

Institution: Manchester Metropolitan University		
Unit of Assessment: C24 Sport and Exercise Sciences, Leisure and Tourism		
Title of case study: Active ageing: informing international, national and local guidelines and interventions to reduce frailty and falls in older adults		
Period when the underpinning research was undertaken: 2000 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Hans Degens	Senior Lecturer to Professor	2004 – present
Alex Ireland	Technician to Lecturer	2010 – present
David Jones	Professor	2004 – 2008
Constantinos Maganaris	Research Fellow to Professor	2001 – 2010
Jamie McPhee	Lecturer to Professor	2009 – present
Christopher Morse	Lecturer to Reader	2004 – present
Marco Narici	Professor	1999 – 2012
Gladys Onambélé-Pearson	Research Associate to Reader	2002 – present
Neil Reeves	Research Associate to Professor	2003 – present
Period when the claimed impact occurred: 1 August 2013 – 31 July 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact Over the past 20 years, researchers at Manchester Metropolitan University have conducted a substantial body of work on the biomechanics and physiology of older muscles and bones. The research has informed significant national and international guidelines that are helping to combat/alleviate musculoskeletal (MSK) deterioration to ageing, and improve quality of later life. For example, the latest UK Physical Activity Guidelines have reshaped major national and local public health interventions within the UK. Locally, our research influenced Stockport Clinical Commissioning Group to implement a 'falls prevention' programme that has delivered measurable reductions in falls risk among targeted older people, and improved the borough's national performance rankings for falls. Unexpected novel findings on the poor balance of fit and active older athletes drove a national awareness campaign that has changed the training habits of many older runners in the UK.		
2. Underpinning research Over the past two decades, researchers at Manchester Metropolitan University have been at the forefront of international research into the biomechanics, physiology and pathology of musculoskeletal (MSK) health and ageing. Our studies investigate MSK health in different populations and trace age-related changes (cellular through to whole organism) using techniques such as dual-energy X-ray absorptiometry (DXA), peripheral quantitative computed tomography, magnetic resonance imaging (MRI), dynamometry, ultrasonography, electromyography, biopsies and single muscle fibre characterisation. Collectively, the research team has authored approximately 500 peer-reviewed publications that have accumulated over 11,000 citations (above expectation) suggesting that the body of work has made a significant contribution to the fields of MSK health and exercise science. Among key studies, we highlight EU-funded work led by Dr Onambélé-Pearson who applied three-dimensional accelerometry to quantify habitual physical behaviour in a population of older adults. Using a validated in-house machine learning algorithm with age-specific activity output cut-off points, the team found that light intensity physical activity correlated positively with bone health determined by dual-energy X-ray absorptiometry (DXA) [1]. These findings provided the first rigorous evidence that replacing sedentary behaviour with only light intensity activity can lead to the maintenance of bone health in older adults. The group has published eight further papers drawing on this study's data. As part of the large-scale EU-funded MYOAGE project, McPhee led studies with European collaborators to investigate how muscles become smaller and weaker in older age, and how these changes affect physical capability. His work confirmed that the average person will lose around 30% of their leg muscle mass by the time they are 70-80 years old, and that maintaining a physically-active lifestyle with specific exercises and activities helps to preserve muscle mass, physical capability and health [2]. The project also examined the level of agreement between MRI and DXA in estimating thigh muscle size in young and older men and women and found		

DXA underestimated the age-related loss of thigh muscle mass in comparison to MRI [3]. This validation study is cited within the revised European Working Group on Sarcopenia in Older People consensus paper on definition and diagnosis.

Funding from the Medical Research Council (MRC) enabled McPhee, Degens and Ireland to undertake comparative studies using the largest ever cohort of elite master athletes (aged 35-90+) to help create a model for 'optimal' ageing by examining the effects of long-term exercise on mobility, frailty, injury and quality of later life. Findings from these studies confirmed that even highly competitive endurance runners experience significant age-related loss of muscle mass, strength, bone mass and balance. A comparison of sprint versus endurance runners showed that increased loading from power-based events (e.g. sprinting) could lead to higher bone mineral densities, suggesting longer-term benefits to bone health from strength-based exercise regimes. However, the studies also found that postural stability in older runners was no better than the balance of healthy, non-active people of a similar age; both groups of older people showed significantly more sway than younger adults. The finding suggested that without specific balance training, older runners could still be at high risk from falls and fractures despite their remarkable activity and fitness levels [4].

