Exercise and Older People:

Strategies to Prevent, Treat and Delay Frailty

by

Agathe Daria Jadczak

Thesis submitted in fulfilment of the requirements of the degree of

Doctor of Philosophy

Adelaide Medical School

Discipline of Medicine

Faculty of Health and Medical Sciences

University of Adelaide, South Australia, Australia

October 2017

Table of Contents

List of Tables

List of Figures

Publications

Jadczak, Agathe Daria; Makwana, Naresh; Luscombe-Marsh, Natalie; Visvanathan, Renuka; Schultz, Timothy J. Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol. JBI Database of Systematic Reviews and Implementations Reports, 2016; 14(9):93-102.

Jadczak, Agathe Daria; Makwana, Naresh; Luscombe-Marsh, Natalie; Visvanathan, Renuka; Schultz, Timothy J. Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review of systematic reviews. JBI Database of Systematic Reviews and Implementations Reports. Accepted for publication on 23 November 2017.

Jadczak, Agathe Daria; Dollard, Joanne; Mahajan, Neha; Visvanathan, Renuka. The perspectives of pre-frail and frail older people on being advised about exercise: a qualitative study. Family Practice, 2017:1-6. DOI 10.1093/fampra/cmx108.

Jadczak, Agathe Daria; Tam, Khai Loon; Yu, Solomon; Visvanathan, Renuka. Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people. Australasian Journal on Ageing, 2017; 36(3):E7-E13. DOI: 10.1111/ajag.12412.

Jadczak, Agathe Daria; Tam, Khai Loon; Visvanathan, Renuka. Education Medical Students in Counselling Older Adults About Exercise: The Impact of a Physical Activity Module. Journal of Frailty and Aging. Accepted for publication on 19 September 2017.

Jadczak, Agathe Daria; Luscombe-Marsh, Natalie; Taylor, Penelope; Barnard, Robert; Makwana, Naresh; Visvanathan, Renuka. The EXPRESS Study: Exercise and Protein Supplementation Study to Support Autonomy in Community-Dwelling Frail Older Adults: Study Protocol for A Randomized Controlled Pilot and Feasibility Study. Pilot and Feasibility Studies, 2018; 4(8). DOI 10.1186/s40814-017-0156-5.

Jadczak, Agathe Daria; Mahajan, Neha; Visvanathan, Renuka. The feasibility of geriatric assessment tools and standardised exercise with frail older people. Journal of Frailty and Aging, 2017; 6(4):195-198.

Yu, Solomon; Khow, Kareeann; Jadczak, Agathe Daria; Visvanathan, Renuka. Sarcopenia in older people: clinical screening and intervention a review article. Current Gerontology and Geriatrics Research, 2016 (2016), 5978523.

Conference Presentations

Oral Presentations

Jadczak, Agathe Daria; Tam, Khai Loon; Visvanathan, Renuka. Educating medical students in counselling older adults about exercise: the impact of a physical activity module. The Queen Elizabeth Hospital Research Day, 19 & 20 October 2017, Basil Hetzel Institute Adelaide, SA, Australia.

Jadczak, Agathe Daria; Dollard, Joanne; Mahajan, Neha; Visvanathan, Renuka. The perspectives of older people at-risk of frailty on being advised about exercise. 21st IAGG World Congress of Gerontology and Geriatric, 23-27 July 2017, Moscone Centre, San Francisco, CA, USA. Published in Innovation in Aging, 2017; 1 Suppl: 1395. DOI:10.1093/geroni/igx004.5136.

Jadczak, Agathe Daria; Dollard, Joanne; Mahajan, Neha; Visvanathan, Renuka. Older peoples' perspectives on being advised about exercise - What role do general practitioners play? A qualitative study. The Queen Elizabeth Hospital Research Day, 21 October 2016, Basil Hetzel Institute Adelaide, SA, Australia.

Jadczak, Agathe Daria; Tam, Khai Loon; Yu, Solomon; Visvanathan, Renuka. Medical students' perceptions of the importance of exercise and their perceived competency in prescribing exercise. World Congress on Active Ageing, 28 June - 1 July 2016, Melbourne Convention and Exhibition Centre, Melbourne, VIC, Australia. Published in the Journal of Ageing and Physical Activity, 2016; 24 Suppl: S59-S60.

Jadczak, Agathe Daria; Tam, Khai Loon; Yu, Solomon; Visvanathan, Renuka. Medical students' perception of the importance of exercise and their perceived competence in prescribing exercise. Student-led Educational Conference, 20 November 2015, University of Adelaide School of Education, Adelaide, SA, Australia.

Jadczak, Agathe Daria; Tam, Khai Loon; Yu, Solomon; Visvanathan, Renuka. Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise improves after an undergraduate geriatric medicine course. The Queen Elizabeth Hospital Research Day, 16 October 2015, Basil Hetzel Institute Adelaide, SA, Australia.

Poster Presentations

Jadczak, Agathe Daria; Dollard, Joanne; Mahajan, Neha; Visvanathan, Renuka. Exercise promotion and the perspectives of pre-frail and frail older people on being advised about exercise: a qualitative study. Florey Postgraduate Research Conference, Adelaide, Australia, 2016.

Jadczak, Agathe Daria; Tam, Khai Loon; Yu, Solomon; Visvanathan, Renuka. Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people. Florey Postgraduate Research Conference, Adelaide, Australia, 2015.

Awards and Scholarships

Council of Student Organisations (CSO) Travel Award, International Association of Gerontology and Geriatrics, San Francisco, California, USA, 2017.

School of Medicine Research Travel Award, University of Adelaide, Adelaide, South Australia, Australia, 2016.

Beacon of Enlightenment PhD Scholarship, University of Adelaide, Adelaide, South Australia, Australia, 2014-2017.

Abstract

Frailty, a prevalent geriatric syndrome observed in clinical practice, is recognised as a condition related to ageing where the evidence base is still developing. Frailty includes clinical indicators, such as fatigue, sedentary behaviour, weight loss, and physical function impairment, and is associated with a higher risk of disability, hospitalisation, loss of independence, and reduced quality of life. It is possible that by 2050, four million Australians aged 70 years and older will either be pre-frail or frail.

Exercise has been proposed as an intervention strategy to prevent, delay and treat frailty. It has been shown to be beneficial in increasing muscle mass, maintaining and restoring muscular strength, improving physical function and mobility, and reducing the risk of falls and fractures. Exercise in combination with nutrition supplements may also be of benefit for pre-frail and frail older adults, however, only a few studies have been conducted and results have to date been conflicting.

Although the benefits of exercise are well known, the uptake of exercise in older people remains poor. Doctors are an integral member of multi-disciplinary healthcare teams and have a role to play in advocating for exercise programs as well as encouraging older people to exercise. Sadly, doctors rarely focus on exercise when making treatment plans and commonly cite the lack of education during medical school as a reason for not prescribing exercise. Exercise has not been a focus of undergraduate medical and where it is included, there remains a gap in the delivery with considerable heterogeneity in the quality of the program.

The aim of this PhD was to address gaps in the literature through different research projects including: a) an umbrella review to determine the most effective exercise characteristics alone or in combination with other interventions on physical function in pre-frail and frail older adults; b) a qualitative study to explore the perspectives of pre-frail and frail older adults on being advised about exercise; c) the impact of a physical activity module on fifth year medical students' perceived competence in counselling older adults about exercise; and d) a study to determine the feasibility and the effects of exercise combined with protein supplements in community dwelling pre-frail older adults.

The umbrella review indicates that multi-component exercise interventions including resistance training, aerobic, balance and flexibility tasks can currently be recommended to prevent, delay and treat frailty. Older people indicated a preference of being advised firstly

by their general practitioner and we successfully demonstrated that a 1.5 hour physical activity module including a theoretical tutorial combined with a practical counselling session impacted positively on senior medical students' perceived competence in advising older people about exercise. Preliminary data from the intervention study suggests that the multicomponent exercise program are feasible, tolerable and safe. However, several non-serious side effects relating to the consumption of the commercially available protein supplements were noted among the participants suggesting that even when protein supplements have undergone extensive consumer acceptance testing, many individuals still require tailored strategies to help them to adjust to this new nutritional product.

Thesis Layout

This thesis is presented in publication format including seven manuscripts with their own referencing and appendices. A general introduction, a background literature review as well as a final discussion including implications for practice and future directions link together all the research that was conducted during this PhD. The references of the introduction, background and discussion chapters are presented together at the end of this thesis.

Statement of Originality

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

I acknowledge that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

………………………………………. ……………………….

Agathe Daria Jadczak Date

Acknowledgements

I would like to express my profound gratitude to my supervisor, Renuka Visvanathan, for your tireless effort, time, patience, encouragement and support during my PhD candidature. I'm glad that I decided to complete my PhD under your supervision and I'm grateful that I could learn and greatly benefit from your expertise in research and the field of frailty.

I would also like to express my profound gratitude to my co-supervisor, Natalie Luscombe-Marsh, for your patience, encouragement, tireless effort, and support during my candidature. Thank you for your kind words, constant advice, guidance, expertise, and assistance.

