported by the linear models.

In line with previous regression analysis, SPA had direct effect on physical activity (*b* [MVPA] = 0.22, *z* = 6.38, *p* < .001, LCI = 0.30, UCI = 0.16) and handgrip strength (*b* [Grip] = 0.39, *z* = 2.49, *p* =0.01, LCI = 0.08, UCI = 0.70). Physical activity predicted handgrip strength (*b* [MVPA-Grip] = 0.64, *z* = 6.64, *p* <, LCI = 0.82, UCI = 0.46) and handgrip strength negatively predicted falls (*b* [Grip-Falls] = -0.05, *z* = -5.22, *p* < .001, LCI = -0.007, UCI = -0.003).

The final model standardised estimates (5000 bootstraps) showed SPA had a small but significant direct effect on falls (*b* [direct] = -0.10, *z* = -4.16, *p* < .001, LCI = -0.15, UCI = -0.06) which was significant. The indirect effect of SPA on falls via physical activity and handgrip strength was also small but significant (*b* [indirect] = -0.009, *z* = -3.80, *p* <0.001, LCI = -0.01, UCI = -0.005). The total effect of SPA on falls was small but significant (*b* [total] = -0.11, *z* = -4.83, *p* < .001, LCI = -0.15, UCI = -0.06), and showed that higher SPA was associated with less chance that someone had fallen the previous 2 years. To explore the unexpected finding that timed walk and MVPA did not directly affect falls was tested again by inclusion into the serial model. This failed to improve model fit by including pathways to falls from MVPA ($\chi2(1) = 257.7$ *p* = .18) or timed walk ($\chi2(1) = -187.6$, *p* = 0.81).

Figure 7.1: Serial mediation of self-perception of ageing on likelihood of experiencing fall in previous 2 years



People with more positive SPA have less risk of falls. They are more likely to engage in physical activity, and stronger grip strength. SPA - Self-perception of ageing, MVPA - moderate or vigorous physical activity, grip strength (Kg), and fall within last 2 years.

Discussion

This study demonstrates that even when sociodemographic and behavioural factors are accounted for, self-perceptions of ageing (SPA) are a significant and important factor in understanding older adults' physical performance. SPA was significantly independently associated with physical activity engagement, handgrip strength, timed walk, and falls risk. When people had more positive SPA, then they were more physically active and had stronger handgrip. These factors contribute to reduced fall risk (Menant et al., 2016). Drawing on the RAM, this research provides new correlation-based evidence that more positive SPA is associated with increased likelihood of engagement in physical activity, and increased physical strength and mobility. This extends current understanding of the risks of ageism to falls, a previously untested physical outcome of SPA.

There is some existing research demonstrating that positive SPA could reflect resilience against future frailty and mobility difficulty. In cross-lagged modelling, SPA was found to predict future health outcomes (Wurm, Tomasik, & Tesch-Römer, 2008). This means that how someone copes with illness is perhaps more important than the illness alone. The RAM provides a framework for understanding how age stereotypes, on which SPA is formed, might contribute to the physical deterioration in older age (Swift et al., 2017). The RAM includes two modes, stereotype threat and stereotype embodiment, by which performance can be affected. Both of these modes create a self-fulfilling prophesy of task disengagement and poor performance. Negative SPA can be a sign of stereotype embodiment. Stereotype embodiment and stereotype threat can deter older adults from engaging with physical activity and impede physical performance (Swift et al., 2012; Wurm, Warner, Ziegelmann, Wolff, & Schüz, 2013). Endorsement of negative SPA is associated with embodiment of negative stereotypes (Levy, 2009), so SPA could predict disengagement from activities which promote older adults' health. Although this study did not test these pathways experimentally, taken together these findings suggest that SPA may be used as an indicator of susceptibility to frailty and so might be considered a psychological component of the frailty phenotype.

Self-efficacy might contribute to this cycle of underperformance and reduced engagement in physical activity (Bandura, 2004). Self-efficacy is broadly the confidence someone has in their ability to perform a task. When self-efficacy is higher, it is associated with better physical performance and increased physical activity. For example, sedentary behaviour is predicted by self-efficacy both in adopting and maintenance of vigorous and moderate exercise programs in community dwelling adults (Sallis et al., 1986). Moreover, Belka et al (2019) identified an inverse relationship between fear of falling self-efficacy and grip strength. They posit that stronger individuals may therefore engage in physical activity with reduced fear of falling and therefore retain muscle strength. This hypothesis is supported assertions regarding the reciprocal relationship between physical activity uptake and self-efficacy (Bandura, 2004). Crucially, negative age stereotype inhibit older adults' physical performance self-efficacy, which in turn is associated with reduced physical functioning (Tovel, Carmel, & Raveis, 2017). However, the causal pathways of SPA and self-efficacy on frailty and falls are not currently clear and deserve additional attention to establish effective intervention methods.

Limitations

The study was potentially limited by missing data because a large proportion of nurse data and self-completion data was absent from the data set. However, the stratified sampling was maintained and so the survey data is still valid to the UK population. Also, as a cross-sectional cohort study, the research is limited in determining causality. However, this research has established the importance of continuing this line of enquiry, as SPA appears predictive of future health outcomes (Wurm et al., 2008, 2013). Further, while these results are statistically significant, the practical importance of early identification of frailty is considerable. Using data from subsequent waves of ELSA data, it will be possible to investigate longitudinally the relationships between SPA with risk of frailty and falls. Therefore, further research is warranted in translating these findings to sensitive measures of frailty and falls risk.

There were also some intriguing findings. Unexpectedly, timed walk and physical activity level did not form the final model predicting falls. As strength is the result of physical activity, then grip strength may account for any benefit of physical activity on fall risk. This is supported by the mediation model as physical activity predicted grip strength, which predicted falls. Existing literature demonstrates the practical application of grip strength in predicting timed walk (Glenn, Gray, & Binns, 2017) and fall risk (Van Ancum et al., 2018). This adheres to the finding that timed walk and physical activity did not make a unique statistical contribution in addition to grip strength in these models. In this case, grip strength may account for physiological and psychological factors which may predispose falls. Further, while walk times were included in initial models in falls prediction, people most vulnerable to falling would not have taken this walk test due to safety concern or disability. Evidence suggests that the inability to complete a walk test indicates higher risk of falling (Martín-Ponce et al., 2014).

Although the effect of SPA on outcomes was significant, this effect was smaller than other factors (such as grip strength, sex, and smoking). This does not marginalise the importance of SPA. Indeed, SPA reflects attitudes which can lead to intentions and behaviours (Oliver, Hudson, & Thomas, 2016; Ryan & Deci, 2000), which in turn affects to health outcomes. There are potentially many other factors which may confound or co-vary with the effect of SPA, which when controlled or modelled may further elucidate the effect of SPA. Also, SPA may form a wider set of beliefs and expectations which determine intentions and behaviour. Certainly, this research offers an enticing opportunity to continuing exploring the role of SPA on physical activity, physical performance, and falls.

The research highlights the important associations of SPA with physical activity, physical performance, and falls risk. Promisingly, existing research supports the translation of the relationship between SPA and physical activity into practice. For instance, an intervention to target older adults' views on ageing showed improved age attitudes and increased activity levels (Wolff, Warner, Ziegelmann, & Wurm, 2014). Therefore, some inference can be made about the direction of causality of SPA on the measures of frailty, that SPA precedes physical activity levels and performance. For this reason, SPA could be developed as an additional diagnostic screening tool to detect frailty risk. Also, this finding is promising because it suggests that SPA may be malleable. Therefore, SPA could help inform development of psychological interventions. For example, SPA intervention could be delivered in advance of physical rehabilitation after a fall, or to encourage positive behaviours and health outcomes as people grow older.

Conclusion

Ultimately, understanding older adults' self-perceptions of ageing and the mechanisms by which these operate may offer opportunity to improve early identification of vulnerability to frailty and also inform effectively targeted interventions. Developing understanding in this area presents a potential gateway to progressing public health strategies and improved health outcomes in older adult populations. There is opportunity to continue discovery of the pathways by which SPA can affect physical abilities. Doing so could have benefit at personal, social, and economic levels. Finally, while Study 1 and Study 2 are laboratory based studies, Study 3, although using a representative sample, is correlational. Therefore, the next step in this thesis is to explore the relationships between attitudes to age, age stereotypes and activity in applied settings. Studies 4 and 5 do this by investigating the effect of two different physical activity programs, in the community and in care homes, respectively.

Chapter 8 - Intergeneration dance theatre reduces younger people's implicit negative age attitudes

Abstract

Intergenerational contact has benefits for both younger and older generations, for younger people it can reduce negative age stereotypes, and reduce anxiety about getting older (Drury, Hutchison, & Abrams, 2016). For older generations, intergenerational contact can improve wellbeing and cognitive performance (Abrams et al., 2006; Teater, 2016). Research suggests that bringing generations together to share a common goal or purpose can facilitate these benefits. Creative arts, such as theatre, can provide space for bringing generations together, but there is very little research evaluating the benefits of these programs. This study sought to evaluate a Moving Memory dance theatre group intergenerational program (younger group N = 12, mean age = 18.5; older group N = 9, mean age = 65 years), working towards a performance. The study attempts to assess the impact of the program and intergenerational contact on attitudes to age, self-esteem and wellbeing, which were measured before and after a 14-week program. A comparison of IAT response times (RT) before and after the program showed younger people demonstrated less bias towards stereotype congruent stimuli (young = good) after the program. There was a trend for improvements in self-esteem, although this did not reach significance. Further, younger participants' frequency and quality of contact with older adults were significantly correlated with their IAT score (number correct) before and after the program. Importantly, the reduction in IAT bias for stereotype congruent stimuli as measured by reaction time demonstrates benefits of the using dance theatre to reduce ageism. The study highlights the potential for intergenerational dance theatre to maintain positive intergenerational contacts. Although findings are limited by sample size, this study has implications for translating intergenerational contact theory into practice.

Introduction

The benefits of remaining physically active in later life to physiological health, wellbeing and quality of life have been well established (BMA, 2016). The World Health Organisation (WHO) summarises that participation in 'social, economic, cultural, spiritual and civic affairs' (WHO, 2002) are crucial to older adults' wellbeing. Providing these opportunities, irrespective of physical and cognitive decline, underpins the WHO's active ageing agenda, where active ageing is defined as "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (WHO, 2002). In addition, the positive psychological effects of participation, inclusion and activity, can in turn perform a crucial protective role against functional limitations (Matarasso, 1997; McAuley, Szabo, Gothe, & Olson, 2013). Remaining physically active in later life can have important positive effects on wellbeing and quality of life too (BMA, 2016). This relationship may be bidirectional as wellbeing may protect against functional limitations (Matarasso, 1997; McAuley, Szabo, Gothe, & Olson, 2013).

Age UK (2017) posit that creative and cultural participation such as art and dance is one of the top three most important contributors to older adults' wellbeing. Indeed, theatre performance has been found to improve older adults' quality of life and physical performance (Noice, Noice, & Kramer, 2014). These reports highlight the importance of physical activity both for social and clinical purposes. Furthermore, The Department of Health recommends participatory performance art interventions, which improve balance and falls outcomes, enhance wellbeing, and have systemic positive impacts in terms of self-identity (Department of Health, 2011).

An example of an artistic project that involves creative expression and physical activity is dance theatre. Moving Memory is a Kent-based dance theatre group that bring older adults together to rehearse and perform autobiographic dance. The autobiographical elements of this are interesting because self-identity is a crucial factor for predicting engagement with physical activity (Strachan, Brawley, Spink, & Glazebrook, 2010). In this questionnaire study of older adults attending physical activity classes, past experiences of physical activity predicted physical activity identification. Moreover, when people more highly identified with physical activity then life satisfaction was also greater. That is, people who think it is more important to participate and engage in physical activity because it is a core part of their identity also reported higher levels of life-satisfaction. Although caution should be applied when interpreting correlational studies, this suggests that stronger physical identification could be important for life satisfaction. In another study, wellbeing benefits from physical activity was demonstrated (Stoll & Alfermann, 2002). Participants completed different questionnaires about general wellbeing before and after either a 14-week mixed exercise program (including elements of endurance, strength, coordination and flexibility), a foreign language course, or no intervention. The exercise program, but not the control groups, showed improvements to body self-concept. This measure captured how someone perceived their physical fitness, physical attractiveness, and physical self-worth. So, this study demonstrates the way physical activity can affect an individual's view of themselves. In terms of age identity, self-perceptions of ageing are correlated to the adoption of preventative health behaviours such as eating a healthy diet, and exercise frequency Levy & Myers, 2004). This highlights the importance of positive age identity for older adults' psychological and physical heath. An individual's self-esteem, broadly defined as their self-worth, is dependent upon identity and self-concept (Baumeister, 1999; Deci & Ryan, 1995). The interaction between these aspects is essential to understand as engagement in physical activity can improve the way someone sees themselves and so can affect their sense of self-worth.

The intergenerational element of Moving Memory is interesting because positive intergenerational contact can reduce older adults' susceptibility to stereotype threat. Stereotype threat theory asserts that the presence of an unfavourable social comparison elicits a negative affective and physiological response (Levy et al., 2008), and reduces older adults' cognitive (Barber, 2017) and physical performance (Hausdorff et al., 1999; Swift et al., 2012). Intergenerational contact is shown to reduce older adults experiences of stereotype threat, even when imagined (Abrams et al., 2008). Older participants (age M = 72 years) were asked to 'imagine meeting a young stranger for the first time' (contact condition). They were instructed to note the young person's appearance, conversation, and things that could be learnt from the stranger. Alternatively, participants imagined an outdoor scene (no contact). On a subsequent maths test, the contact condition were not as vulnerable to stereotype threat, they performed better on the maths test and were less anxious about the test than the no contact group were. Moreover, intergenerational contact is evidenced to reduce perceptions of prejudice (Pettigrew & Tropp, 2006). This is in line with contact theory which asserts that intergroup conflict can be reduced through developing shared goals, cooperation, equal status and organisational support (Pettigrew, 1998). This is important because reducing perceptions of prejudice can have important self-identity and self-esteem benefits (Major, McCoy, Kaiser, & Quinton, 2003).

Drury (2016) asserts that intergenerational contact can reduce younger people's anxiety about meeting someone from an older age group (intergroup anxiety), and also reduce their worries about growing older themselves (ageing anxiety). Young people held more positive age attitudes when either direct or indirect contact with older people was higher quality, and this effect was mediated by intergroup anxiety and ageing anxiety. Similar effects are also achieved when these contacts are imagined, as imagined contact decreased ageing anxiety (Prior & Sargent-Cox, 2014). Further, Abrams (2006) demonstrated that more positive intergenerational experiences prior to a cognitive task reduced feelings of prejudice and also reduced in-group identification. These positive experiences also moderated the age based stereotype threat effects on a cognitive task. Translating intergroup contact theory in practice, more favourable attitudes have been found across various applications. For example, intergenerational shared activities such as music and show and tell (Meshel & McGlynn, 2004) have improved both younger and older people's attitude toward the other group in a 6 week program. Moreover, in this study, older adults' life satisfaction was more positive after the intervention. These research findings support the World Health Organisation's approach to tackling international ageism. This approach posits that in order for active and healthy ageing to take place then age barriers and ageism need to be reduced (WHO, 2002).

This evaluation of the Moving Memory project seeks to identify the effects of intergenerational dance theatre on older and younger people's, implicit and explicit age attitudes, intergenerational anxiety, and self-esteem. In line with contact theory it is hypothesised that:

1) The greater contact frequency and quality achieved through the intergenerational dance workshops will improve younger people's explicit attitudes to age, reducing young people's ageing anxiety and intergenerational anxiety,
2) As intergenerational contact can reduce negative age attitudes, then more positive implicit age attitudes is also expected across age groups,
3) Participation in the Moving Memory dance theatre project is also expected to benefit older and younger people's self-esteem.

Method

In June to August 2018 The Moving Memory Dance Theatre Company, in partnership with Gulbenkian, Canterbury and Kent County Council, and Arts Council England, delivered a project which included aims to introduce older people to creative activity. The project involved dance theatre weekly 2-hour workshops for 10 weeks for active older and younger people, culminating in the production of a new performance piece entitled 'Start Stomping'. It was performed six times in outdoor public locations, premiering at 'Boing!' festival, Kent. Moving Memory recruited to the project through word of mouth, University of Kent Students' Union, Moving Memory website, and existing community groups. Outcome measurements were recorded before the program had started, then again after the program had finished in a single-arm within-subject design. Explicit measures of intergenerational contact experiences were completed by young people only. Research ethics were approved by the University of Kent Research Ethics Advisory Group (Prop 102_2017_18).

Participants

Participants consisted of 21 individuals either in younger (n = 11; mean age=18.5, SD = 2.2) or older (n = 10; mean age= 65, SD = 5.0) age groups who had enrolled in the dance theatre project. Participation in the study was not a prerequisite of taking part in the dance theatre workshop.

Procedure

Paper-based and computer-based data collection was conducted before a 14-week series of dance theatre workshops had commenced, and then data collection was repeated two weeks following the performance.