Finally, Manchester Metropolitan researchers were first to report that ageing effects can be slowed down/reversed in connective tissue by strength training. Using ultrasonography, Reeves conducted a study to show that strength training in old age increases the stiffness and Young's modulus of human tendons *in vivo*, suggesting that resistance training may reduce the risk of tendon injury in old age. Training improved contractile force production and the rapid execution of motor tasks, which lowered fall risk in older adults [5]. He was also first to demonstrate that accurate assessment of 'specific force' can increase in older adults following strength training by controlling carefully for agonist muscle activation, antagonist co-contraction, muscle volume and architecture, and patella tendon moment [6].

3. References to the research

Note: Citations, Web of Science (citations against expected citations) – January 2021.

1. **Onambele-Pearson** G, Wullems J, Doody C, Ryan D, **Morse** C, **Degens** H, (2019). Influence of Habitual Physical Behavior – Sleeping, Sedentarism, Physical Activity – On Bone Health in Community-Dwelling Older People. *Front. Physiol.* 10:408. DOI: 10.3389/fphys.2019.00408. *Citations: 3 (expected 3)*.
2. **McPhee** JS, Hogrel J-Y, Maier AB, Seppet E, Seynnes OR, Sipilä S, Bottinelli R, Barnouin Y, Bijlsma AY, Gapeyeva H, Maden-Wilkinson TM, Meskers CG, Pääsuke M, Sillanpää E, Stenroth L, Butler-Browne G, Narici MV, **Jones** DA, (2013). Physiological and functional evaluation of healthy young and older men and women: design of the European MyoAge study. *Biogerontology* 14:325-337. DOI: 10.1007/s10522-013-9434-7. *Citations: 41 (expected 24.97)*.
3. Maden-Wilkinson TM, **Degens** H, **Jones** DA, **McPhee** JS, (2013). Comparison of MRI and DXA to measure muscle size and age-related atrophy in thigh muscles. *J. Musculoskelet. Neuronal Interact.* 13(3):320-328. <http://www.ismni.org/jmni/pdf/53/07DEGENS.pdf>. *Citations: 67 (expected 13.1)*.
4. Leightley D, Yap MH, Coulson J, Piasecki M, Cameron J, Barnouin Y, Tobias J, **McPhee** JS, (2017). Postural stability during standing balance and sit-to-stand in master athlete runners compared with nonathletic old and young adults. *J. Aging Phys. Act.* 25(3):345-350. DOI: 10.1123/japa.2016-0074. *Citations: 6 (expected: 5.87)*.
5. **Reeves** ND, **Maganaris** CN, **Narici** MV, (2003). Effect of strength training on human patella tendon mechanical properties of older individuals. *J. Physiol.* 548(3):971-981. DOI: 10.1113/jphysiol.2002.035576. *Citations: 306, (expected: 64.28)*.
6. **Reeves** ND, **Narici** MV, **Maganaris** CN, (2004). Effect of resistance training on skeletal muscle-specific force in elderly humans. *J. Appl. Physiol.* 96(3):885-892. DOI: 10.1152/japplphysiol.00688.2003. *Citations: 175 (expected: 46.05)*.