I received the Beacon of Enlightenment Scholarship from the University of Adelaide funding my living expenses, fees and health insurance during my PhD candidature. I'm grateful and truly appreciate the financial assistance that I received from the University of Adelaide.

I would also like to thank my co-authors for their kind advice, support and assistance: Dr Khai Tam and Associate Professor Solomon Yu who supported me with the medical students' project. Dr Joanne Dollard and Dr Neha Mahajan for your guidance during my qualitative study. Dr Timothy Schultz for your expertise in regards to the umbrella review and Ms Kylie Lange for the statistical advice across the projects.

I would also like to thank Robert Barnard, Brooke Wymond, Donna Preston, Kerri Ireland, Teila Jaques and Dr Kareeann Khow for your support and assistance during the EXPRESS Study. Without your kind support and timely assistance this study would not have been possible.

I would like to thank my mum, my dad, and my sister for their kind words, encouragement and support from the other side of the world. I would also like to thank my partner for your kind words, tireless support, encouragement, and patience throughout my PhD. A big thank you also to all my Australian friends for distracting me in a positive way and giving me a joyful and unforgettable time here in Australia.

Also, a big thank you to all my study participants and students who volunteered for my research and to Ms Barbara Brougham for her editorial assistance.

Exercise and Older People:

Strategies to Prevent, Treat and Delay Frailty

Chapter 1

Introduction

The number of people aged 65 years and older is expected to triple in the next 30 years[1,2]. In Australia, 24% of Australians will be aged 65 years and older by 2050, almost a quarter of the Australian population[3]. The increase in older people will lead to an increase in age-related diseases, institutionalisation and healthcare costs[2].

Frailty, a common geriatric syndrome in clinical practice, is associated with ageing. It is suggested that 3.2% of community-dwelling older adults aged 65-70 years and 26% of people aged 85 years and older are frail[4]. In institutional settings, such as nursing homes, the quoted prevalence figures for frailty increase to 52.3%, with another 40.2% classified as pre-frail%[5]. The higher prevalence in nursing homes can be partially explained by the fact that institutionalisation might be a consequence of frailty[6]. Intervening earlier, when people in the community are still only at-risk of frailty, may therefore be an important strategy by which to avoid early institutionalisation.

Frailty is highly prevalent in older people, increases with age, is greater in women than in men, and is more prevalent in people with lower education and income, poorer health and higher rates of comorbidities, chronic diseases and disabilities[7]. By 2050, it is estimated that four million Australians aged 70 years and older will either be pre-frail or frail[7]. Frailty is therefore a major public health issue that warrants the attention of researchers, policy makers and health service providers. Only through a collective effort will the translation of cost-effective programs that allow older people to age independently for longer in their own homes be achieved.

Frailty is defined as a clinically recognisable state of increased vulnerability to stressors resulting from age-associated decline in reserve and function[2]. It includes clinical indicators, such as, fatigue, sedentary behaviour, weight loss, and physical function impairment[2,8]. Frailty is associated with a higher risk of disability and falls, hospitalisation, loss of independence, mortality, and reduced mobility and quality of life[9,10]. Pre-frail older adults have an intermediate risk of these outcomes, as well as an increased risk of becoming frail over three to four years compared to non-frail older adults[4].

Ageing can be accompanied by physiological changes, such as reduced hormone production, oxidative stress, poor cellular oxygenation and reduced mobility[11]. While many people experience the natural physiological alteration of ageing cells with no unwarranted health issues, for a large number of older people growing older will mean growing frailer.

Frailty is a dynamic syndrome that is treatable and reversible if early intervention is provided[8]. Researchers globally are investigating intervention strategies that might either prevent or treat frailty. To date, interventions that include rather than exclude exercise, appear to be the most effective strategy to prevent, delay and treat frailty[12]. Exercise is thought to be beneficial in increasing muscle mass, maintaining and restoring muscular strength, improving physical function and mobility, and reducing the risk of falls and fractures in frail older adults[13]. Exercise also contributes to maintaining independence and quality of life[14].

However, there is still much research to be undertaken and it remains to be clarified which exercise characteristics (type, frequency, duration, and intensity) are most effective in improving the physical function of frail older people, and whether the benefits of exercise can be amplified by combining it with simple nutritional strategies, including the use of protein supplementation. Potentially, exercise in combination with nutrition might be more beneficial than exercise alone for pre-frail and frail older adults in the treatment of frailty[15,16]. Currently, only a few studies have been conducted in the frail older population and results have been contradictory[17-19]. Without a greater understanding of the effects of a nutritional supplement-exercise regimen on frail older adults, it will continue to be difficult, if not impossible, to successfully implement long-term treatment programs to effectively manage frailty.

To make things more difficult, the uptake of exercise in older people, especially those classified as frail, is thought to be poor[20,21]. There is a need to not only promote exercise programs to community-dwelling pre-frail and frail older adults, but also to ensure that these programs are feasible and will be adhered to. This is critical if the public health issue of frailty is to be managed, and the predicted rise in healthcare costs as a result of frailty is to be mitigated. A better understanding of older people's opinions in regards to who should advise them about exercise and where this advice should be provided is vital; however, to date, research has been sparse.

Doctors are an integral member of any healthcare team and have a role to play in encouraging older people to exercise[20,22]. They can do this by increasing awareness of the importance of exercise, allaying fears, helping to overcome perceived barriers and by providing direction as where to go and what to do[23]. Concerningly, lack of advice from the doctor is reported to be a barrier to improved exercise uptake amongst older people[24]. Additionally, doctors cite the lack of education during medical school as a reason for them failing to prescribe exercise or counselling for their patients[25].

A potential reason for the lack of knowledge cited by doctors could relate to the fact that exercise is not a part of many undergraduate medical curricula[26]. A recent review of US medical curricula suggests that over half of the medical students trained in the United States received no formal education on exercise[27]. Similar findings were also noted in the United Kingdom[26]. Even when exercise is included in the curriculum, there is a gap in the delivery, with considerable heterogeneity in teaching methods, duration, quality and placement[28,29]. Research evidence as to what advice and exercise works and why, and what is not effective is limited, especially where it relates to older people.

With the above as a brief introduction to the focus area of my research, the aim of this PhD was to address gaps in the literature through various research studies. This thesis is organised as follows:

Chapter 2 includes an overall background to the research undertaken for this PhD, including recent definitions of frailty, the epidemiology, including prevalence, incidence, mortality and other adverse health outcomes, the pathogenesis, diagnostic and screening tools, as well as strategies to prevent, treat and delay frailty in the community.

Chapter 3 presents an umbrella review to determine the most effective exercise characteristics, alone or in combination with other interventions, on physical function parameters in pre-frail and frail older adults. The findings indicate that multi-component exercise interventions, including, in particular, resistance training, can currently be recommended for pre-frail and frail older adults to improve muscular strength, gait speed, balance and physical performance. Other types of exercise were not sufficiently studied and their effectiveness is yet to be established. The chapter is a reproduction of a published protocol (Appendix 1) and a manuscript accepted for publication (Appendix 2).

Chapter 4 presents the findings from a qualitative study undertaken to explore pre-frail and frail older adults' perspectives on being advised about exercise. The results suggest that pre-frail and frail older adults have a positive attitude towards exercise and indicate a preference for being advised on exercise, firstly by their GP, and then other health care professionals. Participants living in the community reported difficulties in accessing information on exercise, while participants living in retirement villages reported having access to relevant information and being encouraged to participate in exercise. The chapter is a reproduction of a peer-reviewed and published manuscript (Appendix 3).

Chapter 5 presents the findings from a survey undertaken amongst senior medical students to determine their perceived importance and competence in advising older adults about exercise. The results indicate that senior medical students perceive exercise for older people as important, but feel only moderately confident in their ability to prescribe exercise to older people. Students perceived a lack of knowledge as the main barrier to doctors prescribing exercise. The chapter is a reproduction of a peer-reviewed and published manuscript (Appendix 4).

Chapter 6 focuses on research into the efficacy of introducing a physical activity (PA) module into the curriculum of medical students to provide them with the necessary knowledge and skills to advise older patients about exercise. The findings indicated that a short, 1.5 hour PA module, including a one hour exercise tutorial combined with a 30 minute practical counselling session, improves medical students' exercise counselling abilities. It is hoped that the outcome of this research will inform medical curriculum development at universities and lead to increased counselling rates later in clinical practice. The chapter is a reproduction of a peer-reviewed and accepted manuscript (Appendix 5).

Chapter 7 presents the findings of a study which was undertaken to determine the feasibility of several geriatric assessment tools for use in future research involving frailer older adults. The results suggest that geriatric assessment tools need to be amended to make them briefer and more comprehensible, and that alternative or additional tools for neuropsychological assessments should be considered to accommodate the frail population's physical and mental limitations. The chapter is a reproduction of a peer-reviewed and published manuscript (Appendix 6).