Measures: All participants

Implicit attitudes - measured via the Implicit Age Attitudes Test (IAT; Greenwald, Mcghee, & Schwartz, 1998). The IAT is a computer-based reaction time task used to measure the strength of associations between two pairs of concepts, with faster reaction times indicating stronger link between the two concepts. It has been used extensively to quantify implicit prejudice (Greenwald & Banaji, 1995; Greenwald, Nosek, & Banaji, 2003). Participants respond to either young or old face stimuli with positively or negatively valence words (e.g. joy, happy or hate, disgust). According to Greenwald et al (2003), the more closely related a concept is with an evaluation, the faster and easier participants will respond to it, therefore, participants should be quicker to match and pair consistent or congruent related concepts (young face with positive words, or old face with negative words) than incongruent concepts (young faces with negative words or old faces with positive words). Following a brief practice trial to familiarise with the keyboard and procedure, participants were shown 20 randomised trials in four blocks: young vs old faces, positive vs negative evaluative words, congruent faces and words (good words and young faces), then incongruent faces and words (e.g. good words and old faces). The average response times of categorising stimuli in the congruent condition are compared to the incongruent condition. Participants who categorise items faster in the congruent condition are considered to have an implicit preference for young people compared to old people (Greenwald et al. 2003).

The IAT was administered via PsychoPy software delivered via PC and was based on Harvard IAT (https://implicit.harvard.edu/implicit/Study?tid=-1). The program was developed by University of Kent Psychology Support Team. Reaction time and number of correct items per block were recorded. Then, two composite measures were calculated by subtracting the congruent trials score from the incongruent trials score for response time and number correct. This means that for reaction time, lower negative scores (further below 0) indicate greater preference for stereotype congruent stimuli (young = good) and higher positive scores (further above 0) indicate greater preference for stereotype incongruent stimuli (old = good).

Self-esteem - measured using Rosenberg's Self Esteem ten-item questionnaire (Rosenberg, 1965). Items included statements such as "I wish I could have more respect for myself". Participants rated agreement/ disagreement with the statements using a 4-point scale. Higher numbers indicate higher self-esteem.

Measures: Younger group only

Explicit measures of intergenerational contact experiences (The Intergenerational Contact Questionnaire; Drury et al, 2016):

- *Current contact frequency* – participants reported on a scale how often they interact with older people (1 - very rarely to 7 - very often).
- *Contact quality* – measured by three 7-point scales (1 - none to 7 - very many).
- A composite measure was calculated from contact frequency and contact rating as in previous research (Drury et al. 2016).
- *Intergenerational anxiety* - measured on three pairs of bipolar adjectives asking participants how they would feel interacting with older adults on a 7-point scale (1= tense to 7 = relaxed, 1 = calm to 7 = nervous (R), 1 = stressed to 7 = unstressed). Participants were instructed that this should be interaction with a typical older adult and not specifically someone that they interact with. Higher scored responses indicated more intergroup anxiety. Similar measures have been used in previous research (e.g. Bousfield & Hutchison, 2010)
- *Ageing anxiety* – measured through four scales where participants responded how they felt about ageing themselves: 'I am worried that I will lose my independence when I am old', 'I am relaxed about getting old', 'I am concerned that my mental abilities will suffer when I am old', and 'I do not want to get old because it means I am closer to dying'. Responses were recorded on a 7-point scale (1 - strongly disagree to 7 - strongly agree). Higher scores indicate greater anxiety about ageing. This is adapted from scales used in previous studies (e.g. Lasher & Faulkender, 1993).

Participant age and gender were also recorded to control for demographic factors which may affect measures.

Statistical analysis

Between (age group) and within-group (before or after intervention) differences were investigated with repeated measures analysis of covariance. Levene's test tested for equality of variances. All analyses were conducted using R (R Core Team, 2019, R: Vienna, Austria).

Results

Preliminary analysis revealed no statistically significant differences between younger and older age groups on all measures (all p >.05). However, T-tests showed a marginally significant effect that older people had slightly lower self-esteem, $t(16) = 2.06$, $p = .06$ (*Mean* older = 1.8; younger = 2.2; *SD* older = 0.45, younger = 0.45). Correlations between variables are presented in Table 8.1. Pre-intervention, younger people reported high levels of contact quality (M = 6.0, SD = 0.7) and quality (M = 5.7, SD = 1.2) with older adults. The more often that a younger person had contact with an older person then the higher their rating of quality was likely to be ($r(9) = 0.6$, $p = .02$). Additionally, younger participants' IAT score (number correct) was positively correlated with contact frequency ($r(9) = 0.8$, $p = .02$), and with contact quality ($r(9) = 0.7$, $p = .046$). When younger people had more frequent and better quality contact with older people, then the difference in number of IAT items correct was smaller between congruent and incongruent trials. A similar association was found between the composite contact experience measure and IAT number correct ($r(9) = 0.8$, $p = 0.02$). This implies that when younger people had greater contact with older people then they showed less preference for stereotype consistent stimuli, so potentially demonstrated less ageism.

Contact measures were also significantly correlated with ageing anxiety, where more frequent ($r(9) = 0.9$, p <.001) and higher quality ($r(9) = 0.9$, p <.001) contact were associated with less ageing anxiety. This was reflected in the composite contact measure too ($r(9) = 1.0$, p <.02).

Contrary to expectations in hypothesis 1, ANOVA did not show any significant change over time for any of the questionnaire-based explicit measures of ageing anxiety or intergenerational anxiety (before vs after intervention).

Table 8.1: Correlation of baseline measures

	M (SD)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. Contact Frequency	6.0 (1.3)									
2. Contact Rating	6.5 (0.6)	0.6								
3. Contact Score	6.25 (0.8)	0.9 ***	0.9 ***							
4. Intergroup Anxiety	5.3 (0.9)	0.3	0.5	-0.2						
5. Ageing Anxiety	4.3 (0.9)	0	-0.2	-0.3	-0.2					
6. Actual Age	45.8 (26.6)	0.9	0	-0.9	0.9	-0.4				
7. Subjective Age	38.2 (19.0)	-0.9	0.8	0.2	-0.4	1	1 ***			
8. IAT Difference (RT, s)	0.9 (7.3)	0.3	0.6	-0.4	0.4	0.6	0.6	0		
9. IAT Difference (Number correct)	3.3 (11.9)	0.8 *	0.7 *	0.8 *	0.8	0	-0.2	-0.2	-0.1 **	
10. Self Esteem	2.1 (0.9)	0	-0.3	-0.3	0.2	-0.1	-0.6	-0.6	-0.4	-0.4

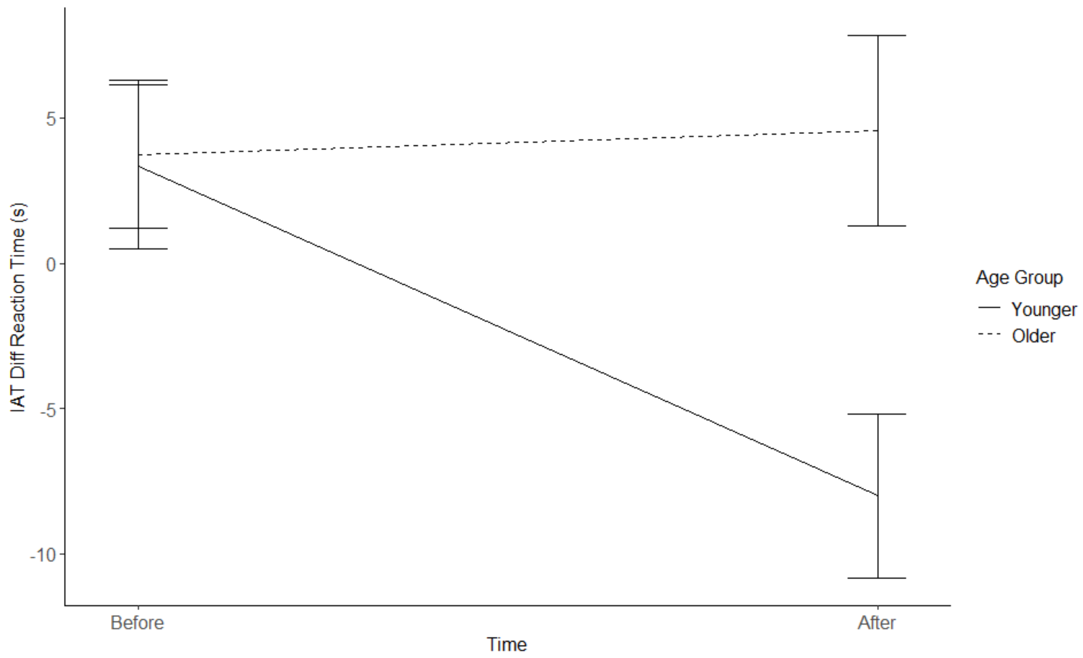
*Note: * indicates significance at p<0.05, ** indicates significance at p<0.01, *** indicates significance at p < 0.001*

Hypothesis 2 was that that implicit preferences for younger adults relative to older adults would be higher before the intervention than afterwards. For younger participants, this difference should be greater, showing the intervention reduces implicit bias against older adults. For older participants, this difference is likely to remain unchanged. After adjusting for two outliers in the younger group (extreme IAT RT values), T-tests showed that there was no significant difference between age groups in congruent vs incongruent RT or number correct ($p > .05$). Except, a marginally significant difference in reaction time between age groups was apparent after the intervention, where younger people showed less bias for younger faces than older people did (Older group *M* = 3.74, SD = 1.76; Younger group *M* = -8.01 seconds, *SD* = 9.9).

Repeated measures ANOVA showed a significant interaction effect between time (before vs after intervention) and age group on IAT RT ($F(1,12) = 4.45$, $p = 0.05$, $\eta^2 = 0.17$). Post-hoc Tukey HSD tests revealed that young people's IAT RT (difference between congruent and incongruent trials) showed the preference for stereotype congruent stimuli (congruent score greater than incongruent score) was reversed (difference before intervention *M* = 3.32 seconds *SD* = 0.99; after *M* = -8.01 seconds, *SD* = 9.9).

T-tests showed that older people reported lower self-esteem than younger people overall, $t(22) = 2.33$, $p = .03$ (younger *M* = 2.4, *SD* = 0.9; older *M* = 1.8, *SD* = 1.0). In relation to hypothesis 3, mixed models with person as random intercept showed that although there was a slight increase in reported self-esteem following the performance (before intervention *M* = 2.0, *SD* = 0.9; after intervention *M* = 2.3, *SD* = 1.2), this did not reach significance ($p > .05$). There was no interaction between time and age group ($p > .05$).

Figure 8.1: Differences in IAT reaction time between age groups over time



After the intervention, younger people's IAT response time score (difference between congruent and incongruent trials) was significantly lower.

Table 8.2: Measures for younger people before and after the intervention

	Baseline		**After Intervention**	
	Mean	*SD*	*Mean*	*SD*
Self-Esteem	2.2	0.4	2.8	1.3
Contact Frequency	5.7	1.2	5	1.4
Contact Quality	6	0.7	5.8	1
Intergenerational Anxiety	5	1.3	4.8	1
Ageing Anxiety	4.4	0.7	4.7	0.9
IAT Score - reaction time	3.3	1	-17	15.9
IAT Score – number correct	2.3	0.5	-0.5	10.3

Note: Mean and standard deviation.

Table 8.3: Measures for older people before and after the intervention

	Baseline		**After Intervention**	
	Mean	*SD*	*Mean*	*SD*
Self-Esteem	1.8	0.4	1.9	0.6
IAT Score - reaction time	3.7	4.6	4.6	1.8
IAT Score – number correct	10.2	17.9	1.3	0.6

Note: Mean and standard deviation.

Discussion

The intergenerational dance programme indicated a change in younger people's implicit age attitudes indicating a reduction of ageism, supporting hypothesis 2. Further, implicit attitudes were more favourable of older adults when contact experiences were better i.e. frequent high quality contacts with older people. Importantly for the younger participants, stereotype embodiment theory would suggest that this may have positive downstream consequences in terms of embodiment of a positive age stereotypes when the younger cohort grow older (Levy, 2009).

This is important as stereotype embodiment can have an impact on all four domains of active ageing (economic, behaviour, social, personal). For example, physiological effects of negative age attitudes have been identified which show increased susceptibility to adverse cardiovascular events (Levy, Hausdorff, Hencke, & Wei, 2000). Furthermore, when negative age attitudes are held by individuals, this may increase the risk of stereotype threat. This occurs when an individual is at risk of confirming a negative stereotype about a group they may be perceived as belonging to (Steele & Aronson, 1995). Cognitive and physical performance effects have been found when older adults are threatened in this way. For example, stereotype threat effects have been shown to reduce older adults' memory (Lamont et al., 2015) and strength (Swift et al., 2012) performance. When the perceived risk of stereotype threat is high, individuals may escape potential negative age-related appraisal by avoiding the situation entirely. In the case of older adults' physical health, this may include avoiding exercise or physical activity. Ultimately, that negative age attitudes were reduced in this intervention suggests that the risk of stereotype threat is reduced, which may have important benefits for performance and engagement in physical tasks as the younger group grow older.

Meanwhile, the explicit questionnaire measures remained unchanged. Although this was contrary to hypothesis 1, this is in line with stereotype theory that stereotypes operate by subtle mechanisms, often below the surface of awareness (Levy, 2003). Stereotypes offer a heuristic for fast and efficient cognitive processing and are selectively recalled, therefore reinforcing stereotype congruency. Exemplifying this, when college students asked to make decisions about negative traits they were faster when primed with the word 'old' than with the word 'young' (Perdue & Gurtman, 1990). At a younger age, downward social comparison towards older people tends to be favourable as distinctiveness is gained from older outgroups and higher status is asserted (Tajfel & Turner, 1979). However, unlike other forms of prejudice, age stereotypes held in youth are embodied into self-stereotypes as those people grow older. The current research demonstrates a successful intervention to reduce negative age self-stereotypes and stereotypes of ageing and therefore challenge the embodiment of negative stereotypes of age.

Alternatively, it is quite possible that this study was underpowered to detect significant changes in these measures. In relation to hypothesis 1 and 3, social desirability effects may be apparent in the explicit measures of ageing and self-esteem. Therefore, in the baseline questionnaires it is feasible that younger participants felt obliged to report more favourably of older adults and ageing, especially so as they had already enrolled on an intergenerational dance theatre project. This would therefore reduce the strength of the change in age attitudes and increase the need for additional power. Expected effects in terms of improvements in self-esteem and contact experience were not identified, and this may have been due to combination of time-sensitivity, factors of social desirability, or adequate statistical power to identify more subtle changes. Importantly, this study lacked a control condition, so it is not possible to ascertain whether changes were dependent on factors other than the intergenerational dance theatre. Nevertheless, the findings are consistent with existing literature (Abrams et al., 2008). Additionally, while the benefits of improved age attitudes might have important consequences for health and wellbeing later on, it is not possible to determine the permanence of the effects from this study. The exploration of these effects longitudinally would be beneficial to understand how these improved attitudes change over time.

Younger people's implicit age attitudes improved following the Moving Memory dance theatre program. This suggests stereotypes of ageing are more positive, which could serve a protective function through the life course in terms of internalisation of ageing representations (Levy, 2009), as well as the reduction in prejudiced attitudes towards older adults (del Carmen Requena et al., 2018). These findings translate intergenerational contact theory into practice, extending understanding of the ways that negative attitudes may be intervened.

Chapter 9 - An armchair-based dance program can improve care home residents' physical performance and wellbeing

Abstract

Care home residents spend considerable time sedentary, and this is associated with clear risks. Even in frail populations, physical activity has physiological and psychological benefits that increase resilience to the physical and mental health deterioration prevalent in older populations. Therefore, overcoming barriers for care home residents to engage in physical activity is paramount. The purpose of this study was to investigate the change in older adults' wellbeing and physical performance from a 10-week intervention of armchair-based dance. Participant engagement in the program was expected to improve age attitudes which would be related to improvements in psychological and physical measures. To explore this, 48 participants from 5 care homes in Kent were visited twice before the program commenced to complete baseline assessment, and once after it had finished to assess changes from this baseline in a pre-post design. Physical performance was measured using handgrip dynamometry and seated functional reach test. Wellbeing was assessed by a range of questionnaires. Age, sex, and presence of a health condition were controlled for. Results showed that physical activity levels increased ($F(1, 33) = 3.73$, $p = .048$) when people attended the program (baseline $M = 1.70$, $SD = 0.3$; post-intervention: mean = 2.26, $SD = 0.3$) compared to people who did not attend (Baseline $M = 1.61$, $SD = 0.4$; Post- intervention $M = 1.42$, $SD = 0.3$). When physical activity increased, then there was an increase in non-dominant handgrip strength ($F(1, 33) = 4.56$, $p = .04$). Generally, increases in physical activity were associated with more positive age attitudes and greater quality of life. Attendance in the sessions was associated with reduction in negative age attitudes and increased feelings of autonomy. In the main, the aims of the intervention were supported, although the study was limited by absence of control group and was biased by self-selection of participants to the intervention group. The study highlights the need to identify activities which promote care home residents' physical activity, as well as methodological challenges testing this population.