External funding

Since 2013 members of the current team have been awarded over GBP2,000,000 in external funding through competitive RCUK/UKRI and charity funding calls (e.g. Innovate UK, MRC, Diabetes UK, EU, Dowager Countess Eleanor Peel Trust, British Heart Foundation) alongside industry. Grants related to the underpinning research references include:

- MOVE-AGE European Doctorate Program on prevention of mobility loss with ageing. European Erasmus Mundus Joint Doctorate Programme (Ref: 2011-0015). 2011-2020. Total award EUR6,500,000 (09-2011) of which EUR1,069,919 (09-2011) awarded to Manchester Metropolitan. Lead: Degens.
- MYOAGE: Understanding and combating age-related muscle weakness. FP7 European Union, 2009-2013. Grant ref: 223576. Total award: EUR11,200,000 (01-2009), of which EUR590,400 (01-2009) awarded to Manchester Metropolitan (Leads: McPhee, Narici).
- The consequences of motor unit remodelling for motor control: an important factor in loss of mobility with old age. 2013-2017. MRC (MR/K025252/1). Award: GBP570,841. PI: McPhee.
- Describing habitual levels of physical activity (PA) in older people in terms of impact loads and how this relates to bone and other systems. 2013-2017. MRC (Ref: MR/K024973/1). Total award: GBP825,544, with GBP80,000 to Manchester Metropolitan. Co-I: McPhee.

Additional indicators of research quality

- McPhee contributed to Greater Manchester's application to become the first UK Reference Site of the EU's Active and Healthy Ageing initiative. It achieved a top 3* rating based on excellence in development, adoption and scale-up activity, and healthy ageing practices.
- McPhee was invited to and joined, an Advisory Group for Public Health England entitled 'Wider Impacts of COVID-19 on Physical Activity, Deconditioning and Falls in Older Adults'.
- The British Association of Sport and Exercise Sciences Expert Statement on Physical Activity and Exercise during Covid-19 'lockdowns' and 'restrictions' draws recommendations on the benefits of decreasing sedentary behaviour (underpinned by reference [1]) from the updated UK Physical Activity Guidelines (see Section 4 below).
- Peer-reviewed publications from the body of work have informed, and are cited in, current, influential position stands and international clinical and practice guidelines, independent of the research group. These include: the 2009 American College of Sports Medicine (ACSM) position stand on exercise and physical activity for older adults (Citations: 2,047; papers referenced include [5,6]); the 2019 National Strength and Conditioning Association (NSCA) position statement on resistance training for older adults (Citations: 78; 12 papers referenced); and the European Working Group on Sarcopenia in Older People 2 revised consensus on definition and diagnosis of sarcopenia (Citations: 1,271; references [3]).

4. Details of the impact

Updating the UK Physical Activity Guidelines

Manchester Metropolitan's research on habitual sedentary behaviour and bone health [1] informed the key shift in emphasis in the updated UK Chief Medical Officers' (CMO) Physical Activity Guidelines, published September 2019. The revised guidelines emphasise that *"any activity (even light) is better than none"* and highlight the risks associated with prolonged sedentary periods, irrespective of overall activity [A]. The paper [1] provided the key evidence supporting two new recommendations for older adults: a) to spread higher volumes of light intensity activity throughout the day to maintain bone health; and b) that bone mineral density is greater in those who meet the moderate to vigorous physical activity thresholds. The significance of this shift in guidance is highlighted in the report's executive summary: *"We now know that even relatively small increases in physical activity can contribute to improved health and quality of life... we recognise the benefits that can be achieved at levels both above and below the thresholds."* The report also stresses the increased body of evidence that muscle strengthening activities can delay the natural age-related decline in muscle mass and bone density, and that balance and flexibility exercises are important for older adults [A].

According to NHS Digital, the updated guidelines averaged 200 views per day on the GOV.UK website in December 2019 (approximately 73,000 unique views per year compared to 60,000 for the 2011 version) indicating significant reach and sustained public and professional engagement with the guidelines (these figures do not take account of additional reach via access to copies hosted on other websites). Survey data suggests approximately 20% of UK GPs (approximately 7,000 FTE GPs according to the General Practice Workforce dashboard, December 2019) have good awareness and knowledge about the guidelines; 40% of GPs use the General Practice Physical Activity Questionnaire to inform their advice to patients [C].