Chapter 8 is a study protocol that was developed to determine the feasibility and the effects of an exercise intervention combined with protein supplements in pre-frail and frail older adults living in the community. I substantially contributed to the development of the protocol using knowledge acquired during the earlier research; and was especially involved in the development and implementation of the exercise components, and the preparation of the database, data collection booklets and assessments. The trial reported in this chapter is ongoing. It is a randomised controlled pilot and feasibility study, and data continues to be collected. The chapter is a reproduction of a peer-reviewed and published protocol (Appendix 7).

Chapter 9 presents the preliminary findings of the randomised controlled pilot and feasibility study described in Chapter 8. The focus in this chapter is on the feasibility aspects of the study, including recruitment, pre-frail and frail older peoples' compliance and retention, as well as the safety and tolerability of the trial. The preliminary findings indicate that the multicomponent exercise program performed five times per week are feasible, tolerable and safe. However, the data also indicate that pre-frail and frail older adults living in the community preferred to exercise at, or close to home, rather than at the study-specific exercise centres. Several non-serious side effects relating to the consumption of the commercially available protein supplements were also noted among the participants suggesting that even when protein supplements have undergone extensive consumer acceptance testing, many individuals still require tailored strategies to help them to adjust to this new nutritional product.

Chapter 10 briefly discusses the key research findings arising from the investigations associated with this thesis, presents the impact of this research on clinical practice and provides an outline of possible future research.

Chapter 2

Background

This chapter provides a snapshot of frailty, a geriatric syndrome prevalent in clinical practice with a rising significance for the ageing population. It includes recent definitions, the epidemiology, including prevalence, incidence, mortality and other adverse health outcomes, followed by the pathogenesis, diagnostic and screening tools as well as strategies to prevent, treat and delay frailty in the community.

2.1. Definition

Frailty is defined as a clinically recognisable state of increased vulnerability resulting from age-associated decline in reserve and function across multiple physiologic systems[2]. It correlates with increasing age. However, it is not an inevitable consequence of ageing. There are currently two major frailty definitions that have been described in the literature - the frailty phenotype and the frailty index. The frailty phenotype defines frailty as a distinct clinical syndrome meeting three or more of the following five physical indicators[4]:

- weakness
- slowness
- low physical activity levels
- exhaustion
- unintentional weight loss

The frailty index, on the other hand, defines frailty as cumulative deficits identified in a comprehensive geriatric assessment[30]. No single operational definition has been agreed upon yet, and hence, both definitions will be described in more detail in the ‘Diagnostic and screening’ section of this chapter (i.e., 2.4).

2.2. Epidemiology

The following section considers the prevalence and incidence of frailty, its progression as well as the consequences of frailty.

2.2.1. Prevalence

Frailty is highly prevalent in older people, but the prevalence varies depending on the definition used and various factors including age, gender and setting[8]. The prevalence of frailty varies between 4.0 and 59.1%[7] and the rate of prevalence is highly dependent on the criteria and definition used for the syndrome. Indeed, weighted rates of frailty, according to the definition of the frailty phenotype (9.9%), as opposed to broader definitions, such as the frailty index (13.6%), were reported to be significantly different in a recent systematic review[7].

According to the frailty phenotype (considered a relatively easy tool to determine whether a person is physically frail) the mean prevalence of frailty across many European communities was reportedly 17% (range 5.8% in Switzerland to 27.3% in Spain)[31]. Data acquired from a study of a longitudinal cohort of Australian women confirm these numbers[32]; and, more recently, data from a study in Adelaide have suggested that the prevalence of frailty is 18% when using the phenotype criteria, but 48% when using the frailty index[33].

In regards to setting, the prevalence of frailty appears to be greater in nursing homes than in the community[7]. A recent systematic review estimated that 52.3% of older people living in nursing homes are frail (range 37.9%-66.5%) and 40.2% are pre-frail (range 28.9%-52.1%)[5]. These findings suggest that institutionalisation might be a consequence of frailty[6]. Intervening in the community might therefore be an important strategy to prevent institutionalisation and lower the prevalence of frailty in our society.

Regarding age, the prevalence of frailty increases as age increases until a plateau is reached around the age of 90 years[4]:

- 3.2% among 65–70 years
- 5.3% among 71–74 years
- 9.5% among 75–79 years
- 16.3% among 80–85 years
- 25.7% among 86–90 years
- 23% over 90 years

Based on data from a recent systematic review, it can be extrapolated that by 2050, four million Australians aged 70 years and older will either be pre-frail or frail, demonstrating the rising significance of frailty in our ageing population[7].

Frailty, therefore, seems to increase with age, is more prevalent in women and people with lower education and income, poorer health, who are residing in aged care homes, and who have higher rates of comorbidities, chronic diseases and disabilities[7].

2.2.2. Incidence and Progress

The annual incidence rate of frailty varies between 22.5/1000 to 71.8/1000 person years, and seems to be higher in community-dwelling older women than men[4,34,35].

Frailty is a dynamic syndrome that is both preventable and reversible. It begins most often as weakness followed by slowness[36,37]. Over time, 43.3% of older people transit to a greater state of frailty, 12.9% to 23% of frail older people recover to a pre-frail stage, whereas 13.1% to 20.1% die within 1.5 years[4,34]. While it remains unclear which strategies are most successful in reversing frailty, early interventions including primarily exercise and nutrition can help to prevent, delay and reverse frailty[4,32]. Considering the rising prevalence of frailty, an effort should be made to prevent and treat this geriatric condition as early as possible as this might contribute to a reduced risk of poor health outcomes, institutionalisation and rising healthcare costs.

2.2.3. Morbidity, Mortality and Other Adverse Health Outcomes

Frailty is associated with the loss of independence, reduced quality of life and a higher risk of disability, falls and fractures, cognitive impairment, and hospitalisation[9,10]. The syndrome is strongly associated with in-hospital mortality, prolonged hospital care, and the primary composite outcome[38].

Between 46.2% and 67.7% of frail older people have comorbidities and 21.5% experience a combination of frailty, comorbidity and disability[10,39]. However, frailty without comorbidity or disability is present in 26.6% of the frail population, which supports the fact that frailty can also appear as a singular syndrome[39]. With regards to disability, frailty may be a physiological precursor to disability, but it is also a possibility that disability itself, through decreased physical activity, could lead to frailty[2].

Frailty is also associated with a higher risk of cognitive impairment and depression[40,41]. Some studies suggest that frailty and cognition, for example, interact with each other in the form of a declining cycle associated with ageing where cognitive impairment increases the risk of frailty and frailty increases the risk of cognitive decline[40]. A similar bidirectional and dynamic association has also been found between frailty and depression later in life[41].

2.3. Pathogenesis

There are several physiological factors in the pathogenesis of frailty that have been discussed in the literature, including the role of chronic inflammation and its effects on the musculoskeletal system, as well as changes in the endocrine system and the role of cardiovascular diseases. As this was not the focus of this PhD, the following section only touches briefly on some of these biological mechanisms and concludes with a brief overview of other risk factors that may accelerate the development and progression of frailty.

2.3.1. Biological Mechanisms

A possible fundamental underlying biological mechanism that could accelerate the progression of frailty, both directly and indirectly, though different pathophysiological processes is chronic inflammation, including its detrimental effects on the musculoskeletal system (e.g., sarcopenia).

2.3.1.1. Chronic Inflammation

The relationship between frailty and elevated levels of common inflammatory mediators is well documented. There is a strong association between elevated levels of interleukin 6 (IL-6), an individual inflammatory molecule, and frailty[42]. IL-6 in elevated levels is said to directly contribute to frailty and its components, such as decreased muscle mass, strength, and slow motor performance[42]. Another marker for inflammation, the total white blood cell (WBC) count, regularly taken in clinical practice, has also been shown to have a direct association with frailty when elevated[43]. Infections, such as chronic or persistent cytomegalovirus (CMV) and increased counts of specific T-cells ($CCR5^+$) that have a type 1 pro-inflammatory phenotype, have been found to be associated with frailty[44,45]. Because of such evidence, it has been suggested that a heightened inflammatory state is involved in the pathogenesis of frailty.

2.3.1.2. Musculoskeletal System

Chronic inflammation affects the musculoskeletal system and contributes to weakness, slowed motor performance, sarcopenia and therefore frailty[46]. Sarcopenia is defined as the loss of muscle mass and performance, and is thought to be a key contributor to frailty[47].

Sarcopenia and physical frailty overlap and share many common factors, including physical function impairment, compromising weak muscle strength, slow gait speed and poor balance (Figure 2.1). The causal relationship between sarcopenia and frailty continues to be debated.

The question is whether physical frailty is due to sarcopenia or sarcopenia is a clinical manifestation of frailty[8].

The adverse endocrine and immune components of frailty might potentially upset the balance which maintains muscle homeostasis and controls new muscle cell formation, hypertrophy and protein loss, and therefore can accelerate the progression of sarcopenia[39]. Chronic diseases can also contribute to sarcopenia which in turn contributes significantly to disabilities. Age-related changes in α-motor neurons, type I muscle fibres, muscular atrophy, poor nutrition, growth hormone production, sex-steroid levels, and low physical activity levels are reported to be the main causes for the development of sarcopenia[46].