Introduction

Increasing longevity demonstrates the success of 20th century medicine and lifestyle, but as people live longer, they are also more likely to be living with one or more long term conditions. Approximately 92% people of people living in a UK care have at least one long term condition, and 17% have at least three conditions (Bowman, Whistler, & Ellerby, 2004). Frailty is widely considered a long-term condition and is prevalent in around 6.5% of the population over 60 years, rising to 65% in those over 90 years (NHS, 2019). With appropriate physical activity intervention, health and wellbeing outcomes may be improved for people with frailty (Academy of Medical Royal Colleges, 2015). Better evidence is required to identify and develop interventions that maintain or improve health, wellbeing and independence, and the imperative for this is captured by the emergence of Social Prescribing Policy (NHS England, 2019). There is evidence that older adults' positive self-perceptions of ageing are associated with increased physical activity (Andrews et al., 2017) and better health outcomes (Levy, Slade, Kunkel, & Kasl, 2002). This therefore presents mechanisms to be leveraged for intervention to promote care home residents' health.

The British Medical Association (Wilson, 2016) assert the importance of being physically active in older age. This can help maintain the ability to perform physical tasks. Retaining physical ability is not only essential to carry out tasks of daily living, but it is also predictive of health outcomes. For example, those in the lowest third handgrip strength are the most likely to be hospitalised or die due to a chronic health condition (Leong et al., 2015). Physical activity is known to curb the trajectory of age-related biological decline such as sarcopenia, age-related loss of muscle mass (Marcell, 2003), and can also increase longevity and increase disability-free lifespan (Ferrucci et al., 1999; Hubert, Bloch, Oehlert, & Fries, 2002). Physical activity also promotes mental health (Arent, Landers, & Etnier, 2000; Netz, Becker, Tenenbaum, & Wu, 2005). In addition to intrinsic enjoyment and pleasure from physical activity (McPhee et al., 2016), these benefits could be attributed to physiological (Adlard & Cotman, 2004; Stranahan et al., 2008) and psychosocial (McAuley et al., 2000) factors. For example, in an experimental setting, McAuley et al. (2000) evaluated aerobic and strength training training in older adults, and found that exercise frequency and improvements in social relations were key determinants of improvments in subjective wellbeing. This relationship is shown to be recipricol, as in longitidunal analyses, Steptoe et al (2015) showed that wellbeing seems to serve a protective role against mortality and disease. Therefore, intervening in the negative cycle of wellbeing and deteriorating physical health by engagement in physical activity is therefore crucial.

In Chapter 7, the significant association between physical activity, age attitudes, and physical performance was demonstrated using ELSA survey data. When older adults' age attitudes were positive, then engagement in physical activity was higher, and physical performance was better, compared to people with more negative age attitudes. There is empirical basis underpinning this direction of causality, as self-perceptions of ageing may reflect embodied age stereotypes which prompt disengagement from activities in older age (Swift et al., 2017). However, there is also reason to believe that this relationship is bidirectional, that engagement in physical activities decrease negative age attitudes. Previous positive experiences of physical activity increase physical task self-efficacy and can increase self-esteem (Mcauley, Blissmer, Katula, Duncan, & Mihalko, 2000; McAuley et al., 2005). This means that initially low-intensity intrinsically pleasurable activities may provide a gateway to more vigorous activities with greater physiological and psychological benefits.

Despite these benefits, everyday activities seem to present more challenges with ageing and risks and withdrawal from exercise behaviour is not uncommon (Garber et al., 2011). In care homes, sedentary behaviours are the most common, with 79% time spent sedentary compared to just 1% time spent in moderate to vigorous activities (Age UK, 2015). This is concerning as physical inactivity has been highlighted as risk factor for a range of diseases, as well as physical frailty and mortality (Booth, Roberts, & Laye, 2012). Evidence suggests there are both physical and psychological barriers to older adults' engagement in physical activity. Many older adults perceive their physical health as a barrier to a physically active lifestyle (Chen, 2010; Rhodes et al., 1999). Additionally, mobility difficulties can lead to depression, and further disengagement from physical activities (Keogh, Kilding, Pidgeon, Ashley, Gillis, 2005). This means that a vicious cycle is propagated unless a suitable intervention is identified.

Psychosocial factors may contribute to creating a barrier for older adults to be physically active. For example, in cross-sectional survey, older adults' (mean age = 71) age attitudes were found to be associated with physical activity levels (Meisner et al., 2013). These results are supported by longitudinal findings. Positive attitudes of ageing were found to be predictive of physical activity in follow up 6 years later, even when controlling for health condition (Wurm et al., 2010). Levy (1996) showed that the effect of negative age stereotypes on memory performance is mediated by self-efficacy. Briefly, self-efficacy is defined as the confidence an individual has in their ability to perform a task (Bandura, 1977). This means that socially dependent age stereotypes can affect the confidence that someone has in their ability to complete a task, which influences their performance as result. Physical performance can be predicted by an individual's self-efficacy too (Seeman, Unger, Mcavay, & Mendes De Leon, 1999). As well, older adults engagement with physical activity is associated with self-efficacy (McAuley, 1993). Furthermore, McAuley et al. (2013) purport the relationship between wellbeing and physical activity is also mediated by self-efficacy. Consistent with self-efficacy theory (Bandura, 1977), the researchers assert that the relationship that self-efficacy shares with physical activity is reciprocal, that an individual's physical activity self-efficacy is bolstered by previous experience of physical activity, and that previous outcomes are a strong predictor of future physical activity. This means that older adults' self-perceptions of ageing are a crucial factor of consideration when identifying ways to promote older adults' physical activity uptake.

In summary, ABST and stereotype embodiment studies show how stereotypes and attitudes to age impact on performance and engagement in activity (Swift et al., 2017). This relationship may be reciprocal, as physical activity has a bidirectional relationship with other measures of wellbeing (McAuley et al., 2000). Therefore, the purpose of this study is to explore and evaluate the impact of a physical activity intervention on usual outcomes (performance and wellbeing) but also on novel outcomes not explored before (attitudes to age).

Previous intervention evaluations have detailed the value of physical activity to wellbeing. However, their effect on improving attitudes to age is less well known. If the intervention can improve attitudes to age, then it strengthens evidence for health and competence related age stereotypes. Such evidence is useful, because it can further inform theoretical understanding of age stereotypes in relation to physical activity, and can help inform future interventions.

The Right Step is a Kent-based company of 15 professionally trained dancers delivering workshops to targeted populations. This company deliver a program called Active Armchairs, which is an armchair-based dance program aimed at older adults in care. It was designed in 2011 with support from Age Concern (now Age UK) and CVS Medway (now Medway Voluntary Action) to provide physical activities and social experiences for older adults. Active Armchairs has been delivered in over 20 care homes and day centres across Kent. Props, music, movement, and games play a part in the session to facilitate and promote physical activity.

The aim of this research is to investigate the causal relationship of physical activity upon age attitudes and ABST, and whether wellbeing and physical performance also improves as a result. Specifically, the research will evaluate whether engagement in Active Armchairs program improves care home residents wellbeing, and improves performance in physical tasks which have clinical importance as they are indicative of functional ability.

To evaluate the effect of older adults' attendance at the Active Armchairs program, psychological measures will be captured by self-report questionnaire, and physical performance will be measured by seated functional reach, hand grip strength, as well as by a questionnaire to be completed by care home staff (functional independence measure), and tested in a pre-post design. Attending the Active Armchairs sessions is expected to improve age attitudes, which will be associated with increased self-efficacy and greater wellbeing, as well as improved physical performance.

Hypotheses

1) Participation in Active Armchairs dance program will improve physical performance as measured by hand grip strength and functional reach. Functional assessments made by staff are also expected to reflect improvements in physical performance.

2) Participation in Active Armchairs dance program will improve attitudes to age and positive effects on self-reported psychosocial measures relating to wellbeing (loneliness, self-efficacy, self-esteem, and CASP).

3) There will be a positive relationship between physical performance and the psychological measures relating to wellbeing. That is, improvements in physical performance will be related to improvements in psychological measures.

Method

The intervention observational field study was a multi-centre, single-arm within subjects design. Physical and psychological measures were taken before the Active Armchairs program had started, then again after the 10 week program had finished. Research ethics were approved by the University of Kent Research Ethics Advisory Group (Reference 0621819).

Participants

From 5 care homes across Kent, 48 people took part in the study (41 females, 7 males). Eligibility was determined on the basis of the capacity to consent independently. This assessment was carried out according to the Mental Capacity Act (2005) two-part screening for mental capacity to consent. Participants were eligible if they free from neurological conditions or serious health complications that would make tests unsafe to carry out.

Procedure

Participants carried out a seated test of functional reach, and maximal handgrip strength in self-selected dominant and non-dominant hand before completing questionnaires. The procedure was carried out in a room controlled from external distraction, and in the same room on each occasion per care home. Data collection was carried out on three occasions: 5-weeks before the start of the intervention (T1), one week before the start of the intervention (T2), and one week after the intervention (T3), at 0, 5, and 15 weeks respectively. The 10-week armchair-based dance intervention commenced after the baseline data was collected. The two pre-intervention (T1, T2) trials allowed the stability of the baseline to be assessed. The researcher was not informed who attended the sessions until after the final data collection to protect from bias.

Physical measures

Grip strength - measured using a digital hand dynamometer (MIE, Leeds: UK), repeated three times on each hand to ensure accuracy. The maximum value was recorded.

Modified functional reach test – While seated adjacent to a wall with the arm closest to the wall outstretched horizontally, participants reached forward. The change between start and end position of the first interphalangeal joint was recorded (Lynch, Leahy, & Barker, 1998).

Figure 9.1: Modified functional reach test.

Picture from https://www.uni-muenster.de

Psychosocial measures

Self-esteem – The Rosenberg Self-Esteem Scale (Rosenberg, Schooler, Schoenbach, & Rosenberg, 1995) is a commonly used 10-item questionnaire for measuring self-esteem, which is a general measure of self-worth (four response categories strongly 1

= disagree/ 4 = strongly agree). Scale score reliability was acceptable (a = 0.74). Higher scores indicate greater self-esteem.

Age attitudes - The Age Attitudes Questionnaire (Laidlaw et al., 2007) consists of three sub scales. Each subscale consists of 8 items rated for agreement against a 5-point scale e.g. “I see old age mainly as a time of loss”, “My health is better than I expected for my age”, “Wisdom comes with age”. These were acceptable for the psychosocial (a = 0.83) and psychological growth (a = 0.72) subscales, although scale reliability for physical change subscale was poor (a = 0.49). Scores were reverse coded so that higher scores reflected more positive attitudes.

Self-efficacy – The Self-efficacy for Exercise Scale (Resnick & Jenkins, 2000) asks participants to rate the confidence out of 100 with which they think they will be able to continue an activity for different periods of time e.g. “I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the next TWO weeks”. Scale score reliability was good (a = 0.84)

Loneliness – Three items from the original UCLA Loneliness Scale (Russell, Peplau, & Ferguson, 1978) (e.g. “how often do you feel left out”) which have been validated for use with older adults (Hughes, Waite, Hawkley, & Cacioppo, 2004; Steptoe, Shankar, Demakakos, & Wardle, 2013), were included. Scale score reliability was good (a = 0.87). Higher scores indicate greater loneliness.

Quality of life – The CASP-12 questions (Hyde, Wiggins, Higgs, & Blane, 2003; Wiggins, Netuveli, Hyde, Higgs, & Blane, 2008) measures quality of life against 4 dimensions: Control, Autonomy, Self-realisation, and Pleasure (CASP). It is a shorter version of the CASP-19, concatenating the autonomy and control dimensions and validated by the original CASP-19 authors. Items are rated for agreement against a four item scale, e.g. “I feel that my life has meaning”. Higher scores mean greater quality of life. These subscales had acceptable to good scale reliability (Control: a = 0.6, Autonomy: a = 0.71, Self-realisation: a = 0.78, Pleasure: a = 0.74).

Subjective age - “How old do you feel?” Any numeric value below 130. This was included as a simple measure of age identity. As this is embedded with age stereotypes, a low subjective age can indicate that someone has more negative self-perceptions (Hess & Dikken, 2010; Zacher & Rudolph, 2019). This value was then subtracted from the actual age to create the variable for subsequent analyses.

Threat concern – Two questions about how the participant felt during the physical activity testing were rated against a 7 point scale ‘Were you worried that your ability to perform well on the test was affected by your age?’, ‘Were you worried that if you performed poorly on the test, the researcher would attribute your poor performance to your age?’. These questions have been used in previous research (Abrams et al., 2008, 2006), and were also used to measure ABST in Chapter 5 and Chapter 6 higher scores means greater threat experienced.

Current physical activities – Physical Activity Scale for the Elderly (PASE) scale was completed for activities undertaken in the previous week. (Scoring 1 = low physical activity levels, 4 = high).

Functional independence measure (FIM) –This questionnaire measures the level of disability on an 18-point (e.g. communication, grooming, walking) graded classification scale (1=total assistance; 7=complete independence). For the purpose of the current research this was be completed by the care home staff. Scale score reliability was good for the cognitive scale (a = 0.82) and acceptable for the motor scale (a = 0.63).

Session attendance – participants were asked how many sessions they attended. This was modelled as both a dichotomous (yes/ no) and a continuous predictor (number of sessions attended).

Statistical analysis

Due to the potential for decline in health to affect the validity of measuring benefits from the intervention, T1 was compared to T2 to assess baseline reliability of the pseudo-control comparison for all measures. T-tests were used to assess differences between T1 and T2. There were no significant differences between the two pre-intervention data collection points (T1 and T2) for any measures (all $p>0.05$). Then, to adjust for potential individual level variation in scores, the mean for each measure pre-intervention was calculated, i.e. (T1+T2)/2. To investigate the impact of the active armchairs intervention, this baseline was compared to the post-intervention measure at T3.

To investigate whether physical (hypothesis 1) and psychological (hypothesis 2) measures changed over time, and whether this change was dependent on intervention attendance, person and care home were included hierarchically in multilevel regression models to account for random effects. These models are also more suited when data contains missing observations. In line with previous evaluations of physical activity interventions (Bauman et al., 2012; Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Kelley & Abraham, 2004), participants age, sex, and health status were controlled for. Using recommended step forward approach for multilevel modelling (Hox, 2010; Peugh, 2010), Model 1 contained time only, Model 2 included interaction of time with attendance, Model 3 included demographic covariates. Model 4 was the same as Model 3, and also explored the effect of physical activity levels on outcome measures. Conditional and marginal R-squared values are given based on Nakagawa et al. (2017). Briefly, marginal R-squared reflects fixed effects variance only, whereas conditional R-squared also reflects the random effects. Mixed effects model assumptions (linearity, random distribution of residuals, homoscedasticity, normally distributed errors and random effects), were checked by plotting error residuals and random effects.

To address the third hypothesis and assess the relationship between changes in psychological and physical measures, the difference between (averaged) baseline and post-intervention scores was calculated for each measure so that higher numbers showed that scores had increased. Then, the change in physical measures was used to predict change in psychological measures, controlling for the demographics factors.

All analysis was performed using R (R Core Team, R Foundation for Statistical Computing: Vienna, Austria).

Results

Participants

There were 48 participants (age *M* = 82.5 years, *SD* = 10.3) recruited from 5 care homes. The number of participants recruited per care home ranged between 8-

12. There were 7 (15.5%) males at baseline and 19 participants (45.2%) had a self-reported clinical health condition recognised to affect strength. There was no significant difference in the sex, age, or number of health conditions by care home. Most people (N= 33, 85%) attended at least one session. Women attended more sessions than men, ($t(38) = 2.60$, p = 0.03; Women mean = 8 sessions, Men mean = 3 sessions). At T1, 48 pre-intervention observations were recorded, 47 at T2, and 39 post-intervention observations at T3. These differences are attributable to participant choice on the day of data collection (5 participants), absence or illness (3 participants), and mortality (1 participants).

Preliminary Analyses

Pre-intervention, dominant and non-dominant grip were correlated (r(48) = .88, p < .001), although these were not correlated with reach. Care home staff assessment of the Functional Independence Measure motor score was correlated with reach ($r(46)= .40$, p = .007), and grip strength in dominant hand ($r(46)= .36$, $p = .001$) and non-dominant hand ($r(48)= .42$, $p = .004$). Average grip strength in dominant hand was below healthy age norms (Dodds et al., 2014) for people age 70+ (females M= 139N, SD = 50.7, norm = 200N; males M = 208N, SD = 46.6; norm = 330N). No sex or age differences were identified for reach. A comparison of all measures by sex is shown in Table 9.1. When people were older, handgrip was weaker in dominant ($r(46)= -.54$, $p<.001$) and non-dominant hand ($r(46) = -.51$, $p <.001$). Functional reach was not associated with age. Threat concern was correlated with negative age attitudes only ($r(46) = .28$, $p = .05$). There was generally strong correlation between the other psychological measures, although these were not correlated to the physical measures. Of note, age attitudes (Negative $r(46) = -.6$, $p < .001$; Physical $r(46) =.45$, $p <.001$; Positive $r(46)= .7$, $p < .001$) were correlated with self-esteem. Mixed effects models showed that even when controlling for age, sex, and presence of a health condition then negative ($b = 0.30$, $t(46)= 4.88$, $p<.001$) and physical change ($b = 0.21$, $t(46) = 2.30$, $p =.03$) age attitudes were associated with lower self-esteem. Correlations of psychological and physical measures are shown in Table 9.2 and Table 9.10.