An indicator of the significance of the new guidelines is the Government's commitment to create two new Expert Committees for Communications and Monitoring & Surveillance to support better implementation of the guidelines compared to 2011 [A,C]. The revised guidelines

have been incorporated into national programmes including *All Our Health* (a healthcare skills framework to prevent avoidable illness) and *Moving Medicine* (supports healthcare professionals to advise patients on physical activity for disease prevention and management). The *Moving Healthcare Professional Programme* takes a whole system approach to embed up-to-date evidence-based physical activity guidance into clinical training. It reaches over 6,000 healthcare professionals per year through continuing professional development and has embedded education materials in almost three-quarters of English medical schools [C].

Public communications campaigns with extensive reach indicate the national significance of the guidelines; they also show that the guidelines underpin public messaging. For example, current NHS exercise advice for older adults emphasises, “*any activity is better than none. The more you do the better, even if it's just light activity*” [D]. During the coronavirus pandemic, Public Health England made two publications available to encourage the population to stay physically active during the initial lockdown. The *Health and Wellbeing at Home* blog post had 8,332 views [E]. The *Active at Home* booklet drew on the national guidelines to help older people stay active and maintain their strength and balance during lockdown. It was downloaded 2,924 times, but 250,000 hardcopies were distributed to vulnerable and shielding adults in Department for Environment, Food & Rural Affairs (DEFRA) food boxes. A further 250,000 hardcopies were distributed by physical activity, health and wellbeing leads across local authorities, NHS organisations and charities [E].

Shaping local evidence-based best practice in frailty awareness and falls prevention

The impact of Manchester Metropolitan research on health interventions and outcomes is best illustrated in local falls prevention work taking place in Stockport. In 2014-15 McPhee advised the Greater Manchester Health and Social Care Partnership of the health benefits of physical activity for older adults. Initially shared in a white paper, the work was later adapted and published as an evidence review in *Biogerontology* (DOI: 10.1007/s10522-016-9641-0). This synthesis cited 16 Manchester Metropolitan research papers, including [2,3] and additional studies of Masters athletes. This work directly shaped the Stockport Physical Activity Strategy 2015-18 that advised engagement with older people to “*provide and promote opportunities to reduce sedentary behaviour*” and “*ensure access for older/vulnerable people to locality level activities*” [F]. This approach is now embedded in the current Stockport Active Communities Strategy [G].

In its Joint Strategic Needs Analysis (JSNA) in 2016, Stockport Clinical Commissioning Group (CCG) found there were 2,748 injuries from falls in the over 65 each year. The borough was in the worst performance quartile nationally for injuries from falls in older people, and falls prevention was thus adopted as a public health priority. Drawing again on McPhee’s research evidence and expertise, the local CCG established *Steady in Stockport*, a holistic service for falls and fracture prevention, and bone health improvement. Between November 2017 and April 2019, *Steady in Stockport* helped 2,670 residents (11.94% of 22,360 people aged over 65 with frailty). Stockport CCG Commissioning Lead for Community Services says, “*we know we are reaching a significant proportion of people at risk of falling and injury*” [G]. The JSNA 2020 analysis shows a significant 22% drop in emergency transportation for fall injuries since the launch of *Steady in Stockport* (205 to 159 conveyances per month). Latest NHS data show that injuries from falls in residents aged over 65 have decreased to 2,313 per year. Stockport is no longer in the worst performing quartile for this indicator. The total economic cost savings to the local NHS Trust from this service are estimated at GBP2,400,000 within five years of launch [G].

Stockport worked with its leisure services provider to create *Stay Steady*, a community-based falls prevention class, as advised by McPhee. In 2018-19, 297 residents participated; they had had an average of 2.5 falls during the 12 months prior to the course. Physical performance testing showed most participants improved, typically lowering their falls risk from ‘high-to-moderate’ to ‘moderate’. The majority of completers self-reported increased confidence in performing everyday activities without losing their balance, showing a significant improvement in their quality of later life, and a 20%-40% reduction in falls risk according to NICE guidance [G].