Skeletal muscle is also crucial for bone health. Frailty has therefore been shown to have a direct relationship with osteoporosis and osteopenia[48].

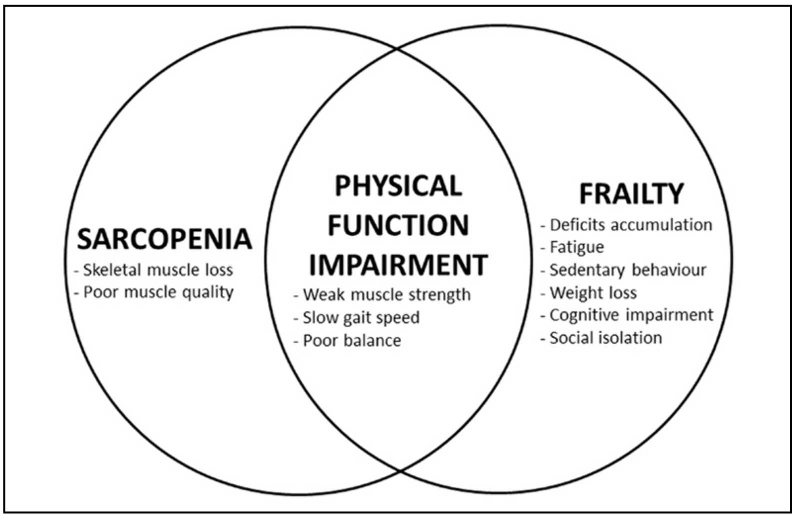


Figure. 2.1: Relationship among sarcopenia, frailty, and physical function impairment[8]

2.3.1.3. Endocrine System

The endocrine system is a collection of glands that produce hormones to regulate metabolism, growth and development, tissue function, sexual function and reproduction, amongst others.

The age-related decrease of oestrogen in postmenopausal women and the gradual decrease of testosterone in older men contribute to the decline in muscle mass and muscle strength, which in turn leads to the development of frailty and sarcopenia[49]. Significantly lower levels of sex and growth hormones have been described in frail older adults compared to non-frail older adults[49], suggesting that decreasing hormone levels are involved in the pathogenesis of frailty.

Other hormones that have been associated with frailty include vitamin D and cortisol, and recent findings suggest that vitamin D insufficiency may contribute to frailty, particularly in older men[50].

2.3.1.4. Cardiovascular System

Frailty has been associated with selected acute and chronic diseases, and in particular with cardiovascular disease (CVD)[4]. The mechanism remains to be clarified, but may be related to chronic repetitive injury and neuro-hormonal activation imposed by CVD, including ischemic heart disease, hypertension or valvular heart disease[51]. Furthermore, small-vessel disease and low-grade inflammation can impair blood flow to skeletal muscle, causing sarcopenia and muscle weakness, whilst accelerating physical frailty[40].

2.3.2. Risk Factors

There are several risk factors that can contribute to the development, progression and acceleration of frailty. They include low physical activity, malnutrition, polypharmacy, as well as age, gender, socio-economic status, the social environment, and psychological well-being. Where possible, these risk factors should be identified early and mitigated.

2.3.2.1. Low Physical Activity

Low physical activity is a core contributor to the development of frailty, associated with its development and progression[4]. It can accelerate the loss of muscle mass, strength and physical performance[4]. Breaks, even if short (i.e., 10 mins)[52], in sedentary behaviour can protect against frailty and reduce poor health outcomes[53]. Breaks in sedentary behaviour are also positively associated with components of physical fitness directly related to frailty[4]. It is suggested that 80% of transitions to frailty involve exhaustion, which raises the possibility that decreased energy production may be involved in the transition towards severe frailty[2].

2.3.2.2. Malnutrition and Protein Intake

Unintended weight loss is a core component of frailty and can accelerate the progression of frailty and sarcopenia[4].

Increasing age is associated with reduced appetite[54] which can result in many older people failing to meet the recommended daily dietary allowance, including protein intake recommendations, which has important implications for skeletal muscles[55]. The rationale for more protein relates to older people having limited muscle protein synthesis, possibly due to muscle anabolic resistance[56], but it remains unclear whether the anabolic resistance is caused by low dietary protein intake or other factors. New evidence has shown that older adults require higher dietary protein requirements to counteract age-related changes in protein metabolism and higher catabolic state associated with chronic or acute diseases[54]. The type and timing of protein ingestion may also have an important role in muscle synthesis[57]. Higher protein consumption has been associated with a lower risk of frailty[58]. Incorporating more protein into the diet is thus a rational strategy for frailty prevention. Chapters 8 and 9 address this issue by examining the feasibility and the effects of protein supplements in pre-frail and frail older adults.

Reduced appetite and early satiety may not only lead to insufficient dietary protein, but can also contribute to unintended weight loss, which can exacerbate muscle and bone density loss and so may accelerate frailty[59].

2.3.2.3. Polypharmacy

Polypharmacy is seen as a possible factor that contributes to the development of frailty[60]. Anticholinergic (atropinic) drug exposure, for example, has been shown to be related to frailty and greater functional decline, falls and increased occurrence of dementia and delirium. Anticholinergics are also related to hip fractures, in-hospital mortality and decreased ability to bathe, groom, dress, transfer and to be mobile[61].

Dehydration is also associated with frailty and is often made worse by inappropriate use of diuretics to treat pedal edema[61]. Additionally, the diuretic can result in urinary incontinence and the rush to the toilet can at times result in a fall and, if unfortunate, cause fracture. It is recommended that frail older adults have their medications reduced to six or less to decrease the risk of frailty[61]. Other medication optimisation strategies, such as simplifying medication administration should also be considered.

2.3.2.4. Age, Gender and Low Socio-Economic Status

Increasing age is accompanied by physiological changes, such as reduced hormone production, oxidative stress, poor cellular oxygenation and reduced mobility, which can, in turn, increase the risk of the development of frailty.

Female gender has also been associated with frailty and may be related to the fact that women have less muscle mass compared to men, which may confer an intrinsic risk for the development of frailty[62].

Lower socio-economic status, as measured by low education and/or low annual income independent of age, race, and comorbidity, has also been associated with frailty[62]. Older women with less than a high school degree have a threefold greater chance of developing frailty, and those with a low yearly income have a two times greater chance of frailty than their more educated and wealthier counterparts[63].

2.3.2.5. Psychological Well-Being and Social Environment

Psychological wellbeing has long been associated with 'successful ageing'. Depressive symptoms have been shown to be associated with frailty, suggesting that depression may contribute to the etiology of frailty. This hypothesis is plausible given that older individuals with depression often lose weight, become less active, and therefore, can lose more muscle mass and strength[41].

A recent review highlighted the fact that social environment and frailty are also related, and that neighbourhood dimensions and social participation can also play a role in the development of frailty[64].

2.4. Diagnostic and Screening

Frailty, early in the disease trajectory, is easily overlooked because its manifestations can be subtle or dismissed as normal ageing, while physicians have been trained to identify specific medical diseases rather than overall vulnerability[65]. The recognition of frailty in clinical practice and the availability of practical and accurate screening tools, in addition to diagnostic (or assessment) methods, are therefore crucial in the management of frailty as there is evidence that the degree of frailty can be reduced with early interventions[32].

The following section describes the available and validated tools that can be used for frailty screening in the community and list their associated cut-off criteria as well as their advantages and disadvantages for use in a community-setting.

2.4.1 Assessing for Frailty

Frailty can be assessed using different definitions and approaches. Two major frailty definitions are currently described in the literature, the frailty phenotype and the frailty index, which are presented in more detail below.

2.4.1.1 Frailty Phenotype

One of the most commonly used definitions for frailty is the frailty phenotype by Fried et al. (2001)[4]. It uses a physiological approach to categorise adults into non-frail (0 indicators), pre-frail (1-2 indicators) and frail (≥ 3 indicators) based on the accumulation of the following five physical indicators[4]:

- unintentional weight loss
- exhaustion
- slow walking speed
- weakness
- low physical activity

The frailty phenotype was developed and validated during the Cardiovascular Health Study[4]. It has been shown to predict poor health outcomes in older people, including incident falls, worsening mobility, disability, activities of daily living, hospitalisation, and death. Pre-frail older adults have an intermediate risk of these outcomes as well as an increased risk of becoming frail over 3-4 years compared to non-frail older adults[4].

To define frailty using Fried's phenotype criteria, a number of questionnaires and physical assessments are necessary, which are presented in Table 2.1 together with their associated cut-off criteria.