Table 9.1: Baseline measures by sex

Measure	Female, **N = 39**	Male, **N = 9**
Age	84 (10)	76 (12)
Subjective Age	53 (27)	55 (24)
Grip strength – Dominant hand (N)	126 (47)	249 (94)
Grip strength – Non-dominant hand (N)	117 (42)	184 (97)
Functional Reach (cm)	22 (10)	27 (9)
CASP - Control	2.47 (0.74)	2.44 (0.85)
CASP - Autonomy	3.02 (0.83)	3.28 (0.51)
CASP - Self-Realisation	3.05 (0.80)	3.35 (0.39)
CASP - Pleasure	3.12 (0.79)	3.37 (0.42)
Self-esteem	2.78 (0.45)	2.73 (0.35)
Loneliness	1.61 (0.59)	2.17 (0.57)
Self-efficacy	20 (29)	24 (33)
Age Attitudes - Negative	2.82 (0.82)	2.92 (0.51)
Age Attitudes - Physical	3.55 (0.74)	3.61 (0.34)
Age Attitudes - Positive	3.56 (0.64)	3.76 (0.35)
FES- Motor	4.79 (1.50)	5.03 (1.61)
FES - Cognitive	5.54 (0.99)	5.99 (0.71)

Note: Mean, (SD)

Table 9.2: Baseline correlations – Physical measures

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Age							
2. Functional Reach (cm)	-.1						
3. Grip strength – Dominant hand (N)	-.54**	.2					
4. Grip strength – Non-dominant hand (N)	-.51**	.24	.88**				
5. Physical Activity Levels (PASE)	-.09	-.03	-.04	-.10			
6. FIM - Motor	-.14	.40**	.36*	.42**	.17		
7. FIM - Cognitive	-.03	.27	.31*	.46**	-.05	.30*	
8. Sessions Attended	.06	-.02	.14	.09	.13	-0.16	.08

*Note: * indicates p < .05. ** indicates p < .01. Sessions attended included to show that a range of physical abilities attended the sessions.*

Table 9.3: Post-intervention correlations – Physical measures

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Age							
2. Functional Reach (cm)	-.47**						
3. Grip strength – Dominant hand (N)	-.56**	.49**					
4. Grip strength – Non-dominant hand (N)	-.59**	.69**	.86**				
5. Physical Activity Levels (PASE)	-.15	.25	.23	.26			
6. FIM - Motor	-.18	.19	.43**	.43*	.02		
7. FIM - Cognitive	.06	-.25	.03	-.01	.01	.40*	
8. Sessions Attended	.16	-.27	-.13	-.13	.39*	-.13	-.02

*Note: * indicates $p < 0.05$. ** indicates $p < 0.01$.*

Physical Measures

Multilevel models were used to test hypothesis 1, that the intervention would improve physical performance. Model 1 showed that there was no significant main effect of time for any measures. Physical measures at pre and post intervention are reported in Table 8.9. Model 2 showed that the time by attendance interaction for was significant for physical activity ($b = 0.59$, $t(38) = 2.49$, $p = .03$), and Model 3 showed that this relationship was significant even when controlling for age, sex, and presence of a health condition ($b = 0.43$, $t(38) = 2.49$, $p = .03$). Figure 8.2 shows the interaction between attendance and time on physical activity levels. Post-hoc Tukey HSD showed that compared to baseline, only participants who attended the workshops reported greater level of physical activity after the intervention period (Attended, baseline *M*: 1.70, *SD* = 0.3; post-intervention: *M* = 2.26, *SD* = 0.3; Not attended, baseline: *M* = 1.61, *SD* = 0.4; post- intervention: *M* = 1.42, *SD* = 0.3). Importantly, this means that the program was effective at increasing physical activity levels. Although people who attended more sessions had greater physical activity levels post-intervention ($r(37) = 0.39$, $p = .02$), they were not necessarily the most active people at baseline ($r(37) = 0.13$, $p = .40$). This suggests improvements are not attributable to characteristics of self-selection. Model outputs for physical measures are shown in Table 9.5 to Table 9.4. Model 1-3 showed no significant effect of the program on any of the other physical measures.

In Model 4, which includes physical activity as a predictor, a significant interaction between physical activity levels and time was identified for non-dominant handgrip strength, ($b = 26.9$, $t(38)=2.84$, $p = .04$). This showed that non-dominant grip strength increased when people had higher physical activity levels (when PASE = 4 baseline *M* = 115N, SD = 34N; post-intervention *M* = 158N, *SD* = 14N), whereas handgrip became weaker over time (PASE = 1 baseline: *M* = 119N, *SD* = 25N; post-intervention: *M* = 90N, SD = 26N) for those with the lowest physical activity. Therefore, there is some support for hypothesis 1 that the intervention would improve physical performance, although this support is caveated in that performance only improved when physical activity levels were increased.

Figure 9.2: Intervention attendance increases physical activity level

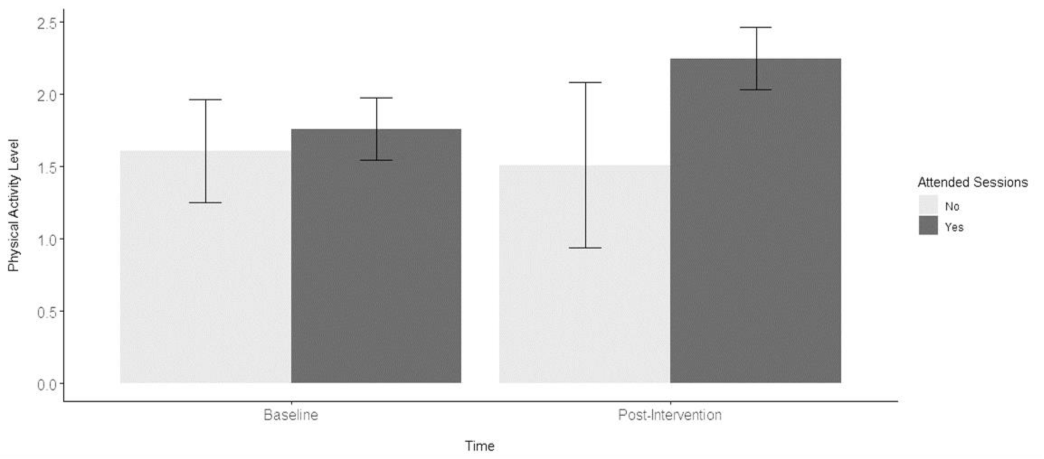


Figure 9.3: Intervention attendance increases Autonomy

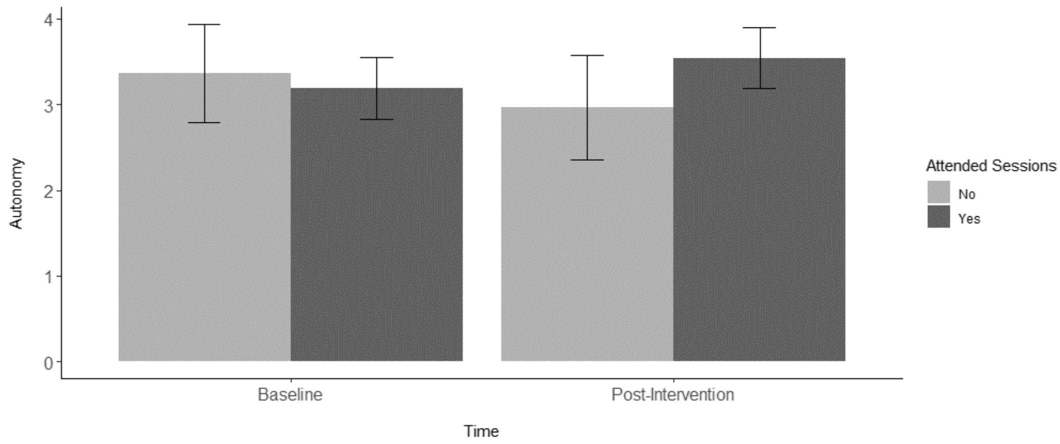


Table 9.4: Multilevel models for physical activity

	Model 0		Model 1		Model 2		Model 3	
Predictors	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
(Intercept)	1.88 ***	0.1	1.69 ***	0.1	1.61 ***	0.2	2.48 ***	0.6
Time (Post-Intervention)			0.45 ***	0.1	-0.1	0.3	0.06	0.3
Attended (Yes)					0.15	0.2	0.27	0.3
Time (Post-Intervention) * Attended (Yes)					0.59 *	0.3	0.43 *	0.3
Age							-0.01	0.01
Sex							-0.47 *	0.2
Any Health Condition							0.2	0.2
Random Effects								
σ^2	0.29		0.19		0.18		0.17	
τ_{00}	0.16		0.20		0.18		0.11	
ICC	0.36		0.51		0.49		0.38	
Marginal R^2 / Conditional R^2	0.0 / 0.36		0.11 / 0.57		0.18 / 0.58		0.34 / 0.59	
AIC	168		153		147		126	

** p<0.05   ** p<0.01   *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table 9.5: Multilevel models for dominant handgrip strength

	Model 0		**Model 1**		**Model 2**		**Model 3**		**Model 4**	
Predictors	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
(Intercept)	147.3 ***	11.2	147.4 ***	11.4	158.5 ***	21.2	409.8 ***	74.8	384.9 ***	80.5
Time (Post-Intervention)			-0.27	5.8	19.25	14.3	13.16	14.4	10.87	15.1
Attended (Yes)					-17.0	25.4	1.49	27.9	-10.73	36.8
Time (Post-Intervention) * Attended (Yes)					-22.7	15.6	-16.7	15.7	-21.16	16.9
Age							-3.41 ***	0.86	-3.24 ***	0.9
Sex							96.90 ***	27.8	101.2 ***	27.4
Any Health Condition							12.32	18.1	10.0	17.9
Physical Activity									-2.21	11.2
Time (Post-Intervention) * Physical Activity									18.51	10.8
Random Effects										
σ^2	640		640		632		630		620	
τ_{00}	5776		5777		5699		2796		2673	
ICC	0.9		0.9		0.9		0.82		0.81	
Marginal R^2 / Conditional R^2	0.00 / 0.90		0.0 / 0.90		0.02 / 0.90		0.54 / 0.92		0.56 / 0.92	
AIC	952		954		934		832		834	

** p<0.05   ** p<0.01   *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table 9.6: Multilevel models for non-dominant handgrip strength

	Model 0		**Model 1**		**Model 2**		**Model 3**		**Model 4**	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	128.57 ***	9	127.97 ***	9.3	124.93 ***	17.4	259.04 ***	75.8	379.66 ***	84.3
Time (Post-Intervention)			1.52	5.6	12.3	14.8	10.23	15.2	10.29	14.7
Attended (Yes)					2.55	20.8	19.69	28.3	-90.9 *	43.4
Time (Post-Intervention) * Attended (Yes)					-12.37	16	-10.25	16.4	-18.1	16.6
Age							-1.98 *	0.88	-2.40 **	0.82
Sex							60.05 *	28.2	62.96 *	25.9
Any Health Condition							17.44	18.4	13.79	16.9
Physical Activity									-11.02	10.9
Time (Post-Intervention) * Physical Activity									78.70 **	25
Random Effects										
σ^2	567		568				588		557	
τ_{00}	3627		3619		3649		2900		2360	
ICC	0.86		0.86		0.86		0.83		0.81	
Marginal R^2 / Conditional R^2	0.0 / 0.87		0.00 / 0.86		0.002 / 0.87		0.26 / 0.88		0.34 / 0.88	
AIC	906		908		890		811		805	

** p<0.05 ** p<0.01 *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table 9.7: Multilevel models for functional reach

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	23.49 ***	1.2	22.82 ***	1.5	24.34 ***	2.7	40.22 ***	10	40.87 **	12.7
Time (Post-Intervention)			1.56	1.9	2.14	4.4	1.77	4.8	2.09	4.92
Attended (Yes)					-2.03	3.3	3.36	4.4	-2.01	7.26
Time (Post-Intervention) * Attended (Yes)					-0.53	4.9	-0.13	5.3	-1.65	5.47
Age							-0.27 *	0.1	-0.26 *	0.12
Sex							6.51	3.7	7.36	3.78
Any Health Condition							0.95	2.4	0.51	2.46
Physical Activity									-0.84	3.09
Time (Post-Intervention) * Physical Activity									6.19	3.82
Random Effects										
σ^2	73.5		72.3		73.4		74.3		72.2	
τ_{00}	29.5		30.1		30.0		16.9		17.6	
ICC	0.29		0.29		0.29		0.19		0.2	
Marginal R^2 / Conditional R^2	0.0 / 0.29		0.006 / 0.29		0.01 / 0.30		0.17 / 0.32		0.18 / 0.34	
AIC	638		639		629		575		578	

** p<0.05 ** p<0.01 *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Psychosocial Measures

To test the second hypothesis, that the intervention would improve psychosocial measures, then multilevel models were again used with care home and person nested hierarchically. Outcomes in Model 1 were predicted by time only, in Model 2 then the cross level interaction of time and session attendance was included. Model 3 included demographic covariates and Model 4 included change in physical activity (as physical activity by time interaction).

For subjective age, there was a significant effect of time in Model 1 (b = 12.9, t(38) = 3.09, p = .004). This suggested that people felt older after the intervention than before. However, when the interaction with attendance was included (Model 2) and when demographic variables were included (Model 3-4) then this effect was no longer apparent. This means that factors other than attending the sessions caused this effect.

For Autonomy, there was no significant effect in either Model 1 or Model 2, although the interaction of time and attendance was significant in Model 2 when demographic covariates were included in the model. This showed that session attendance improved Autonomy (b = 0.76, t(38) = 2.13, p = 0.04; Attended baseline: mean = 3.12, SD = 0.4; post-intervention M = 3.48, SD = 0.4; Not Attended baseline M = 3.34, SD = 0.4; post-intervention M = 3.00, SD = 0.4). This interaction showed that for people attended the sessions then autonomy increased more than for people who did not attend. Tukey comparisons did not show any significant pairwise comparisons for autonomy or age attitudes. Model 4 showed that physical activity was the only significant predictor (b = 0.40, t(38) = 2.19, p = .03). When people were more physically active then they also reported more autonomy.

Physical activity was a significant predictor for self-realisation in Model 4 (b = 0.49, t(38) = 2.53, p = 0.01). People who were more active had reported high self-realisation. This was not qualified with interaction with time, and no other effects from any other models were significant.

For Pleasure, time was a significant predictor in all models (Model 1: b = 0.47, t(38) = 6.10, p < .01), even when accounting for demographic variables (Model 3: b = 0.55, t(38) = 5.91, p = .009; baseline M = 3.25, SD = 0.7; post-intervention M

= 3.66, *SD* = 0.5). These effects were not qualified by an interaction with attendance which suggests that factors other than the intervention are responsible for this effect.

For negative attitudes to age, there was no effect of time (Model 1). Although, an effect of time appears in later models (Models 3 and 4) when covariates were added (Model 3: *b* = -0.52, *t*(38) = 2.33, p = 0.03). In these models time negatively predicted attitudes to age, suggesting that negative attitudes to age were reduced post intervention, but only when age, sex and health condition were controlled for. There was no effect of attendance in any of the models, but there was a significant time by attendance interaction in Model 2, which remained in Model 3 and 4, where covariates and the time by physical intervention interaction were added respectively. The significant time by attendance interaction in the best fit model (Model 3, AIC= 147) revealed that for people who attended the sessions, then negative age attitudes reduced whereas it increased slightly for people who did not attend the sessions (*B* = 0.72, *t*(38) = 2.25, *p* = .009; Attended: baseline *M* =3.01 ,*SD* = 0.4, post-intervention *M* = 2.49, *SD* = 0.3; Did not attend: baseline *M* = 2.90 ,*SD* = 0.2, post-intervention *M* = 3.05, *SD* = 3.1).

Age attitudes about physical change were more positive after the intervention (*b* = 0.33, *t*(38) = 2.30, *p* = .03). While including attendance as a predictor in Model 2 failed to reveal any significant effects, Model 3 and 4 showed that the only significant predictor for this outcome was presence of a health condition (Model 4: *b* = -0.56, *t*(38) = -2.57, *p* = .01), highlighting the relationship between physical health and social identity.

Positive age attitudes were also higher after the intervention compared to baseline in Model 1 (*b* = 0.19, *t*(38) = 2.53, *p* = .02). Model 2 showed that people who attended had more positive age attitudes (*b* = 0.60, *t*(38) = 2.97, *p* = .005), but this effect was not qualified by interaction with time. This effect was no longer significant when demographic factors were included in Model 3 and Model 4.