Changing the training routines of older runners

The surprise findings from studies of Masters athletes (as published in [4], see Section 3) led to a targeted awareness campaign delivered by Manchester Metropolitan and the British Masters Athletics Federation (BMAF) to encourage older competitive and leisure runners to incorporate specific balance training into their routines. *Athletics Weekly* (AW), the UK’s top

running magazine, published three articles in magazines (circulation: 10,000; readership: 31,000 per week) and online (approximately 1,500 reads per article) [H]. An independent focus group of older athletes run by AW showed runners changed their training routines after reading about the research in the magazine. One female 75-year old athlete said: *"I've long suspected I was unbalanced in daily activities and needed to do something about it... since starting to concentrate on balance training I have found ordinary daily tasks better and feel my running is improving"* [H]. A piece also appeared in the Times2 newspaper supplement (reach: 1,160,000 across all platforms) and the race information booklet distributed to 57,000 participants (6,500 aged over 65) in the Great North Run 2018, seeking to motivate behavioural change at scale.

BMAF distributed a printed booklet entitled *Strong and Balanced*, about the research, to athletes at UK and European competitions [H]. A retrospective survey showed that among athletes who received the booklet from BMAF, 86.1% were motivated to change their balance training habits; 44.4% said they had already implemented changes. After reading the booklet, the proportion of Masters athletes who now do up to 40 minutes of balance training per week increased from 50.0% to 83.3%. Extrapolating these findings to the 900 athletes who received a booklet suggests approximately 400 Masters athletes have increased their balance training duration and an additional 375 athletes intend to make changes (and may have done so already); this represents 15.5% of BMAF's 5,000 members. Most significantly, the survey suggests that 375 athletes have added a balance training component that was previously missing from their training programmes. The strong evidence of behavioural change at scale is also significant because better balance reduces the personal risk of falls and injuries for runners (see comment from focus group attendee above), but also contributes to NHS cost savings (approximately GBP26,000 per hip fracture avoided) [H].

Informing international exercise guidance for older adults

Evidence from 12 Manchester Metropolitan peer-reviewed papers, including [5,6] have directly informed current exercise practitioner position stands/statements for ACSM and NSCA (see Section 3). These two documents underpin the practice of more than 110,000 certified medical and healthcare professionals across 70 occupations in sports medicine and exercise science in 90 countries, regarding the use of resistance training to maintain muscles mass and strength in older people [I]. The ACSM position stand also informs the bulk of the clinical guidelines *Exercise Prescription in Older Adults*, published by The American Academy of Family Physicians (AAFP) in 2017, which has 136,700 active members across the USA [I].

5. Sources to corroborate the impact

- A. UK Chief Medical Officers' Physical Activity Guidelines (Sept 2019) *references Manchester Metropolitan research regarding sedentary behaviour, physical activity and bone health.*
- B. Information provided by NHS Digital *provides evidence of downloads and page views for the 2011 and 2019 guidelines indicating significant and sustained reach.*
- C. Publications in Nutrition Bulletin (DOI: 10.1111/nbu.12409) and BMS Med. Educ. (DOI: 0.1186/s12909-019-1517-y) *describe the reach of the guidelines to medical professionals, and influence on practice.* NHS Digital data *provide evidence of size of UK GP workforce.*
- D. The NHS Live Well webpage "Physical activity guidelines for older adults" emphasises that *"any activity is better than none. The more you do the better, even if it's just light activity".*
- E. Copies of *Health and Wellbeing at Home* and the *Active at Home* booklet (Public Health England, 2020) *draw on the 2019 physical activity guidelines and refer to the benefits of frequent physical activity on bone health.* Freedom of Information letter from Public Health England gives *evidence of reach and hardcopy distribution.*
- F. Stockport Physical Activity Strategy 2015-18 *acknowledges research of Professor McPhee.*
- G. Testimonials and data supplied by Consultant for Physical Education, Sport & Physical Activity, Stockport Borough Council and Senior Commissioning Manager, NHS Stockport Clinical Commissioning Group *provide evidence and management data on the significance and reach of benefits delivered through the falls prevention programmes.*
- H. Evaluation report gives *evidence of significant change in athletes' balance training regimes arising from the media articles and BMAF's distribution of the booklet Strong and Balanced.* Corroboration available from President BMAF (details added to the submission system).
- I. Copies of the current ACSM, NSCA and AAFP guidelines and *evidence of the reach of the guidelines to their membership and registered practitioners.*