Table 2.1: Fried phenotype indicators and assessment tools[4]

Frailty indicator	**Assessments and cut-off criteria**
Weight loss	Weight loss of >4.5 kg or ≥ 5% per year
Exhaustion	Question 29 & 31 from the 36-Item Short Form Health Survey (SF-36) Question 7 & 20 from the Centre for Epidemiological Studies Depression Scale (CES-D)
Slow gait speed/slowness	gait speed men: 0.65/0.76m/s (≤173/>173cm) women: 0.65/0.76m/s (≤159/>159cm)
Weakness/low strength	grip strength men: 29-32kg according to BMI women: 17-21kg according to BMI
Low physical activity	Minnesota Leisure Time Activity Questionnaire, threshold score 90 Question 23 & 27 from the 36-Item Short Form Health Survey (SF-36) men: energy expenditure <383kcal/week women: energy expenditure <270kcal/week

The indicators ‘exhaustion’ and ‘low physical activity’ can be assessed using questions from the 36-item Short Form Health Survey (SF-36)[66], the Centre for Epidemiological Studies Depression Scale (CES-D)[67] or the Minnesota Leisure Time Activity Questionnaire[4]. ‘Low physical activity’ can also be assessed using accelerometers that measure older adults’ physical activity levels over a specific period of time[68].

The physical assessments include gait speed and grip strength. Gait speed is a strong predictor for adverse health outcomes in community-dwelling older people and is usually measured over a distance of four meters[69]. Isometric hand grip strength correlates with muscle strength and is strongly related with lower extremity strength. It is a quick and simple measurement, usually assessed by using a dynamometer[70].

The construct of the physical phenotype is regarded as being distinct from disability or comorbidity, and hence, the frailty phenotype is considered to be highly predictive of future decline in physical health[4].

2.4.1.2. Frailty Index

An alternative way in which to define frailty is the frailty index (FI). The FI defines frailty as a risk index based on the number of deficits accumulated over time[30]. The FI includes a detailed 70 item inventory of clinical deficits consisting of diseases, disabilities, physical and cognitive impairments, psychosocial risk factors and laboratory abnormalities[30]. The FI was developed and validated during the Canadian Study of Health and Ageing[72]. FI cut-off points to define frailty status are[73]:

- FI $\leq$ 0.08 non-frail
- FI $\geq$ 0.25 frail

A potential issue with the FI cut-off method is that it does not take age into account, especially given the fact that the FI increases exponentially with age[74]. Nor does the FI distinguish frailty from disability or co-morbidity as these factors are included in the genesis of the FI score[2].

2.4.1.3. Frailty Phenotype versus Frailty Index

No single operational definition for frailty has been agreed upon. The frailty phenotype defines frailty as a distinct clinical syndrome meeting three or more of five physical phenotypic criteria, while the FI defines frailty as a state reflected by cumulative deficits collected during a comprehensive geriatric assessment (Table 2.2).

The comprehensive geriatric assessment (CGA) is a 'multidimensional, interdisciplinary diagnostic process to determine the medical, psychological, and functional capabilities of a frail older person in order to develop a coordinated and integrated plan for treatment and long-term follow-up'[75]. The CGA might help to detect frailty, but is resource intensive, requiring the administration of different validated screening tools. It is usually administered by a multidisciplinary team. The feasibility of validated geriatric assessment scales for use in frailty research involving frail older people was the basis for the research presented in Chapter 7.

Table 2.2: Main characteristics of the frailty phenotype and the frailty index[76]

Frailty phenotype	Frailty index
Signs, symptoms	Diseases, activities of daily living, results of a clinical evaluation
Possible before a clinical assessment	Doable only after a comprehensive clinical assessment
Categorical variable	Continuous variable
Pre-defined set of criteria	Unspecified set of criteria
Frailty as a pre-disability syndrome	Frailty as an accumulation of deficits
Meaningful results potentially restricted to non-disabled older persons	Meaningful results for every individual, independent of functional status or age

The FI appears to be a more sensitive predictor of adverse health outcomes[2] than the frailty phenotype. However, the phenotype is highly predictive of future decline in physical health[4], and may be useful for the identification of older people at risk of future negative health outcomes, well before disability has set in. The frailty index, on the other hand, summarises the results of a CGA by providing an objective marker for the accumulation of multiple deficits[76].

2.4.2. Screening for Frailty

There are multiple screening tools for frailty, with little agreement regarding their validity, reliability or accuracy[77,78].

Experts have yet to agree on how extensive screening should be[60,78] while screening tools need to be quicker and more practical if they are not to be a barrier to widespread frailty screening[65]. However, the accuracy of a tool should not be excessively compromised as inaccurate identification of a person as frail can result in the initiation of a number of inappropriate investigations and follow-up tests that can be time-consuming[65].

2.4.2.1. The FRAIL Screen

The FRAIL screen is a quick and simple screening tool that does not require measurements by health professionals and has been validated in various populations across the globe[60,79]. It includes five questions about fatigue, resistance, ambulation, illness, and weight loss, representing the frailty phenotype[60,80]:

- Are you fatigued?
- Do you have difficulties walking up one flight of steps?
- Are you unable to walk at least one block?
- Do you have more than five illnesses?
- Have you lost more than 5% of your weight in the past six months?

The FRAIL screen can be completed in 15 seconds and categorise adults into non-frail (0 indicators), pre-frail (1-2 indicators) and frail (≥ 3 indicators) based on the number of yes responses. It is a useful screening for primary care as it is brief and simple, and it is said to be able to detect changes in frailty in both directions, and thus may be useful in monitoring change[60]. There is no equipment required and the FRAIL screen can be administered over the phone.

The FRAIL screen was used as the primary screening tool throughout the studies conducted as part of this PhD because of its brevity and ease of administration. This screening tool was used in the research described in Chapters 4, 7, 8 and 9.

2.4.2.2. The Edmonton Frail Scale

The Edmonton frail scale (EFS) includes nine indicators of frailty, including cognition, self-rated health status, functional independence, social support, medication use, nutrition, mood, continence, and mobility. The answers are graded from 0 to 2 points and the frailty status is diagnosed using the following cut off criteria[81]:

- not frail (≤ 5 points)
- vulnerable (6-11 points)
- severe frailty (≥ 12 points)

The EFS is a brief, valid and reliable tool that can be completed in less than five minutes by health care professionals without special training in geriatric medicine[81]. However, the EFS includes drawing activities, as well as a mobility test that requires equipment. The EFS therefore can’t be self-administered or completed over the phone.

2.4.2.3. The Groningen Frailty Indicator

The Groningen frailty indicator (GFI) is a multi-domain frailty measurement that was found to be reliable and valid in a Dutch community-dwelling population[82]. The GFI examines 15 components of mobility, vision, hearing, nutrition, co-morbidity, cognition, psychosocial and physical fitness and can easily be administered over the phone as it does not require any specific equipment or space[83]. It is a widely used self-report screening instrument for identifying frail older adults. Of the 15 diagnostic items, the cut-off point for frailty is set at four or more[82]. The sensitivity of the GFI was reported to be low (0.58) and specificity was 0.72[84].

2.4.2.4. PRISMA-7

The PRISMA-7 is a screening tool validated in a community-dwelling population aged 75 years and older[85]. It consists of a set of seven yes/no questions with three or more yes responses indicating frailty. The PRISMA 7 can be self-administered and used as a postal questionnaire. It doesn’t require any additional equipment. The PRISMA 7 tool exhibits relatively high sensitivity (0.83) and specificity (0.83) for identifying frailty. However, wide confidence limits indicate considerable uncertainty and it is suggested that this instrument should not be used as a single test to identify frailty[84].

2.4.2.5. Gait Speed

Gait speed is a reliable and valid measurement widely applied within the research literature[86]. It has been found to have high sensitivity (0.99), but limited specificity (0.64) in identifying frailty[84]. The cut-off point can be set at ≤ 0.8 m/s[4,78].

Gait speed can predict the risk of adverse health outcomes and there is sound evidence to support the use of gait speed as a single-item assessment tool for screening for frailty in community-dwelling older adults[65]. The required time to measure gait speed is estimated to be less than five minutes[65]. However, general medical practices do not often have enough physical space to conduct a walking test, and so there is a logistical barrier to the adoption of this method in general practice settings.

2.4.2.6. Grip Strength

Grip strength is a quick and simple measurement, usually assessed by using a dynamometer[70]. Measuring grip strength using a dynamometer takes approximately two minutes[65]. Handgrip strength is a reliable measurement for overall muscle strength and predicts functional decline, morbidity and mortality[70]. Grip strength alone was found to be sensitive (1.00) and specific 0.90) for the Fried frailty phenotype[65]. Adding gait speed to grip strength or vice versa substantially increases the precision of this screening tool, but also compounds logistical challenges[65]. Whilst the use of dynamometers requires minimal training and the cost is relatively affordable for most medical practices, such equipment is not routinely available in most general practices.

2.5. Management

Frailty is a dynamic syndrome that is reversible and treatable[8,32]. Preventive strategies go along with treatment interventions and should be initiated as early as possible before the loss of skeletal muscle mass, strength and physical function occurs. Exercise and nutrition interventions play a significant role in the management of frailty. The literature indicates that exercise interventions have a significant impact on the management of frailty[87], while other evidence goes even further to suggest that the combination of exercise and nutrition is the key intervention to prevent, treat and slow the progress of frailty[88].

Interventions, such as hormones and other medical treatments, are still under investigation with no clear evidence of benefit yet, and hence, will only be discussed briefly herein.