Participants' stereotype threat concern were lower after the intervention as shown in Model 1 (*b* = -1.19, *t*(38) = 4.47, *p* < .001; baseline *M* = 2.80, *SD* = 0.2; post-intervention *M* = 1.65, *SD* = 0.3). After the intervention period, people reported less feelings that they would perform poorly because of their age or that their performance would be judged negatively because of their age. This effect was apparent irrespective of whether participants had attended the sessions (Model 2), although it was not apparent when demographics factors were controlled (Model 3 and Model 4). Therefore, factors other than the intervention may have influenced this finding, or the absence of a true control group restricted identification of a more general positive effect at the care home level. That is, other members of the care home group may have benefitted from a sub-group attending the sessions.

No models showed significant effects for time or session attendance for Control, self-esteem, loneliness, or functional independence measures. Tables for these models are shown in the Appendix.

Relationship between psychological and physical changes

The third and final hypothesis was that psychological and physical improvements would be related. This hypothesis was tested using multilevel models to control correlated error at the care home level. The dependent variable in these models was the difference between baseline and post-intervention for physical and psychological dependent and independent variables. When demographic factors were controlled, increases in physical activity levels were associated with improvements in the psychological measures related to wellbeing. Specifically, greater physical activity levels were associated with a significant improvement in: positive age attitudes ($b = 0.15$, $t(38) = 2.15$, $p = .04$), age attitudes relating to physical self ($b = 0.45$, $t(38) = 2.34$, $p = .04$), Autonomy ($b = 0.34$, $t(38) = 2.15$, $p = .04$), and also marginally significant improvements in Control ($b = 0.28$, $t(38) = 1.98$, $p = .06$). Table 8.8 shows the values predicted by the final model for lowest and highest physical activity score. Overall, these findings demonstrate the positive effect that change in physical activity levels had on psychological measures related to wellbeing and identity, although this was not the case for all measures.

Unexpectedly, no other significant relationships between change in psychological and physical performances changes were identified. Change in physical activity was not associated with self-esteem. Table 8.9 shows mean and SD for all measures at baseline and post-intervention.

Table 9.8: Predicted values for wellbeing based on physical activity levels.

	Low physical activity (PASE = 1)		**Higher Physical Activity (PASE = 4)**	
	Baseline	Post-intervention	Baseline	Post-intervention
Age attitudes - Physical	3.63 (0.5)	3.46 (0.5)	2.75 (0.7)	4.06 (0.5)
Age attitudes - Positive	3.74 (0.7)	3.62 (0.4)	3.20 (0.8)	4.00 (0.6)
CASP Autonomy	3.10 (0.3)	2.85 (0.3)	2.97 (0.4)	4.15 (0.2)
CASP Control	2.55 (0.4)	2.32 (0.3)	2.20 (0.4)	3.21 (0.3)

Note: Predicted values (standard error).

Table 9.9: Measures at baseline and post-intervention

Measure	**Baseline, N = 48**	**Post-Intervention, N = 39**
Subjective Age	54 (26)	66 (19)
Functional Reach (cm)	23 (10)	24 (11)
Grip strength – Dominant hand (N)	139 (56)	137 (67)
Grip strength – Non-dominant hand (N)	128 (51)	127 (56)
CASP - Control	2.47 (0.75)	2.70 (0.92)
CASP - Autonomy	3.07 (0.79)	3.47 (0.68)
CASP - Self-realisation	3.10 (0.75)	3.13 (0.76)
CASP - Pleasure	3.17 (0.75)	3.69 (0.52)
Self-esteem	2.77 (0.43)	2.85 (0.36)
Loneliness	1.68 (0.60)	2.26 (1.43)
Self-efficacy	2.77 (0.43)	2.85 (0.36)
Age Attitudes - Negative	2.84 (0.79)	3.02 (0.80)
Age Attitudes - Physical	3.56 (0.70)	3.93 (1.06)
Age Attitudes - Positive	3.59 (0.61)	3.89 (0.60)
FIM - Motor	4.79 (1.51)	4.51 (1.70)
FIM - Cognitive	5.64 (0.97)	5.66 (1.39)
Threat Concern	2.80 (1.56)	1.51 (1.09)

Note: Mean (SD).

Table 9.10: Baseline correlations – Psychological measures.

Variable	1	2	3	4	5	6	7	8	9	10
1. Subjective Age										
2. Control	.14									
3. Autonomy	-.11	.54**								
4. Self-realisation	.04	.52**	.79**							
5. Pleasure	0	.51**	.79**	.89**						
6. Self-esteem	.11	.70**	.62**	.63**	.64**					
7. Age Attitudes - Negative	.15	.59**	.70**	.70**	.72**	.60**				
8. Age Attitudes - Physical	.15	.41**	.59**	.72**	.68**	.45**	.58**			
9. Age Attitudes - Positive	.08	.53**	.59**	.60**	.67**	.70**	.59**	.60**		
10. Loneliness	.13	-.14	-.22	-.18	-.22	-.30*	-.05	-.12	-.2	
11. Threat Concern	-.29*	-.25	.07	.01	.02	-.28	-.03	.14	-.06	.2

*Note: * indicates p < .05. ** indicates p < 0.01.*

Table 9.11: Post-intervention correlations - Psychological measures

Variable	1	2	3	4	5	6	7	8	9	10
1. Subjective Age										
2. Control	-.35*									
3. Autonomy	-.33*	.41*								
4. Self-realisation	-.12	.55**	.43**							
5. Pleasure	-.08	0.23	.61**	.46**						
6. Self-esteem	-.36*	.69**	.50**	.51**	.43**					
7. Age Attitudes - Negative	.06	.23	.39*	.47**	.37*	.3				
8. Age Attitudes - Physical	-.1	.15	.36*	.23	.3	.15	.27			
9. Age Attitudes - Positive	-.17	.44**	.36*	.36*	.37*	.61**	.06	0.33		
10. Loneliness	.04	.16	.12	-.05	.09	.01	.04	.06	-.04	
11. Threat Concern	.19	-.13	.01	-.16	.09	.22	.05	.23	.34*	-.08

*Note: * indicates p < .05. ** indicates p < .01.*

Discussion

The aim of this study was to explore whether the care home residents benefitted from a 10-week programme of low intensity physical activity in terms of physical performance and wellbeing. The intervention was successful in increasing care home residents' physical activity levels. When physical activity increased from attendance in the sessions, so too did physical functioning and the psychological measures. Notably, age attitudes improved when people took part in the programme. Physical activity levels predicted the improvements in wellbeing (as measured by pleasure, autonomy, and self-realisation). Age attitudes were associated with other measures of wellbeing too, and improvements were positively correlated.

Physical performance

The first hypothesis, that the sessions would improve physical performance, was partially supported. Although there was no direct effect of attendance on grip strength or modified reach, attendance at the sessions increased physical activity levels and this increase in physical activity was associated with improvement in non-dominant grip strength. This is important because poor handgrip defines the frailty phenotype (Fried et al., 2001; Viana et al., 2013). Crucially, handgrip strength is prognostic of mobility difficulties and chronic health outcomes (Leong et al., 2015; Martín-Ponce et al., 2014; Sallinen et al., 2010). Therefore the improvements in handgrip strength from this short program of enjoyable physical activity should not be understated. Improvements in handgrip strength transcend obvious benefits to physical function, and serve as markers of improved underlying health.

This study corroborates well-established research asserting strength gains from physical training in older age (Vandervoort, 2002; Young & Skelton, 1994). Moreover, in this case, the participants were often frail. Frailty is regarded as state beyond a threshold of physiological capacity whereby an individual is unable to adapt to stressors (Cesari et al., 2013). It is therefore noteworthy that improvements in physical performance were identified in this population, although this change may not be directly attributable to physiological changes. Improvements could have been due to elevated wellbeing through the enjoyable physical activity. However, this speculation was not supported by the data. Fundamentally, these tasks have important clinical prognostic application so this finding should not be overlooked.

Psychosocial measures

The second hypothesis was supported, programme attendance improved some of the psychosocial measures. Specifically, when people attended then age attitudes and autonomy improved, whereas these measures worsened for those who did not attend. This showed that someone's attitude of their age, and their sense of autonomy, may be improved through engagement in light physical activity. Related to this, an important investigation was to explore the association of age attitudes with other measures of wellbeing such as threat concern, and subjective age. The effect of attitudes on perceptions of threat are reasoned to stem from internalised stereotypes which manifest in a person's subjective age and this is shown empirically in Marquet et al (2018). This research was somewhat supported, as threat concern was correlated with subjective age and with age attitudes. This is meaningful as it demonstrates the deep impact that age stereotypes have upon older adults' wellbeing. This association is well supported in previous research (Bergman & Bodner, 2020; Dionigi, 2015), and highlights the need to further clarify these relationships.

Relationship between physical performance and psychological measures

The third and final hypothesis was also supported as there was a relationship between the physical measures and wellbeing. When physical activity increased then age attitudes and wellbeing measures improved. The interdependence between older adults' physical and psychological wellbeing is supported by previous research (Hudson, Oliver, Thomas, & Higgs, 2011). Qualitative data collected at 10-week intervals across the 30-week physical therapy intervention period showed that wellbeing improved in line with physical performance. Also, benefits of participation were cumulative, so after 10 weeks some moderate tasks were found to be somewhat easier, while after 30 weeks previously impossible tasks were achievable. This suggests that effects from the 10-week Active Armchairs intervention may represent a modest proportion of the potential that could be gained, and that longer programmes of activity may lead to more substantial improvements in older adults' physical and psychological wellbeing. Initiatives that preserve physical functionality and positive self-views can promote self-efficacy and independence (McAuley et al., 2005). As such, these initiatives may attenuate the risks of frailty which are further associated with low quality of life in older adults (Rivera-Almaraz et al., 2018). Therefore, the social aspects of the program should not be overlooked. Mental health and quality of life is known to be positively influenced by participation in social and cultural activities (Greaves & Farbus, 2006). As such, creative and cultural activities are specifically recommended for older adults (Age UK, 2018). The associations demonstrated of age attitudes with traditional measures of wellbeing are meaningful because these positive attitudes can help to overcome barriers to engaging in healthy behaviours, such as physical activity (Mental Health Foundation, 2011). This creates a positive cycle of physical activity, self-perception, wellbeing, and self-efficacy.

Limitations

The study delivered some unexpected results too. Threat concern was lower for all participants after the intervention compared to baseline. This may be attributable to seasonality, as increases in positive affect from summer weather could have protected against feelings of anxiety and threat. This is supported by the increase in Pleasure which was not dependent on attendance in the sessions either. To overcome this, data collection throughout the year during different seasons could be sought. Alternatively, the frequent exposure to the protocol, experimenter, and equipment may have reduced experience of threat and increased pleasure. Indeed, previous experience bolsters self-efficacy which can in turn reduce performance related anxiety (Bandura, 1988). This might be somewhat remedied by a different researcher for each data collection. Similarly, unexpected increases in subjective age were surprising. This could be because over the 3 weeks of the intervention the health of some people deteriorated, or because participants were more honest when they felt more familiar with the researcher. The absence of main effect for loneliness could be because of participants not feeling comfortable to disclose feelings of loneliness which are particularly sensitive, or because people who were willing to participate in the study also benefitted from living communally. Certainly, more research is needed to confirm these suppositions.

Delivering statistically robust intervention research with vulnerable populations is not without challenges (Ellard, Thorogood, Underwood, Seale, & Taylor, 2014). Challenges with care home gatekeeper consent presented a practical challenge to gaining sufficient sample size for a traditional control group. To overcome this challenge, by assessing the stability of the measures before the intervention, it was possible to ensure a more reliable comparison than would be achieved with a single measurement. Nevertheless, this approach falls short of a randomised controlled trial, the gold standard for intervention studies. Further, the sample size could have limited the statistical power this study. Bias was controlled where possible by digital dynamometry, and by the data collection being carried out by an investigator independent of both the care homes and the Active Armchairs program. The physical tasks used in this study were chosen for portability, ease of instruction, and clinical relevance.

Additionally, some changes in physical performance were observed but there was no significant change in the functional independence measures reported by staff. This seems contradictory. However, it was not feasible to approach the same staff members on all occasions to complete the FIM due to staff turnover, shift patterns, and occupational obligations. This unfortunately undermined the reliability of this measure, and may have occluded a genuine change in physical independence as a result. However, that the FIM scores were correlated with physical task performance is reassuring. Regrettably, it was not possible to use self-efficacy scores for analyses. Although the measures of self-efficacy included in this study have been used previously in older populations (McAuley, 1993), it was not possible for many participants to complete this questionnaire due to understanding the abstract concepts involved (e.g. “I am able to continue to exercise at least once per week at moderate intensity, for 40+ minutes without quitting for the next two weeks”). Due to the wealth of health psychology emphasising the role of self-efficacy in exercise behaviours (Mcauley, Blissmer, Katula, Duncan, & Mihalko, 2000; Miller, Ogletree, & Welshimer, 2002), it is crucial to identify robust scales for understanding older adults’ self-efficacy which do not depend on abstract concepts that are difficult for frail populations to respond to. Therefore, simpler scales which have been validated for use with care home populations such as Self-Efficacy for Exercise Scale (Resnick & Jenkins, 2000) could be more suitable for future applications.

Conclusion

The current study shows an increase in physical activity and benefits to health and wellbeing when care-home residents took part in Active Armchairs dance workshops. As a field intervention study, this research has significant practical implications. Care home residents were more physically active when the Active Armchairs physical activity workshops were provided. Increased physical activity levels were associated with psychological and physical performance benefits. These benefits are relatable to national quality standards (NICE, 2013). Therefore, maintaining high quality standards of care may be supported by interventions such as Active Armchairs. This is important not just to maintain or improve physical functionality, but also to promote wellbeing and so contributes to minimising social and physical risks associated with frailty. Future work should explore the effect of care home physical activity programs on mobility. This could include identifying ways to engage people who would benefit most from such programs, and how to address the need for those who do not benefit as much.

Chapter 10 - General Discussion

This thesis presents five studies to address three aims: to extend theoretical understanding of how age stereotypes can affect physical performance, to identify the role of age attitudes in protecting from functional limitations, and to explore how physical activity intervention strategies might affect physical performance and negative self-stereotypes of age. The studies in the thesis employ a range of methods, using controlled laboratory experiments (Chapter 5 and Chapter 6), analysing national representative data (Chapter 7) and exploring the impact of two different interventions in applied settings (Chapter 8 and Chapter 9).

Summary of Empirical Chapters

To extend our understanding of how age stereotypes impact on physical performance, the first two experimental chapters (Chapter 5 and Chapter 6) used the stereotype threat framework and specifically aimed to extend understanding of how ABST operates when older adults perform physical tasks. Chapter 5 sought to understand how stereotype threat operates in terms of psychological and neuromuscular processes. Advancing findings of Swift et al. (2012), a quasi-double blind experimental design was used to minimise experimenter bias, and digital dynamometry ensured accurate measurements. Additionally, separating maximal and sustained handgrip muscle contractions enabled motivational effects of ABST to be investigated, and neuromuscular recruitment responses to be measured using EMG. Threat was expected to reduce the grip strength and time to task failure. When threat evoked anxiety, then participants underperformed: grip strength was lower, and synergist muscles recruitment was altered indicating altered muscle co-ordination. Similar effects on time to task failure were marginally significant. This emphasised the central role of anxiety in stereotype threat underperformance implicated by Steele and Aronson (Steele & Aronson, 1995), and provided empirical support for pathways hypothesised by the Integrated Process Model (Schmader et al., 2008). Further, these findings demonstrated how age-based stereotype threat could cause physical underperformance, and so this established a plausible experimental model for investigating these effects further.

This manipulation was then used to investigate how stereotype threat might affect older adults' postural control in Study 2 (Chapter 6), by considering the additional cognitive load imposed by affective processes. It was hypothesised that sway would increase under threat, and that this effect would be exacerbated when a concurrent task was performed. Supporting previous postural control research in older adults, sway increased for all participants under dual task, indicating reduced stability (Doumas et al., 2009; Melzer et al., 2001; Melzer, Liebermann, Krasovsky, & Oddsson, 2010). Furthermore, for the first time, effects of ABST on postural control were demonstrated. Relative to single task performance, postural sway measured by path length increased for participants in the threat condition during dual task more than that of controls. This suggests that different postural control strategies are deployed when ABST is presented. Specifically, sway was relatively controlled during single task but for participants in the threat condition postural control was altered when ABST and dual task were combined such that there was increased sway within a similar sway area. This could be because ABST imposed some additional cognitive burden, which led to the trend for tightening of postural control (Stins, Roerdink, & Beek, 2011). Alternatively, the effect of threat may be present on the cognitive task which overspills on to the physical performance measure (Beilock et al., 2007; Inzlicht, Tullett, Legault, & Kang, 2011). Interestingly, no effects of condition were identified on the affective measures. This means that the interaction effect of condition by task on sway may happen outside of the affective pathways, or that the measurement of anxiety was not sensitive enough to detect the differences. Crucially, this finding provides evidence for an effect of ABST on a simple physical performance task, but only when cognitive demands are higher. At a practical level, this finding means that older adults' risk of experiencing a fall may be increased when ABST is evoked if cognitive demands are greater. On this empirical basis then falls prevention strategies may be informed.

The second aim of this thesis was to see how positive attitudes to age might protect from functional limitation, extending stereotype embodiment theory and research (Levy, 2009; See also Chapter 4). Using cross-sectional survey data from the English Longitudinal Study of Aging (ELSA) in the third experimental chapter

(Chapter 7), more positive age attitudes were expected to be associated with physical function. In support of the hypotheses, people with more positive age attitudes were more likely to engage in intense physical activity, to have stronger handgrip, walk faster, and less likely to have experienced a fall in the previous two years. These findings presented an enticing prospect to explore the causal relationships between these factors further. Future waves of ELSA will also provide opportunity for cross-lagged models to extend these findings. Chapter 8 and Chapter 9 partly address the need to understand the reciprocity of this relationship, by investigating the effect of enjoyable physical activity on age attitudes.

The third aim of the thesis was to see if physical activity might offer a way to improve older adults' attitudes towards aging. In the fourth experimental chapter (Chapter 8), involvement in an intergenerational dance theatre program was expected to improve older and younger participants' age attitudes. Notably, the program improved younger participants' implicit attitudes to ageing, which Chapter 7 suggests may positively influence their physical activity levels in later life (SPA was associated with physical activity). In the fifth and final study (Chapter 9), it was hypothesised that when care home residents were involved in an armchair-based dance program, then their age attitudes, wellbeing, and physical function would improve. When physical activity was increased because of involvement in the program, then improvements to age attitudes and physical function were identified. Jointly, these chapters demonstrated that age attitudes could be changed through physical activity. Further, given the associations of age attitudes with health and physical function shown in Chapter 7, then the finding that age attitudes are fluid makes a crucial contribution to informing policy direction. These chapters suggest that low intensity dance-related activity could be used as a gateway to increase activity levels, and potentially lead on to more intense activity. Specifically, physical activity can be used to leverage people's age attitude to achieve important health and wellbeing outcomes.

Theoretical Contribution

By addressing current gaps in theoretical understanding of ABST, this thesis proposes explanations by which apparently conflicting findings of ABST effects on physical performance are reconciled. Further, these findings contribute to understanding the psychosocial determinants of the onset and progression of sarcopenia and frailty.

Integrated Process Model (IPM)

To briefly recap the IPM described in Chapter 4 (see Figure 4.3), ABST is posited to evoke an emotional response, expressed as cognitive anxiety through negative thoughts and appraisal processes, as well as via a physiological response as somatic anxiety. This in turn causes disrupted working memory processes which affects performance. The first two empirical studies tested the role of anxiety in ABST effects on handgrip and balance performance. Supporting the role of anxiety hypothesised in the IPM, Study 1 (Chapter 5) demonstrated that anxiety mediated the effect of ABST on handgrip performance. No significant differences were identified between somatic and cognitive anxiety. The same ABST manipulation did not appear to elicit an affective response in Study 2 (Chapter 6). This may have been because those participants, drawn from a different population and tested in a different location than in Chapter 5, were able to dissociate from their age identity and so reduce the identity threat from age stereotypes. It is clear that a better understanding of the factors that protect some people from ABST is called for.

It is intriguing that threatened participants' balance was worse than non-threatened controls when working memory load was greater in Study 2 (Chapter 6). This means that different physical tasks might be affected by ABST through different pathways. For example, compared to standing on one leg which is more likely to consciously controlled, if skills were well practiced or easier they might be more automatically processed. In which case, performing a secondary task may have limited effect on performance. This helps understand some studies where ABST did not lead to physical task underperformance. For instance, threat effects were not seen when task demands were easy (Barber et al., 2020), and why natural walking was unaffected (Chalabaev et al., 2020). This could be because the combined attentional demand of ABST and the physical task was accommodated by individuals. However, when attentional capacity is more challenged (more difficult task, greater anxiety response) then a noticeable disruption to performance may be elicited (Segev-Jacubovski et al., 2011; Yogev-Seligmann et al., 2012).

Mediators and moderators

In the experimental studies, ABST did not affect all people equally. Direct causal relationships of ABST on handgrip strength were not revealed in Study 1 (Chapter 5) as they were in previous research (Swift et al., 2012). IPM would suggest that anxiety is elicited when ABST is present. As the ABST manipulation only affected people's performance if they were anxious, this showed it is necessary to understand the variables moderating effect of the presentation of ABST on anxiety.

Other individual level factors were also considered. For example, gender and presence of a health condition was a covariate of grip strength in Study 1 (Chapter 5), current activity level was a significant predictor of balance in Study 2 (Chapter 6), and of handgrip strength and walk speed in Study 3 (Chapter 7). As these findings moderated the effect of ABST on performance, when such factors are considered in stereotype threat research then they may explain some crucial individual level variation masking the true effect of ABST on physical performance across currently disparate findings in current literature. Further, Study 4 (Chapter 8) and Study 5 (Chapter 9) showed that physical activity could improve age attitudes. This means that physical activity is a moderator and an effect of age stereotypes. This is crucial because increases in physical activity and improvements in age stereotypes may generate positive cycle, ultimately to the benefit of older adults' physical health (Kanda & Hashizume, 1998; Porter, Vandervoort, & Lexell, 1995) and wellbeing (McKee & Schüz, 2015). The bidirectional nature of physical activity and age stereotypes is discussed later in this chapter.

Stereotype Embodiment

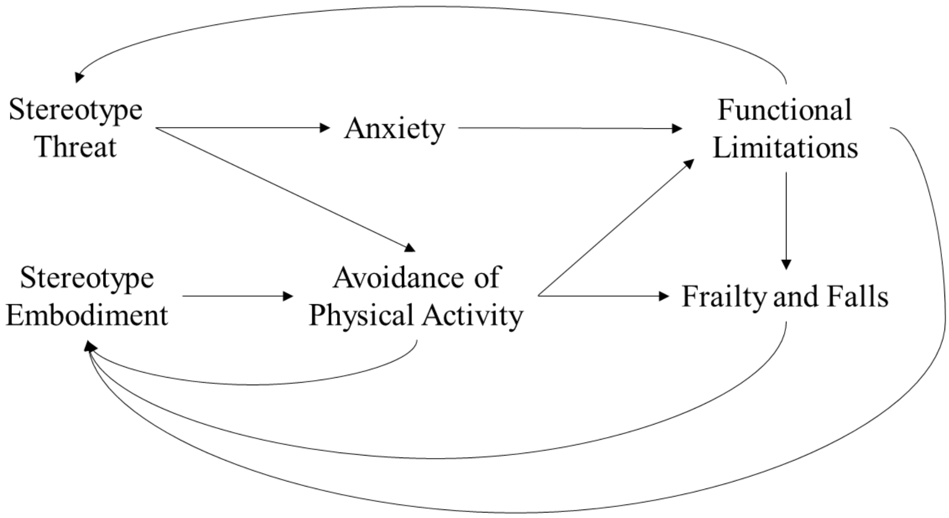
As reviewed in Chapter 4, stereotype embodiment is the internalisation of cultural representations which become self-defining (Levy, 2009). This thesis helps understand how stereotype embodiment can be associated with functional limitation and low physical activity levels as people grow older. In Study 3 (Chapter 7), the direct effect of stereotype embodiment, as measured by SPA, on fall risk was demonstrated. This effect was also indirectly mediated by lower physical activity, leading to weaker handgrip strength, which contributed to increased falls risk. The Risks of Ageism Model (RAM) posits that as stereotype embodiment gains salience from self-relevance then stereotype embodiment is self-fulfilling (Swift et al., 2017). This feedback loop is demonstrated in Study 5 (Chapter 9), as people who became more physically active held more positive age attitudes after they had taken part in the intervention. This understanding helps extend the RAM in terms of the effects and mechanisms of age stereotypes on physical task performance as presented in the following section.

Extending the RAM: The role of age stereotypes in the development of frailty

Conceptual models of frailty typically present aging in terms of biological decline (Fried et al., 2001; Kilgour et al., 2013), as presented in Figure 3.1 (p25). The important role of psychosocial factors in this system are highlighted throughout this thesis. Factors such as self-stereotypes of age have the potential for exacerbating or attenuating the trajectory of physical functionality and health. Containing findings from this thesis, a model is shown in Figure 10.1 to incorporate the role of age stereotypes in this cycle.

This theoretical model provides a framework for further understanding and investigation of the role of age stereotypes in the cycle of sarcopenia. Fundamentally, it describes the bidirectional relationship between age stereotypes, physical activity, and physical performance as evidenced in this thesis.

Figure 10.1: Psychophysiological model of negative age stereotypes and physical performance.



Studies 1 and 2 (Chapter 5 and 6) showed ABST impaired physical performance, and this effect was mediated by anxiety. Study 3 (Chapter 7) showed mediation effect of embodied stereotypes on falls directly, and indirectly, as avoidance of physical activity increased functional limitations which increased falls risk. Studies 4 and 5 (Chapter 8 and 9) showed that engagement in group physical activity improved self-perceptions of ageing. The pathway from ABST to avoidance of physical activity are supported elsewhere (von Hippel, Kalokerinos, & Henry, 2013). The lack of affective response in Chapter 6 is described by the pathway from functional limitation to stereotype threat. Awareness of a functional limitation may increase the salience of threat in a performance setting (Levy, 2009). Pathways from functional limitation and frailty and falls reflect the cyclical nature of age stereotypes, functional limitations, and health events (Wurm et al., 2013).

Implications

This thesis has important practical implications for therapists, clinicians, researchers, policy makers, and individuals of all ages. Even with subtle written instructions, ABST caused handgrip strength underperformance via anxiety (Chapter

5), and led to alterations in postural strategy when cognitive demands were greater (Chapter 6). These measures were used in this research because these types of tasks can form part of clinical assessment. This might include assessing older adults for social care, or clinical decision making about prognosis following surgery. This means clinical practitioners, and researchers using physical performance measures, should seek to control sources of anxiety, including ABST, in order to obtain accurate measurements of physical performance. Else, the validity of these measurements will be curtailed. While reliable measurement of self-efficacy was limited in the studies in this thesis, there is strong evidence that stronger task self-efficacy is associated with reduced anxiety (Chung, Ehrhart, Holcombe Ehrhart, Hattrup, & Solamon, 2010). Self-efficacy is strengthened from previous positive experiences, persuasion, emotional state, and vicarious and imagined experiences. Therefore exploiting these sources may offer a way to mitigate ABST effects, and this deserves to be empirically demonstrated.

Chapter 7 showed more negative age attitudes were associated with low engagement in physical activity, weaker handgrip strength, slower walk speed, and increased likelihood of having experienced a fall. Then, Chapter 8 Chapter 9 showed that age attitudes are fluid and can be changed improved through physical activity. Together, the findings from these chapters are promising because this means there are important health and wellbeing outcomes that may be achieved through improving age attitudes. Therefore, it is possible to intervene through policy to increase provision and access of enjoyable physical activity for older adults to achieve these health benefits. These low-intensity activities can reduce negative age stereotypes which may reduce chronic stress (Levy et al., 2008), and can provide a gateway to more intense activity, leading to even greater benefits.

Research Limitations

In each empirical chapter, specific limitations have been considered. Here, common limitations of from across this body of research are presented.

Sampling

Different recruitment strategies were necessarily employed for each of the empirical chapters. Collectively this is a strength of the thesis. In all cases, individuals gave consent to take part in research. Perhaps this may have led to recruitment of people who were less anxious about the tasks involved, or those who were generally less concerned about engaging in something new. This means that effects were dependent on a self-selecting sample. The effect of sampling was especially highlighted by the difference in affective response between Chapter 5 and Chapter 6. In terms of the generalisability of these findings then, this self-selecting sample is unlikely to be wholly representative of the older adult population. This means that for these chapters, the effect of age stereotypes on performance is more likely ‘best case’ (i.e. underperformance effects are more limited). This means that the true effect of age stereotypes on performance in the general population is likely to be greater than that evidenced in this research.

On this note, it is worth noting the small effect sizes and small sample sizes in some of the experimental chapters (Chapter 5, Chapter 6, Chapter 8, and Chapter 9). It is possible that these studies may have been underpowered to detect statistical significance. Despite these small effects, the cumulative impact of age stereotypes could be much larger if repeated exposures are experienced. While a single ‘dose’ from an experiment may lead to a response of limited practical significance, it suggests that the ‘real world’ effect may be much larger because of this cumulative effect. This proposition has an empirical basis. For example, positive age stereotypes lead to decreased cardiovascular stress, and more exposures lead to a greater effect (Levy, Hausdorff, Hencke, & Wei, 2000). This means that while conclusions drawn from this thesis are attenuated by small sample sizes and small effect sizes (except Chapter 7), what they lack in sample size and in studies of within subjects comparisons only, these studies make up for with high ecological validity (Chapter 8 and Chapter 9). Due to practical issues of recruitment, these studies did not have an independent comparison group, relying on within-groups comparisons to draw conclusions. These studies produced valuable findings and pave the way for RCTs in future studies. Other studies (Chapter 5 and Chapter 6), are experiments which do not have this benefit of external validity but instead make valuable contribution to ABST theory.

Reconciling IPM and STEP models of threat

The experimental chapters in this thesis tested the role of anxiety, and sought to explore how anxiety caused by ABST might demand cognitive resources. As such, the experimental chapters were particularly pertinent to the pathways proposed by the IPM. However, the importance of an affective response is also highlighted by the STEP model (Smith, 2004). Specifically, a negative experience of the task is deemed to be a key determinant of performance. Indeed, this is consistent with self-efficacy theory (Bandura, 1997). This thesis sought to investigate self-efficacy in relation to age stereotypes held by older adults. Greater self-efficacy is associated with more performance approach goals. Conversely, lower self-efficacy is related to more avoidance motivations (Barkoukis, Koidou, & Tsorbatzoudis, 2010; Gao, Lochbaum, & Podlog, 2011; Morris & Kavussanu, 2008; Ommundsen, 2010). Indeed, further exploration of the STEP model may help to understand why some but not all participants experienced anxiety under threat conditions. Specifically, by including goal approach and self-efficacy questionnaires in exploring the effect of ABST on performance (such as in Chapter 5 and Chapter 6) would help elucidate this susceptibility.

Potential explanatory factors

This thesis highlighted the importance of controlling individual factors in being able to detect stereotype effects amongst random variation. The use of linear mixed models strengthened this body of research, allowing for hierarchical relationships to be modelled, such as in multicentre studies (Chapter 9). Further, a range of potential covariates were included in these studies, such as age, gender, and presence of a health condition. More recent research also points towards potential moderating variables which may help to stratify the effect of stereotype threat on performance. For example, one study shows that older adults only walk slower when stereotype threat is evoked if they have poor appraisals of their ability to succeed (Barber et al., 2020). This suggests that measurement of these resource appraisals in future research would be beneficial. A consideration made in this thesis when deciding questionnaires to collect demographic information was to not generate ‘questionnaire fatigue’ to ensure data collected was reliable. Equally, developing an experimental protocol which can delivered under practical constraints is a key consideration of any scientific endeavour. A multitude of individual factors are apparent that could mediate and moderate the effect of stereotype threat on physical performance, and it is likely that there are many more yet to identify and operationalise.

Understanding qualitative experiences of threat

The reliance on quantitative data throughout this thesis supported objective testing of the effect of age stereotypes on physical performance. The use of digital dynamometry (Chapter 5, Chapter 6, and Chapter 9) and large scale survey data (Chapter 7) enabled the inferences made to be as reliable as possible. However, the scope of this thesis did not extend to the phenomenological experience of stereotype threat. A qualitative approach may have provided ideographic insights which could be used to help control individual differences, and so further elucidate the effect of ABST. Also, qualitative measures can help inform interventions that are appealing to individuals. Interventions were opportunistically examined to investigate the relationship of age stereotypes and physical activity (Chapter 8, Chapter 9). There is scope to further develop targeted interventions specifically to improve age attitudes and improve physical performance and a range of methodology will be beneficial to address this need.

Directions and Recommendations for Future Research

Throughout this thesis, opportunities have been presented for future research to extend understanding of how age stereotypes can affect physical performance. For example Study 1 (Chapter 5) showed that some, although not all, people were made anxious by the ABST manipulation. The quasi-double blind design procedure meant that the threat was presented in written form, which may be a less salient presentation than verbally from an experimenter. Despite attempts to increase threat self-relevance in Study 2 (Chapter 6) through age identification and falls efficacy questionnaires, there was no affective response to the written ABST manipulation. Therefore, strengthening this manipulation for more active participants is necessary in future research. Additionally, increase self-relevance of threat is necessary to heighten the salience of the threat. For instance, through fabricated feedback on an initial performance. Study 3 (Chapter 7) showed the need for longitudinal analysis to understand how self-perceptions of aging relate to physical performance, and Study 4 (Chapter 8) and Study 5 (Chapter 9) offered enticing opportunities for using RCTs to better understand interventions to reduce negative age bias and to increase physical activity. Beyond these specific recommendations, and aside from redressing limitations already discussed in this chapter, further recommendations are made.