2.5.1. Exercise Interventions

Exercise is considered to be the most effective strategy to prevent, delay and treat frailty[12]. However, although the benefits of exercise are well known, the uptake of exercise in older people is poor[20]; 45% of people aged over 65 years, and 75% of people aged 75 years and older don't meet the recommended levels of physical activity[21,89].

Promoting exercise programs and generally encouraging older people to take up exercise are therefore critical in managing and preventing frailty in our community[21,90].

Family members and social support networks involving friends and peers are important in encouraging frail older people to exercise. However, social support networks decrease with the severity of frailty, and family members may not only encourage, but might also limit frail older people in their physical activities out of fear for their wellbeing, care and protection[91]. Research investigating frail older people's experiences of being advised about exercise and their opinions regarding who should advise them, and where this should occur, is sparse.

By better understanding frail older people's preferred source of exercise advice, health service providers can ensure that community-based education and awareness programs are not only appropriately composed, but that the information is made available through the most suitable and, if necessary, multiple sources. Chapter 4 of this thesis is addressing this issue by exploring pre-frail and frail older peoples' attitudes in relation to being advised about exercise.

Further barriers to exercise amongst older people comprise health issues (e.g., pain), environmental factors (e.g., lack of transportation), lack of knowledge, and the lack of physician advice[24].

Doctors are an integral member of any healthcare team and have a role to play in encouraging older people to exercise[20,22]. They can do this by increasing patients' awareness of the importance of exercise, allaying fears, helping to overcome perceived barriers and by providing direction as where to go and what to do[23]. Exercise advice provided by doctors in prescription form has been shown to be acceptable and effective in increasing older peoples' physical activity levels[22,92].

However, despite the efficacy of exercise prescription, doctors rarely focus on the need for exercise when recommending treatment, with only one-third of physicians prescribing exercise for their patients[93]. A commonly cited reason for this omission is a lack of training during medical school[25]. This issue is addressed in Chapters 5 and 6 of this thesis, which describes how the current Geriatric Medical Course was evaluated, enhanced and re-evaluated.

Exercise increases muscle mass, maintains and restores muscular strength, improves physical function and mobility, and reduces the risk of falls and fractures in frail older adults[13]. Exercise also helps to maintain independence and to improve quality of life[14].

Multi-component exercise training which targets major muscle groups of the body is used widely in the community with excellent compliance[94] and the evidence demonstrates it positively influences muscle mass, strength and function, as well as reducing cardio-metabolic risk and inflammation, which are key factors in the progression and severity of frailty[95].

Resistance training improves muscle strength and mass by improving the protein synthesis in skeletal muscle cells[96,87]. The stimulation of muscle protein synthesis leads to muscle hypertrophy[97] and addresses a significant problem of frailty - the age-related loss of muscle mass.

Aerobic exercise reduces oxidative stress, improves metabolic control, and optimises exercise capacity[98]. It has also been shown to improve skeletal muscle insulin sensitivity, stimulating skeletal muscle hypertrophy and increasing skeletal muscle mass[87,99], all of considerable benefit in the prevention and control of sarcopenia. However, progressive resistance training is still likely to be far more effective in increasing skeletal muscle mass than aerobic exercise.

Balance training is important, in particular for pre-frail older adults, as this population is at greater risk of falling, since the pre-frail spend more time walking than already frail older adults and are therefore more exposed to risks[100].

Flexibility training is suggested to increase cadence (steps/min), walking speed (m/s), stride length, passive hip extension, and range of motion, resulting in improved gait quality in frail older adults[101]. Exercise has also been associated with a decreased risk of dementia, Alzheimer's disease and mild cognitive impairment, playing a significant role in preventing cognitive decline in older adults[102].

The World Health Organisation recommends at least 2.5 hours of moderate-intensity aerobic exercises per week performed in bouts of at least 10 minutes duration for healthy older adults, as well as muscle-strengthening exercises involving major muscle groups on at least two days per week[52]. Older adults with poor mobility should also perform balance exercises to prevent falls[52]. The American College of Sports Medicine (ACSM)[103] goes further, recommending that resistance and/or balance training should be prioritised over aerobic exercises for older adults.

Recent exercise recommendations for pre-frail and frail older adults include participation in a multi-component exercise program composed of resistance, aerobic, balance and flexibility tasks conducted two to three times per week[104] for a duration of 30–45 minutes for frail older adults and 45–60 minutes for pre-frail adults[94]. A multi-component exercise program is suggested because frailty affects multiple physiological systems simultaneously. Using different exercise modalities allows older adults to capitalise on their remaining physiological assets to overcome their deficits[104].

It has been proposed that pre-frail older adults focus on longer resistance training and balance exercise sessions, as they are at a critical time point, where the goal is to reverse the decline towards frailty. Frail older adults, on the other hand, should complete longer aerobic exercise sessions as the goal is to prevent further regression, and it is believed that this can best be achieved by placing greater emphasis on improving aerobic performance[104] (Figure 2.2).

However, these recommendations are general and exercise prescription should always be individualised to consider the older person's physical limitations, risks and personal goals.

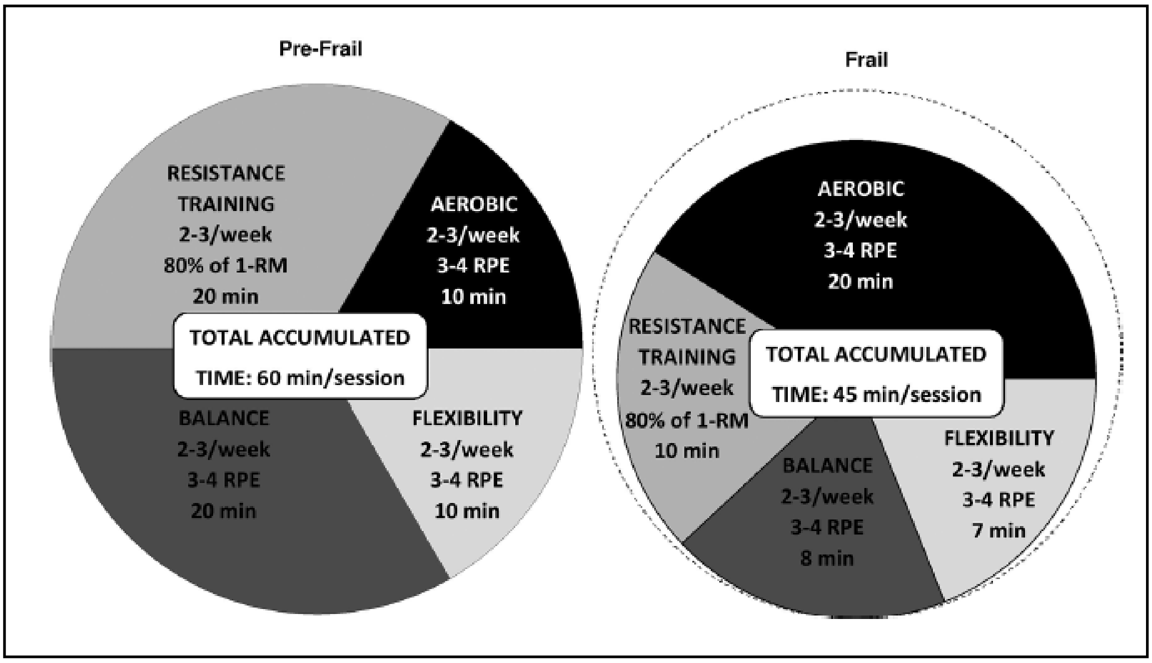


Figure 2.2: Exercise prescription for pre-frail and frail older adults[104]

However, there are still uncertainties as to which exercise characteristics (type, frequency, duration, and intensity) are most effective, either alone or in combination with other interventions. In addition, the rate of exercise progression, including frequency, intensity and duration, remains largely unknown for pre-frail and frail older adults. The research presented in Chapter 3 addressed this issue by reviewing current literature through the conduct of an umbrella review.

2.5.2. Nutrition and Supplementation

Nutrition plays an important role in the management of frailty. It helps to prevent and reverse the loss of muscle strength and mass as daily muscle protein turnover is regulated in large part by nutrition[97]. However, well conducted clinical trials in the field of nutrition and lifestyle for the management of frail older people remain limited and study results are still conflicting.

New evidence has shown that older adults require higher dietary protein to counteract age-related changes in protein metabolism and a higher catabolic state associated with chronic or acute diseases[54]. Not only the amount, but also the type and timing of protein ingested play an important role in muscle synthesis.

The optimal protein intake in people aged 65 years and above is said to be at least 1.0-1.2 g/kg/day[54]. Higher dietary protein intake is associated with an increase in muscle mass and strength[105]. For those who are physically active and those who are unwell with acute or chronic diseases, the recommendation is to have even more dietary protein (1.2-1.5g/kg/day)[54]. Similar to older people who have end stage renal impairment on dialysis, a higher protein intake - at least 1.5 g/kg/day of dietary protein[54] - is recommended. The only exceptional group that needs to limit their protein intake is older people who are non-dialysis dependent with severe renal impairment (estimated glomerular filtration rate [eGFR] <30 ml/min/1.73m^2). Their requirement is as low as 0.6-0.8 g/kg/day[54]. While there is concern among some members of the medical profession that a high-protein diet may affect renal function in older people, to date there is little or no consistent evidence from high quality clinical research trials that high protein intake actually causes renal function decline in older people[54].