The psychophysiological model of negative age stereotypes and physical performance proposed above in Figure 10.1: Psychophysiological model of negative age stereotypes and physical performance. is based on empirical studies of this thesis. However, some pathways remain to be demonstrated experimentally. Specifically, the mechanisms for stereotype threat to cause avoidance of physical activity is speculated from research investigating ABST effects on occupational intentions (von Hippel et al., 2013). Employing similar methodology with physical activity would greatly advance theoretical understanding of ABST, and provide crucial groundwork for targeting interventions to increase older adults' uptake of physical activity. Important factors may moderate this relationship. For example, this thesis showed that when people are healthier, more physically active, and can distance themselves from the stigmatized group, then people might be protected from ABST. It is important for researchers, clinicians, and therapists to be able to identify people most at risk of underperformance, so that interventions or control measures can be implemented. This will be especially valuable to researchers, clinicians, and individuals who wish to manage underperformance from situational factors such as ABST.

This thesis tested ABST effects on handgrip strength and static balance experimentally. Prospects to explore the effect of age stereotypes on other physical performance tasks are appealing. For instance, some previous research has failed to find an effect of ABST on certain physical tasks (Horton et al. 2010; Chalabaev et al. 2020). By applying lessons from this thesis to these studies then these effects may be brought to focus. For example, the ABST effect was identified in Chapter 5 only when the mediating role of anxiety was explored. In Study 2 (Chapter 6), effects of condition were only identified when comparing performance under high and low cognitive load. Similarly, existing research shows the effect of ABST on walking performance (more step errors, slower speed, increase in step variability) in more difficult conditions only when resource appraisals were considered (Barber et al., 2020). This highlights opportunity to hone future research through inclusion of moderators and mediators to identify the effects of ABST.

This thesis pioneered methodological approaches for stereotype threat research, such as use of digital dynamometry and EMG to investigate neuromuscular effects. Although these effects were limited, this does not negate the importance of using these methods. Indeed, EMG can help describe the way that muscle recruitment changes according to psychological factors (Bray, Martin Ginis, Hicks, & Woodgate, 2008), and muscle co-contraction as measured by EMG can be used to assess fall risk (Annese & De Venuto, 2015).

Applying these methods to an ecologically valid physical task could help to refine our understanding of ABST in relation to fall risk. The sit-to-stand (STS) test derives a performance score based on the number of times the person rises from the char in a fixed window of time, or the time taken to complete a fixed number of repetitions. This test is commonly used in research as a measure of lower limb power (Tveter, Dagfinrud, Moseng, & Holm, 2014) and has clinical application to distinguish people at risk of experiencing a fall (Chorin, Cornu, Beaune, Frère, & Rahmani, 2016; Regterschot et al., 2014). Biomechanical measurements can also help classify fallers, such as the time seated during transition (Najafi, Aminian, Loew, Blanc, & Robert, 2002). For example, using 3D motion capture and force plate equipment could detect whether stereotype threat leads to a shift in the way that momentum is generated to enable the person to rise from the chair. These differences could help demonstrate an ecologically valid way in which participants could be at risk of falls in addition to the traditional performance measures. For example, with advancing age, forward lean increases during STS compared to vertical displacement, which can present an increased fall risk (Kerr, White, Barr, & Mollan, 1997). When coupled with EMG, this protocol could help further demonstrate how ABST affects postural control, and how muscle power is generated when fatigued. Further, if STS is repeated in bouts, this will help to corroborate indicative findings from Study 1 (Chapter 5) by showing whether ABST decreases the time to failure of physical tasks. Individual factors such as anthropometry and cardiovascular metrics, as well as psychological predictors such as resource appraisals, goal motivation, self-efficacy, and age attitudes should be considered too. This example presents a way to synthesise the theorised STEP and IPM models, address limitations highlighted in this thesis, and to extend understanding of how age stereotypes can affect physical performance. By addressing this opportunity, more targeted interventions can be developed.

Conclusion

This thesis focussed on the relationships between age stereotypes and older adults' physical performance. This was trisected by testing the effects of stereotype threat on handgrip and balance, by exploring the relationship of age attitudes with the likelihood of experiencing a fall, and by investigating the way in which pleasurable physical activity might influence physical performance and reciprocate self-perceptions of age. Through the use of experimental, survey, and field study approaches across a range of settings, age stereotype literature was extended. The pernicious effect of stereotype threat on physical performance was demonstrated as the role of anxiety in this was evidenced. However, results were mixed, as these findings showed that not everyone was equally susceptible to stereotype threat. This highlighted the importance of individual factors as sources of resistance to underperformance on physical tasks or avoidance of intense physical activities. This has crucial implications for future research in this field. Encouragingly, this research showed that age attitudes are malleable. When people became involved in physical activity then age attitudes improved. These findings are crucial as they pave the way for ensuring the reliability and validity of diagnostic and prognostic applications of physical performance measures in older populations, and for the future development of targeted interventions to promote older adults' health.

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Appendices

Regression model results for chapter 8

Table A1: Multilevel models for subjective age

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	58.9 ***	2.8	53.2 ***	3.4	54.9 ***	6.7	14	23.5	5.6	26.5
Visit (Post-Intervention)			12.8 **	4.1	4.3	11.4	1.56	11.8	18.4	15.5
Attended (Yes)					-2.3	7.95	-6.2	10.3	-9.6	10.5
Visit (Post-Intervention) * Attended (Yes)					9.9	12.3	12.6	12.6	19.5	13.1
Age							0.54 *	0.2	0.5	0.2
Sex							7.8	8.9	7.6	9.2
Health Condition							-1.7	5.5	-1.3	5.6
Physical Activity									7.6	6.3
Time (Post-intervention) * Physical activity									-12	7.6
Random Effects										
σ^2	436		329		322		297		275	
τ_{00}	51		108		67		51		36	
ICC	0.24		0.39		0.42		0.29		0.33	
Marginal R^2 / Conditional R^2	0.0 / 0.23		0.07 / 0.44		0.07 / 0.46		0.16 / 0.40		0.18 / 0.45	
AIC	759		753		739		665		666	

** p<.05 ** p<.01 *** p<.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A2: Multilevel models for Control

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	2.56 ***	0.1	2.47 ***	0.1	2.49 ***	0.2	3.80 ***	0.9	3.04 **	1.1
Time (Post-Intervention)			0.21	0.1	0.01	0.3	-0.04	0.3	-0.12	0.3
Attended (Yes)					0.01	0.3	0	0.4	-0.16	0.6
Time (Post-Intervention) * Attended (Yes)					0.22	0.3	0.27	0.4	0.2	0.4
Age							-0.01	0	-0.01	0
Sex							-0.17	0.3	-0.07	0.3
Any Health Condition							-0.19	0.2	-0.23	0.2
Physical Activity									0.29	0.2
Time (Post-Intervention) * Physical Activity									0.09	0.3
Random Effects										
σ^2	0.36		0.34		0.34		0.33		0.28	
τ_{00}	0.30		0.31		0.31		0.24		0.30	
ICC	0.46		0.47		0.48		0.42		0.52	
Marginal R^2 / Conditional R^2	0.0 / 0.46		0.02 / 0.48		0.02 / 0.49		0.07 / 0.47		0.12 / 0.57	
AIC	208.2		207.8		206.8		188.7		189.1	

** p<0.05 ** p<0.01 *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A3: Multilevel models for Autonomy

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	3.20 ***	0.1	3.07 ***	0.1	2.96 ***	0.2	3.88 ***	0.8	3.02 **	0.9
Time (Post-Intervention)			0.30 *	0.1	-0.13	0.3	-0.41	0.3	-0.5	0.3
Attended (Yes)					0.17	0.3	-0.18	0.3	-0.51	0.5
Time (Post-Intervention) * Attended (Yes)					0.48	0.3	0.76 *	0.3	0.64	0.3
Age							-0.01	0	0	0
Sex							0.12	0.3	0.26	0.3
Any Health Condition							-0.06	0.2	-0.12	0.2
Physical Activity									0.40 *	0.2
Time (Post-Intervention) * Physical Activity									0.04	0.2
Random Effects										
σ^2	0.4		0.36		0.33		0.31		0.27	
τ_{00}	0.23		0.23		0.26		0.18		0.17	
ICC	0.36		0.39		0.44		0.36		0.38	
Marginal R^2 / Conditional R^2	0.0 / 0.52		0.05 / 0.59		0.07 / 0.62		0.11 / 0.54		0.22 / 0.59	
AIC	206.4		203.4		200.8		177		172.4	

** p<0.05   ** p<0.01   *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A4: Multilevel models for Self-Realisation

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	3.10 ***	0.1	3.10 ***	0.1	3.00 ***	0.2	3.98 ***	0.7	3.57 ***	0.9
Time (Post-Intervention)			-0.01	0.1	-0.25	0.3	-0.43	0.3	-0.47	0.3
Attended (Yes)					0.13	0.2	-0.06	0.3	-0.48	0.5
Time (Post-Intervention) * Attended (Yes)					0.28	0.3	0.46	0.3	0.33	0.3
Age							-0.01	0	0	0
Sex							0.11	0.3	0.22	0.3
Any Health Condition							-0.23	0.2	-0.28	0.2
Physical Activity									0.49 *	0.2
Time (Post-Intervention)* Physical Activity									-0.21	0.2
Random Effects										
σ^2	0.27		0.26		0.25		0.24		0.24	
τ_{00}	0.29		0.29		0.31		0.18		0.14	
ICC	0.52		0.52		0.55		0.43		0.37	
Marginal R^2 / Conditional R^2	0.0 / 0.52		0.0 / 0.52		0.02 / 0.56		0.07 / 0.47		0.14 / 0.46	
AIC	189.7		191.7		191.2		162.6		161.1	

** p<0.05 ** p<0.01 *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A5: Multilevel models for Pleasure

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	3.37 ***	0.1	3.1 ***	0.1	2.93 ***	0.2	3.3 ***	0.7	3.32 ***	0.89
Time (Post-Intervention)			0.4 ***	0.1	0.63 **	0.2	0.5 *	0.22	0.55 **	0.21
Attended (Yes)					0.31	0.2	0.11	0.28	-0.34	0.52
Time (Post-Intervention) * Attended (Yes)					-0.2	0.2	-0.11	0.24	-0.22	0.23
Age							0	0.01	0	0.01
Sex							0.24	0.27	0.33	0.26
Any Health Condition							-0.07	0.17	-0.11	0.17
Physical Activity									0.44 **	0.13
Time (Post-Intervention) * Physical Activity									-0.36	0.14
Random Effects										
σ^2	0.22		0.11		0.11		0.1		0.09	
τ_{00}	0.29		0.36		0.35		0.20		0.19	
ICC	0.57		0.77		0.76		0.67		0.67	
Marginal R^2 / Conditional R^2	0.0 / 0.56		0.11 / 0.79		0.15 / 0.80		0.17 / 0.72		0.21 / 0.74	
AIC	171		146		145		117		116	

** p<0.05 ** p<0.01 *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A6: Multilevel models for negative age attitudes

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	2.88 ***	0.1	2.84 ***	0.1	2.63 ***	0.2	3.92 ***	1	3.45 **	1.2
Time (Post-Intervention)			0.1	0.1	-0.45	0.2	-0.57 *	0.2	-0.57 *	0.2
Attended (Yes)					0.29	0.3	-0.16	0.4	-0.1	0.6
Time (Post-Intervention) * Attended (Yes)					0.61 *	0.3	0.72 **	0.3	0.66 *	0.3
Age							-0.01	0	-0.01	0
Sex							-0.06	0.4	0.01	0.4
Any Health Condition							-0.35	0.2	-0.38	0.2
Physical Activity									0.25	0.2
Time (Post-Intervention) * Physical Activity									-0.16	0.2
Random Effects										
σ^2	0.15		0.15		0.12		0.12		0.12	
τ_{00}	0.47		0.46		0.49		0.40		0.40	
ICC	0.76		0.76		0.8		0.77		0.77	
Marginal R^2 / Conditional R^2	0.0 / 0.76		0.004 / 0.76		0.07 / 0.81		0.10 / 0.79		0.11 / 0.80	
AIC	169.6		170.5		164.2		147.0		149.5	

** p<0.05   ** p<0.01   *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A7: Multilevel models for physical age attitudes

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	3.69 ***	0.1	3.55 ***	0.1	3.33 ***	0.3	2.95 **	1	2.35	1.4
Time (Post-Intervention)			0.33 *	0.1	0.28	0.4	0.08	0.4	0.07	0.4
Attended (Yes)					0.29	0.3	-0.06	0.4	-0.46	0.9
Time (Post-Intervention) * Attended (Yes)					0.03	0.4	0.22	0.5	0.04	0.5
Age							0.01	0	0.02	0
Sex							-0.06	0.4	0.12	0.4
Any Health Condition							-0.48 *	0.2	-0.55 *	0.2
Physical Activity									0.21	0.2
Time (Post-Intervention) * Physical Activity									0.27	0.3
Random Effects										
σ^2	0.44		0.39		0.39		0.38		0.38	
τ_{00}	0.35		0.36		0.37		0.26		0.20	
ICC	0.45		0.48		0.48		0.41		0.35	
Marginal R^2 / Conditional R^2	0.0 / 0.45		0.04 / 0.50		0.06 / 0.51		0.12 / 0.48		0.18 / 0.47	
AIC	211.5		208.4		208		186.2		185.3	

** p<0.05 ** p<0.01 *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A8: Multilevel models for positive age attitudes

	Model 0		**Model 1**		**Model 2**		**Model 3**		**Model 4**	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	3.69 ***	0.1	3.61 ***	0.1	3.16 ***	0.2	4.25 ***	0.6	4.42 ***	0.8
Time (Post-Intervention)			0.19 *	0.1	0.29	0.2	0.17	0.2	0.18	0.2
Attended (Yes)					0.60 **	0.2	0.14	0.2	-0.63	0.5
Time (Post-Intervention) * Attended (Yes)					-0.13	0.2	-0.01	0.2	-0.16	0.2
Age							-0.01	0	-0.01	0
Sex							-0.14	0.2	-0.02	0.2
Any Health Condition							0.30 *	0.1	0.25	0.1
Physical Activity									0.18	0.1
Time (Post-Intervention) * Physical Activity									0.17	0.1
Random Effects										
σ^2	0.12		0.1		0.1		0.1		0.08	
τ_{00}	0.31		0.30		0.26		0.12		0.11	
ICC	0.73		0.74		0.71		0.56		0.56	
Marginal R^2 / Conditional R^2	0.0 / 0.73		0.02 / 0.75		0.16 / 0.76		0.16 / 0.63		0.27 / 0.68	
AIC	142.9		138.6		132.3		101.7		94.9	

** p<0.05   ** p<0.01   *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A9: Multilevel models for stereotype threat concern

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	2.18 ***	0.2	2.72 ***	0.2	2.80 ***	0.4	1.9	1.2	1.23	1.5
Time (Post-Intervention)			-1.19 ***	0.3	-1.50 *	0.6	-0.91	0.6	-1.06	0.6
Attended (Yes)					-0.15	0.4	0.44	0.5	1.63	0.9
Time (Post-Intervention) * Attended (Yes)					0.4	0.7	-0.19	0.7	0.15	0.7
Age							0	0	0	0
Sex							-0.08	0.5	-0.21	0.5
Any Health Condition							0.65 *	0.3	0.74 *	0.3
Physical Activity									-0.04	0.4
Time (Post-Intervention) * Physical Activity									-0.26	0.5
Random Effects										
σ^2	2.12		1.38		1.4		1.21		1.13	
τ_{00}	0.06		0.44		0.43		0.18		0.21	
ICC	0.03		0.24		0.24		0.13		0.16	
Marginal R^2 / Conditional R^2	0.000 / 0.03		0.16 / 0.36		0.16 / 0.36		0.23 / 0.33		0.26 / 0.37	
AIC	320.5		304.6		302.4		264.3		265.2	

** p<0.05   ** p<0.01   *** p<0.001. . ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A10: Multilevel models for self-esteem

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	2.79 ***	0.1	2.77 ***	0.1	2.59 ***	0.1	3.02 ***	0.4	2.59 ***	0.4
Visit (Post-Intervention)			0.1	0.1	0	0.2	-0	0.2	0.1	0.2
Attended (Yes)					0.2	0.1	0	0.2	-0.1	0.2
Visit (Post-Intervention) * Attended (Yes)					0	0.2	0.1	0.2	0.1	0.2
Age							<0.01	<0.01	<0.01	<0.1
Sex							-0.2	0.2	-0.1	0.2
Health Condition							0.1	0.1	0.1	0.1
Physical Activity									0.22 *	0.1
Time (Post-intervention)* Physical Activity									-0.1	0.1
Random Effects										
σ^2	0.06		0.06		0.06		0.05		0.05	
τ_{00}	0.06		0.05		0.05		0.02		0.03	
ICC	0.65		0.65		0.64		0.49		0.55	
Marginal R^2 / Conditional R^2	0.0 / 0.65		0.004 / 0.64		0.06 / 0.66		0.05 / 0.52		0.11 / 0.60	
AIC	77.7		78.9		79.4		55.2		53.8	

* *p<0.05* ** *p<0.01* *** *p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Table A11: Multilevel models for loneliness

	Model 0		Model 1		Model 2		Model 3		Model 4	
Predictors	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
(Intercept)	2.81 *	1.2	1.7	1.6	1.81	3.1	-2.9	11.6	-6.7	13.3
Visit (Post-Intervention)			2.6	2.4	0.44	6.3	0.67	7.58	-4.6	9.93
Attended (Yes)					-0.2	3.7	0.28	5.63	0.6	5.75
Visit (Post-Intervention) * Attended (Yes)					2.44	6.8	2.17	8.09	-1	8.57
Age							0.07	0.13	0.11	0.13
Sex							-0.2	4.43	1.06	4.53
Any Health Condition							-2.8	2.71	-3.5	2.74
Physical Activity									0.25	3.65
Time (Post_intervention)* Physical Activity									3.67	4.76
Random Effects										
σ^2	0.22		0.11		0.11		0.1		0.09	
τ_{00}	0.29		0.36		0.35		0.20		0.19	
ICC	0.57		0.77		0.76		0.67		0.67	
Marginal R^2 / Conditional R^2	0.00 / 0.56		0.10 / 0.79		0.14 / 0.79		0.17 / 0.72		0.21 / 0.74	
AIC	171.1		146.6		145		117.3		116.5	

** p<0.05 ** p<0.01 *** p<0.001. ICC – Intraclass coefficient. AIC – Akaike Information Criterion.*

Example Consent form

Title of project: Moving Memory

Name of Investigator: Ian Farr

Participant Identification Number for this project:

Please initial box

1. I confirm I have read and understand the information sheet for the above study (dated:). I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. *(Contact the lead researcher on if55@kent.ac.uk)*

3. I understand that my data will be anonymised before analysis. I give permission for members of the research team to have access to my anonymised data.

4. I have read, understood and completed the Health Questionnaire to the best of my knowledge

5. I agree to take part in the above research project.

Name of participant Date Signature

Lead researcher Date Signature

Example Health Questionnaire

Participant-ID-Number ……………………………………………………………………

Please answer these questions truthfully and completely. The sole purpose of this questionnaire is to ensure that you are in a fit and healthy state to complete the exercise test.

ANY INFORMATION CONTAINED HEREIN WILL BE TREATED AS CONFIDENTIAL.

SECTION 1: GENERAL HEALTH QUESTIONS

Please read the 8 questions below carefully and answer each one honestly: check YES or NO.

	YES	NO
1. Has your doctor ever said that you have high blood pressure that is not controlled by medication?	◻	◻
2. Do you have angina?	◻	◻
3. Do you have a history of stroke or TIA (minor stroke)?	◻	◻
4. Have you ever had an abdominal aortic aneurysm?	◻	◻
5. Do you feel pain in your chest at rest, during your daily activities of living, or when you do physical activity?	◻	◻
6. Do you lose balance because of dizziness or have you lost consciousness in the last 12 months? (Please answer NO if your dizziness was associated with over-breathing including vigorous exercise).	◻	◻
7. Do you currently have (or have you had within the past 12 months) a bone, joint or soft tissue (muscle, ligament, or tendon) problem in your hand that could be made worse by physical activity? Please answer NO if you had a problem in the past but it *does not limit your ability* to be physically active.	◻	◻

8. Do you have particularly sensitive skin such that hypoallergenic electrodes may cause irritation?	☐	☐
9. Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared to take part in the exercise test

Additional Health Questionnaire – Study 1

To be completed after study.

Age: ___________ **Gender:** Male / Female/ Other/ Do not wish to answer (circle)

Please only respond to those that you feel comfortable to do so

	YES	**NO**
Do you have arthritis affecting movement in your dominant hand?		
Are you currently taking any of the following: Cardiovascular medications (Furosemide, Nitrates, Calcium Channel Blockers (CCB) and Fibrates) Antibiotics (Ciprofloxacin and Penicillins) Anti-inflammatory pain killers (Naproxen, Diclofenac) Chemotherapy agents (Cisplatin, Oxaliplatin, Carboplatin, 5FU, Capecitabine, Docetaxel, Paclitaxel)		

Beta- blockers (e.g. Atenolol used for high blood pressure and angina e.g. Tenormin) ACEI (used for high blood pressure and kidney complications from diabetes e.g. Vasotec, Renitec, Altace, Prilace, Ramace, Ramiwin, Triatec, Tritace, Accupril, Coversyl, Aceon,Perindo, Listril, Lopril, Novatec, Prinivil, Zestril, Lotensin, Mavik, Odrik, Gopten, Inhibace) Aromatase inhibitors (used for breast cancer and gynecomastia e.g. Teslac, Arimidex, Femara, Aromasin, Rivizor, Lentaron, Afema) Tamoxifen (used for breast cancer and gynecomastia e.g. Novaldex) Colchicine (used for gout) Hydroxychloroquine (used for arthritis e.g. Plaquenil, Dolquine, Quensyl) Interferon (used for treating MS e.g. Pegintron, Pegasys) Amiodarone (used for atrial fibrillation and irregular heartbeat e.g. Pacerone, Cordarone, Aratac)		
Do you have any of the following medical conditions: Carpel tunnel syndrome Diabetes Sciatica Vitamin B12 deficiency		

Parkinsons Multiple Sclerosis Rheumatoid arthritis		
Have you been prescribed corticosteroids for the last three months or more?		

Participant Instructions - Handgrip

Control

1. You will be asked to grip the hand strength device as hard as you can. It is important that you grip as hard as possible.
2. The purpose of this research is to see how people differ in their performance on various tasks, different types of people will be taking part in this research. You will now be asked to grip the hand strength device for as long as you can at no less than half the amount of your maximum. This will be calculated by the experimenter who will tell you the force to produce.

Threat After MVC

1. You will be asked to grip the hand strength device as hard as you can. It is important that you grip as hard as possible.
2. It is widely assumed that physical capabilities decline with age, such as physical strength and fitness. The purpose of this research is to see whether older people do perform worse on various physical performance tasks compared to younger people. Both older and younger people will be taking part in this research. You will now be asked to grip the hand strength device for as long as you can at no less than half the amount of your maximum. This will be calculated by the experimenter who will tell you the force to produce. Your results will be compared to younger people taking part.

Threat Before MVC

1. It is widely assumed that physical capabilities decline with age, such as physical strength and fitness. The purpose of this research is to see whether older people do perform worse on various physical performance tasks compared to younger people. Both older and younger people will be taking part in this research. You will now be asked to grip the hand strength device

as hard as you can. Your results will be compared to younger people taking part.

2. Keeping in mind the aims of the study, you will be asked to grip the hand strength device for as long as you can at no less than half the amount of your maximum. This will be calculated by the experimenter who will tell you the force to produce. You will now be asked to grip the hand strength device for as long as you can at no less than half of your maximum. Your results will be compared to younger people taking part.

Manipulation Instructions – Balance

Control

The purpose of this research is to see how people differ in their performance on various tasks, different types of people will be taking part in this research. You will be asked to stand with one foot in front of the other for one minute, then after a short rest, to stand on one leg for another minute.

Threat

It is widely assumed that physical capabilities decline with age, such as balance, physical strength, and fitness. The purpose of this research is to see whether older people do perform worse on various balance tasks compared to younger people. Both older and younger people will be taking part in this research. You will be asked to stand with one foot in front of the other for one minute, then after a short rest, to stand on one leg for another minute. Your results will be compared to younger people taking part.

Anxiety Questionnaire

Please rate the extent to which you felt the following while completing the previous balance task …?

	Not a lot						A lot
Under-pressure	1	2	3	4	5	6	7
Nervous	1	2	3	4	5	6	7
Tense	1	2	3	4	5	6	7
Jittery	1	2	3	4	5	6	7
Confident	1	2	3	4	5	6	7
Uneasy	1	2	3	4	5	6	7
Calm	1	2	3	4	5	6	7
Afraid of not doing well	1	2	3	4	5	6	7
Uncomfortable	1	2	3	4	5	6	7

To what extent did you experience the following during the task …?

	Not at all						Very much
Worrying thoughts or concerns?	1	2	3	4	5	6	7
Nervous feelings such as butterflies in your stomach?	1	2	3	4	5	6	7

To what extent did the following affect your performance …?

	Not at all						Very much
Worrying thoughts or concerns?	1	2	3	4	5	6	7
Nervous feelings such as butterflies in your stomach?	1	2	3	4	5	6	7

ABST Questions

Were you worried that your ability to perform well on the test was affected by your age?

Not at all						Very much
1	2	3	4	5	6	7

Were you worried that if you performed poorly on the test, the researcher would attribute your poor performance to your age?

Not at all						Very much
1	2	3	4	5	6	7

Falls Efficacy Scale - International

Now we would like to ask some questions about how concerned you are about the possibility of falling. For each of the following activities, please circle the opinion closest to your own to show how concerned you are that you might fall if you did this activity.

Please reply thinking about how you usually do the activity. If you currently don't do the activity (e.g. if someone does your shopping for you), please answer to show whether you think you would be concerned about falling IF you did the activity.

		Not at all concerned	Somewhat concerned	Fairly concerned	Very concerned
1	Cleaning the house (e.g. sweep, vacuum or dust)	1	2	3	4
2	Getting dressed or undressed	1	2	3	4
3	Preparing simple meals	1	2	3	4
4	Taking a bath or shower	1	2	3	4
5	Going to the shop	1	2	3	4
6	Getting in or out of a chair	1	2	3	4
7	Going up or down stairs	1	2	3	4
8	Walking around in the neighbourhood	1	2	3	4

9	Reaching for something above your head or on the ground	1	2	3	4
10	Going to answer the telephone before it stops ringing	1	2	3	4
11	Walking on a slippery surface (e.g. wet or icy)	1	2	3	4
12	Visiting a friend or relative	1	2	3	4
13	Walking in a place with crowds	1	2	3	4
14	Walking on an uneven surface (e.g. rocky ground, poorly maintained pavement)	1	2	3	4
15	Walking up or down a slope	1	2	3	4
16	Going out to a social event (e.g. religious service, family gathering or club meeting)	1	2	3	4

International Physical Activity Questionnaire

The first question is about the time you spent sitting during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

During the last 7 days, how much time did you spend sitting during a day?

______hours__minutes

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2 Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

______Days	□	How much time did you usually spend walking on one of those days?
or		______hours__minutes
No day		

3. During the last 7 days, on how many days did you do moderate physical activities like gardening, cleaning, bicycling at a regular pace, swimming or other fitness activities.

Think *only* about those physical activities that you did for at least 10 minutes at a time. Do not include walking.

______Days → How much time did you usually spend doing moderate physical activities on one of those days?

or

No day ______hours__minutes

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4. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, heavier garden or construction work, chopping woods, aerobics, jogging/running or fast bicycling?

Think *only* about those physical activities that you did for at least 10 minutes at a time.

______Days → How much time did you usually spend doing vigorous physical activities on one of those days?

or

No day ______hours__minutes

Age Identity Questionnaire

Self-categorisation:

Please tell me which box best describes the age group you see yourself as belonging to. If you see yourself as very young, pick the first letter. If you see yourself as very old, pick the last letter. Otherwise pick one of the boxes in between. Please just circle one letter.

A Very Young

B

C

D

E

F

G

H

J Very Old

(Refused)

(Don't know)

Age Identification

Please tell me if you have a strong or weak sense of belonging to this age group. Choose your answer where 0 means a very weak sense of belonging and 10 means a very strong sense of belonging. ‘This age group’ refers to the age group the identified at the previous question.

Very weak sense of belonging   Very strong sense of belonging

00 01 02 03 04 05 06 07 08 09 10

Don’t know

I have no sense of belonging to any age group

My Actual (chronological) Age__________

The age I feel _______________________

Intergenerational Contact Questionnaire

How often do you have contact with older adults?

Very rarely						**Very Often**
1	2	3	4	5	6	7

How would you rate your contact with older adults?

Poor						**Very Good**
1	2	3	4	5	6	7

How they would you feel interacting with a typical older adult?

Tense	1	2	3	4	5	6	7	**Relaxed**
Calm	1	2	3	4	5	6	7	**Nervous**
Stressed	1	2	3	4	5	6	7	**Unstressed**

How do you personally feel about ageing? (1 = strongly disagree, 7 = strongly agree)

‘I am worried that I will lose my independence when I am old’

1 2 3 4 5 6 7

‘I am relaxed about getting old’,

1 2 3 4 5 6 7

‘I am concerned that my mental abilities will suffer when I am old’

1 2 3 4 5 6 7

‘I do not want to get old because it means I am closer to dying’

1 2 3 4 5 6 7

Functional Independence

Self-Care	
A. Eating	
B. Grooming	
C. Bathing	
D. Dressing - Upper Body	
E. Dressing - Lower Body	
F. Toileting	
Sphincter Control	
G. Bladder Management	
H. Bowel Management	
Transfers	
I. Bed, Chair, Wheelchair	
J. Toilet	
K. Tub, Shower	
Locomotion	
L. Walk/Wheelchair	
M. Stairs	
Motor Subtotal Score	
Communication	
N. Comprehension	
O. Expression	
Social Cognition	
P. Social Interaction	
Q. Problem Solving	
R. Memory	
Cognitive Subtotal Score	
TOTAL FIM Score	

Scoring

Independent:

7 Complete Independence (Timely, Safely)

6 Modified Independence (Device)

NO HELPER:

Modified Dependence

5 Supervision (Subject = 100%+)

4 Minimal Assist (Subject = 75%+)

3 Moderate Assist (Subject = 50%+)

Complete Dependence

2 Maximal Assist (Subject = 25%+)

1 Total Assist (Subject = less than 25%)

Note: Leave no blanks. Enter 1 if patient is not testable due to risk.

Rosenberg Self-Esteem Scale

Participant Identification Number:
<u>Instructions:</u> Below is a list of statements dealing with your general feelings about yourself. Please tick one of four options for each statement.

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
On the whole, I am satisfied with myself.				
At times, I think I am no good at all.				
I feel that I have a number of good qualities.				
I am able to do things as well as most other people.				
I feel I do not have much to be proud of.				
I certainly feel useless at times.				
I feel that I'm a person of worth, at least on an equal plane with others.				
I wish I could have more respect for myself.				
All in all, I am inclined to feel that I am a failure.				
I take a positive attitude toward myself.				

UCLA – Loneliness

Please tick one response box per statement.

	Never	**Sometimes**	**Often**
How often do you feel that you lack companionship?			
How often do you feel left out?			
How often do you feel isolated from others?			

Exercise Self-Efficacy Scale

The items listed below are designed to assess your beliefs in your ability to continue exercising on a ONCE per week basis at MODERATE intensities (upper end of your perceived exertion range), for <u>40+ minutes per session in the future.</u> Using the scales listed below please indicate how confident you are that you will be able to continue to exercise in the future.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NOT ALL CONFIDENT MODERATELY CONFIDENT HIGHLY CONFIDENT

For example, if you have complete confidence that you could exercise three times per week at moderate intensity for 40+ minutes for the next four weeks without quitting, you would circle 100% . However, if you had no confidence at all that you could exercise at your exercise prescription for the next four weeks without quitting, (that is, confident you would not exercise), you would circle 0% . Please remember to answer honestly and accurately. There are no right or wrong answers.

Mark your answer by circling a % for each question

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT WEEK

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT TWO WEEKS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT THREE WEEKS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT FOUR WEEKS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT FIVE WEEKS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT SIX WEEKS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT SEVEN WEEKS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am able to continue to exercise at least ONCE per week at moderate intensity, for 40+ minutes without quitting for the NEXT EIGHT WEEKS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Laidlaw Age Attitude Questionnaire

	Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
Old age is a time of loneliness					
Old age is a depressing time of life					
I find it more difficult to talk about my feelings as I get older					
I see old age as a time of loss					
I am losing my physical independence as I get older					
As I get older I find it more difficult to make new friends					
I don't feel involved in society now that I am older					
I feel excluded from things because of my age					
It is important to take exercise at any age					
Growing older has been easier than I thought					
I don't feel old					
My identity is not defined by my age					
I have more energy now than I expected for my age					
Problems with my physical health do not hold me back from doing what I want					
My health is better than I expected for my age					
I keep as fit and active as possible by exercising					

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
As people get older they are better able to cope with life					
It is a privilege to grow old					
Wisdom comes with age					
There are many pleasant things about growing older					
I am more accepting of myself as I have grown older					
It is very important to pass on the benefits of my experiences to younger people					
I believe my life has made a difference					
I want to give a good example to younger people					

PASE

	Measure	Time spent	Score
Muscle strength/ endurance	hrs/day		
Strenuous sports	hrs/day		
Moderate sports	hrs/day		
Light sports	hrs/day		
A job involving walking or standing	hrs/day		
Walking	hrs/day		
Lawn work	Yes/ No		
Caring for another person	Yes/ No		
Home repairs	Yes/ No		
Heavy housework	Yes/ No		
Light housework	Yes/ No		
Outdoor gardening	Yes/ No		
PASE SCORE			

CASP- 12

Please tick one response box per statement.

	Never	**Rarely**	**Sometimes**	**Often**
My age prevents me from doing things I would like to do				
I feel that what happens to me is out of my control				
I feel left out of things				
I can do the things I want to do				
I feel that I can please myself what I do				
Shortage of money stops me from doing the things I would like to do				
I look forward to each day				
I feel that my life has meaning				
I enjoy the things that I do				
I feel full of energy these days				
I fell that life is full of opportunities				
I feel that the future looks good for me				