The types of protein ingested may also influence muscle protein synthesis[106]. ‘Fast’ proteins, such as whey, are metabolised faster and have a higher level of postprandial essential amino acids. They are thought to be more beneficial than ‘slow’ proteins like casein[106]. However, additional evidence is needed to clarify any advantage of ‘fast’ proteins over ‘slow’ ones in preventing the loss of muscle strength and mass.

In terms of the timing of protein ingestion, evidence suggests the even distribution of protein intake at breakfast, lunch and supper[107]. Other studies have shown benefits from pulse feeding, such as with a main high-protein meal usually at midday[108] and protein intake occurring soon after exercise[109].

Only a few studies have been conducted to examine the impact of protein supplements, either on their own, or in combination with exercise, on physical function in pre-frail and frail older people and studies conducted to date have generated contrasting results for the benefits of protein on muscle mass, strength and mobility[17-19]. For this reason, a feasibility and pilot intervention study described in Chapter 7 was undertaken that is seeking to determine the feasibility of exercise in combination with protein intervention in pre-frail and frail community-dwelling older people. This study will continue past this PhD candidature with the goal of also determining the effects of this intervention on physical function parameters including gait speed, grip strength and physical performance, as well as frailty status, muscle mass, quality of life, nutritional intake, cognitive performance and physical activity levels.

Nutritional supplements, such as beta-hydroxy-beta-methylbutyrate (β-HMB), a metabolite of leucine have been shown to increase muscle mass and reduce muscle breakdown[110]. However, the number of studies using this supplement in older people is still limited. Another supplement is creatine, a guanidine-derived compound synthesised naturally in the human body using several amino acids that can also be sourced from dietary meat, which can be stored in skeletal muscle, resulting in increased muscle strength and mass[111,112]. However, not all studies have found similar benefits[113], while a few other studies using both of these supplements have reported positive effects when combined with exercise[114].

2.5.3. Pharmaceutical Treatment

There is some evidence in the literature that low serum vitamin D levels (<50 mmol) may be associated with reduced muscle mass and strength[115]. Cholecalciferol, also known as vitamin D_3, in doses of 800 IU/day has been shown to decrease the risk of falls, and this reduction is partly related to improved muscle strength[116]. Hence, it is suggested to maintain adequate vitamin D levels according to current recommendations and provide supplements for individuals with low serum vitamin D levels[117]. Further, a recent proof-of-concept randomised-controlled study has found that a particular myostatin inhibitor increases lean mass and might improve functional measures of muscle power[118].

Other pharmacological agents, such as myostatin inhibitor, testosterone, angiotensin converting enzyme inhibitors and ghrelin-modulating agents, are being investigated to treat the loss of muscle mass and strength in older adults. However, there remains inadequate evidence to support their use in practice[119].

Chapter 3

Effectiveness of Exercise Interventions on Physical Function in Community-Dwelling Frail Older People: An Umbrella Review

Summary

Exercise is said to have a positive impact on muscle mass and strength, which improves physical function, and hence, is beneficial for the treatment of frailty. Several systematic reviews discuss the effects of exercise interventions on physical function parameters, such as strength, mobility, gait, balance, and physical performance and indicate that multi-component exercise, including resistance, aerobic, balance and flexibility training, appears to be the best way in which to improve physical function parameters in frail older people. However, there is still uncertainty as to which exercise characteristics (type, frequency, intensity, duration, and combinations) are most effective and sustainable over the long-term. This umbrella review aimed to determine the effectiveness of exercise interventions, alone or in combination with other interventions, in improving physical function in community-dwelling older people identified as pre-frail or frail. The umbrella review was based on a previous protocol published in JBI Database System Rev Implement Rep. 2016; 14(9): 93-102 (Appendix 1 including Statement of Authorship).

The results of this umbrella review confirm that multi-component exercise interventions can currently be recommended for pre-frail and frail older adults to improve muscular strength, gait speed, balance and physical performance. Resistance training alone also appeared to be beneficial, in particular for improving muscular strength, gait speed and physical performance. Other types of exercise were not sufficiently studied and their effectiveness is yet to be established.

Future research should adopt a consistent definition of frailty and investigate the effects of other types of exercise alone or in combination with nutritional interventions so that more specific recommendations can be made.

This research has formed the basis of a research paper that has been accepted for publication in the JBI Database of Systematic Reviews and Implementation Reports (Appendix 2 including Statement of Authorship).

3.1. Background

The world's population is ageing. The proportion of Australians aged 65 years and older, for example, increased from 11.8% to 14.7% between 1994 and 2014[1]. Maintaining health and independence, avoiding functional decline and improving health-related quality of life are significant challenges for older adults[2].

Because ageing is accompanied by physiological changes, such as reduced hormone production, oxidative stress, poor cellular oxygenation and reduced mobility[3], the proportion of older people in danger of becoming frail will increase as the population ages[4]. While many people can experience the natural physiological alteration of ageing cells with no uncommon issues, for large numbers of older people, growing older means growing frailer. Many researchers and geriatricians now consider frailty to be a clinical syndrome, defined by the presence of specified symptoms and signs. The World Health Organisation has noted that frailty has become an indicator of unsuccessful ageing[5].

The most commonly used frailty phenotype criteria by Fried et al.[6] categorises people into robust, pre-frail and frail by using a physiological approach to frailty. Fried et al. propose that the following five indicators are related to each other within a framework of frailty: unintentional weight loss, exhaustion, slow walking speed, low grip strength and low physical activity. A person with three or more of these criteria is categorised as frail; a person with one or two criteria is considered to be pre-frail; and those with none of the indicators are considered to be robust.

In the last two decades there has been a sharp rise in frailty research due to the increasing need for effective interventions to manage the condition[7]. Evidence suggests that exercise interventions can be used to restore or maintain functional independence in older adults[8] and subsequently help to prevent institutionalisation and increasing health care costs. Exercise interventions may also potentially prevent, delay or reverse frailty[9,10].

A preliminary search revealed that several systematic reviews have been conducted to examine the effects of exercise interventions both alone[10-14], and in combination with nutritional supplements[15,16], on important functional parameters in frail older people, such as strength, mobility, gait speed, balance and physical performance. Low muscular strength and slow gait speed, for example, are strong indicators for frailty[17]. Mobility includes a person's ability to physically move and is usually measured by tests including muscular strength and gait, while physical performance is based on the combination of mobility, gait speed and balance tasks representing a person's ability to physically function as a multidimensional concept[18].

The exercise interventions described in the various reviews indicate that multi-component exercise, including resistance, aerobic, and balance training, can alleviate functional decline and improve strength in frail older people[11,12]. Contradictory, the randomised controlled trials included in two of the systematic reviews demonstrated both positive and negative outcomes of the exercise interventions[13,14]. Interventions including both exercise and nutrition supplements also showed contentious results. Lee et al.[19] showed that exercise combined with diet improves strength and gait speed more significantly than exercise alone, whereas Cruz-Jentoft et al.[15] demonstrated that resistance exercise in combination with protein supplementation did not improve muscle strength and physical performance. Uncertainty exists for which exercise characteristics (type, frequency, duration, and intensity) are most effective, either alone or in combination with other interventions. Nevertheless, the American College of Sports Medicine's (ACSM)[20] has published updated guidelines for physical activity in older adults that recommend the prioritisation of resistance exercises over aerobic training for this population. The conflicting results of some of the systematic reviews indicating the need for an umbrella review to better understand and evaluate the effectiveness of exercise interventions and their characteristics.

Therefore, an umbrella review was conducted to examine the effectiveness of exercise intervention, alone or in combination with other interventions, for improving physical function in community-dwelling older people identified as frail or at-risk of frailty. This review was conducted according to an a priori published protocol[21].

The objectives of this umbrella review were to: (i) determine the effectiveness of exercise interventions, alone or in combination with other interventions, for improving physical function in community-dwelling older people who are identified as frail or at-risk of frailty and (ii) examine if any particular intervention type or characteristic is more effective than others.

3.2. Inclusion Criteria

3.2.1. Types of Participants

This umbrella review included systematic reviews involving individuals:

- aged 60 years and above. More specifically, it was proposed that at least 50% of the people included in the review were 60 years or older, OR that the mean age of the people in the study was at least 60 years. If one of these criteria was fulfilled but the other is not, the review was included.

- living in the community. More specifically, it was proposed that at least 50% of people included in the review were living in the community in their own homes.
- identified as frail or at-risk of frailty using an operationalised definition of frailty or standardised criteria to measure frailty. More specifically, it was proposed that at least 50% of the people included in the review were identified as frail or at-risk of frailty.

The following indices for measuring frailty identified by Bouillon et al.[22] were accepted in this umbrella review: Gronigen Frailty Indicator (GFI)[23], Frailty Index (FI)[24], Canadian study of health and ageing (CSHA) Clinical Frailty Scale[25], Vulnerable Elder Survey (VES-13)[26], Tilburg Frailty Indicator (TFI)[27], Physical Frailty Score[28], Phenotype of Frailty[17], Edmonton Frail Scale (EFS)[29] and the Study of Osteoporotic Fractures Index (SOF Index)[30].

Any other frailty indicators used by author/s of systematic reviews which were based on the indices above were also considered for inclusion.

Reviews that did not provide sufficient detail about the sample populations of included studies were excluded. Reviews that did not use an operationalised definition of frailty or standardised criteria to measure frailty according to Bouillon et al. were excluded.[22] Reviews that focused on healthy older people or older people in hospital, sub-acute settings or nursing homes were excluded. Nursing homes were defined as "a facility with a domestic-styled environment that provides 24-hour functional support and care for persons who require assistance with activities of daily living (ADL) and who often have complex health needs and increased vulnerability"[31(p183)].

3.2.2. Types of Interventions

Systematic reviews that evaluated exercise interventions of any form, duration, frequency and intensity, alone or in combination with other interventions designed to alter physical function in frail older people, were included in this umbrella review. The types of exercise interventions included, but not limited to, were:

1. resistance or strength training
2. aerobic or endurance training
3. balance training
4. flexibility or stretching training

5. multi-component training

Systematic reviews that included interventions that were not combined with exercise were excluded. To determine the effectiveness of exercise interventions, included reviews had to use either a control group (i.e. no intervention, placebo intervention, usual care) or a comparator group (i.e. another type of exercise, exercise in combination with other interventions).

3.2.3. Types of Outcomes

The primary outcomes were quantitative measures of physical function in frail older people including:

1. muscular strength defined as the maximal amount of force a muscle can produce measured by, for example, grip strength or lower limb strength
2. gait speed defined as the time it takes to walk a specific distance measured by, for example, 6 Minute Walking Test (6MWT)
3. balance defined as the ability to maintain a controlled body position during task performance measured by, for example, Berg Balance Scale or tandem stand
4. mobility defined as the person's ability to move physically measured by, for example, Timed Up & Go or chair rise & stand
5. physical performance defined as a multidimensional concept based on the combination of mobility, gait speed and balance skills measured by, for example, Physical Performance Test

The umbrella review excluded systematic reviews of physical function outcomes that were measured using non-standard or invalidated measures.

3.2.4. Types of Studies

This umbrella review considered any quantitative systematic reviews with or without meta-analysis that examined the effectiveness of exercise interventions, alone or in combination with other interventions, in relation to improving physical function in frail older people. Included systematic reviews provided:

- a clearly articulated and comprehensive search strategy including at least two or more bibliographic databases
- evidence of critical appraisal/assessment of risk of bias

If it was not clear whether the inclusion criteria were met, authors were contacted for confirmation before including or excluding the review. Furthermore, literature reviews, withdrawn or retracted publications, systematic reviews not published in English, and earlier versions of updated systematic reviews were also excluded.

3.3. Methods

3.3.1. Search Strategy

The search strategy aimed to find both published and unpublished reviews. The following electronic databases were broadly searched for published systematic reviews and meta-analyses: PubMed, EMBASE, CINAHL, Scopus, The Cochrane Database of Systematic Reviews, The JBI Database of Systematic Reviews and Implementation Reports, Web of Science, The Campbell Collaboration Library of Systematic Reviews, Google Scholar. Grey literature was searched using Google and ProQuest Dissertations and Theses. Only reviews published in the English language were considered for inclusion in this umbrella review. Reviews published from 1990 (as this pre-dates some of the earliest work in this field) until September 2016 were considered for inclusion. The final search strategies, which were developed using an iterative process to minimise false positives and optimise results, are included in Appendix I.

3.3.2. Methodological Quality

Reviews selected for retrieval were assessed using the eligibility criteria listed in Appendix II. Reviews that met all the eligibility criteria were appraised by two independent reviewers for methodological validity using a standardised critical appraisal instrument from the JBI System for the Unified Management, Assessment and Review Instrument and the JBI Reviewers' Manual 2014[32]. The following eleven criteria were assessed:

1. Is the review question clearly and explicitly stated?
2. Were the inclusion criteria appropriate for the review question?
3. Was the search strategy appropriate?
4. Were the sources and resources used to search for studies adequate?
5. Were the criteria for appraising studies appropriate?
6. Was critical appraisal conducted by two or more reviewers independently?
7. Were there methods to minimise errors in data extraction?
8. Were the methods used to combine studies appropriate?
9. Was the likelihood of publication bias assessed?

10. Were recommendations for policy/practice supported by the reported data?
11. Were the specific directives for new research appropriate?

The quality of each review was ranked based on the following criteria: 0-33% of criteria met (low quality), 34-66% of criteria met (medium quality) and 67% or more of criteria met (high quality)[32]. No review was excluded on the basis of a critical appraisal score, and all reviews that were appraised and met the eligibility criteria were included in data extraction.

To assist in the sensitivity analysis, the reviews were categorised according to how well they met the eligibility criteria: low quality (0-33% of the criteria met); medium quality (34-66% of the criteria met); and high quality (67% or more of the criteria met). Any differences of opinion between the reviewers were resolved through discussion, or by consulting a third reviewer (TS).

3.3.3. Data Collection and Synthesis

The data were extracted using a standardised JBI instrument designed for umbrella reviews[32]. The following information was extracted from each review included in the umbrella review: 1) type of study design; 2) country where the review was conducted; 3) number of studies in the review; 4) sample size; 5) type of exercise intervention and its characteristics, and its combination with other intervention; 6) effect on physical function parameters; and 7) main results.

Data related to interventions were extracted from selected systematic reviews and tabulated, accompanied by a narrative synthesis to address the review question. All possible statistical measures were retrieved, such as effect size, 95% confidence intervals and heterogeneity.

Interventions were judged on the strength of the evidence for their effectiveness. Beneficial and effective interventions were given a tick (V). Interventions that did not show any benefit were marked with a cross (X). An earlier protocol[21] suggesting the use of traffic light colours was not used because it was not possible to differentiate between a lack of effect (orange) and a detrimental effect (red) for any intervention compared to a control. The effectiveness of the intervention was based on the total number of participants affected positively across the relevant trials (i.e., 7 trials [n=391] showed an increase [↑]; 4 trials [n=602] showed no effects [-]; overall decision X).

An overall assessment of the quality of the evidence for each comparison using GRADE (Grading of Recommendations, Assessment, Development and Evaluation)[32] was not possible. The original GRADE scores derived for the included systematic reviews were rendered inaccurate because the umbrella review extracted a subset of relevant RCTs from the included systematic reviews for all interventions.

3.4. Results

3.4.1. Review Inclusion/Exclusion

The literature search identified 1437 titles, of which 1390 records were from bibliometric databases (Figure 3.1). The search in grey literature identified 47 records. After removing duplicates (n=263), the titles and abstracts of 1174 records were screened independently by two reviewers and 1016 records were excluded as irrelevant to the umbrella review. Full text reviews assessing the eligibility of the remaining 158 records were conducted by two reviewers independently and 151 records failed to meet at least one of the five eligibility criteria (type of study, participants, interventions, outcomes and language). The remaining seven records were advanced to the critical appraisal stage using the checklist for the verification of review eligibility (Appendix II). All seven systematic reviews had been identified from the original search of bibliometric databases. The last search was conducted in September 2016.

3.4.2. Review Characteristics

The seven systematic reviews included a total of 157 randomised controlled trials (RCTs), but only 59 (37.6%) RCTs were considered to be relevant for this review based on the inclusion criteria (Appendix II). The relevant RCTs included one duplicate[11,13] which was considered only once throughout this umbrella review, resulting in 58 relevant RCTs. Information from this subset of RCTs relevant to the umbrella review question was extracted from the selected reviews (Appendix III). The number of participants involved in the relevant trials (n=58) was 6,927 (from a total sample size of 14,642). The grand mean of the mean ages from selected reviews was 80.9 years.

Five systematic reviews reported on the gender of participants from included RCTs[10,12-15] and the majority of the participants were female (68.5%). In regards to the classification of pre-frail and frail participants, five systematic reviews[11-13,15,16] included RCTs only if they followed an operationalised definition of frailty or used standardised criteria to measure frailty. Two systematic reviews,[10,14] including 21 relevant RCTs, however, did not include RCTs based on operationalised definitions or standardised criteria. Instead, participants were simply identified as frail in either text, title or abstract. The 21 RCTs were therefore checked individually to ensure they met the inclusion criteria of this umbrella review.

Of the seven eligible systematic reviews, three were from the Netherlands, two from Spain and one each from the UK and Canada. The reviews were conducted or published between 2008 and 2015. In regards to the individual RCTs (n=58), it was observed that most RCTs (n=52; 89.7%) were conducted in or after 2000 and only six RCTs (10.3%) dated back to 1998.

Heterogeneity was calculated in only one systematic review, which included a meta-analysis in addition to a narrative synthesis.11 The other six systematic reviews conducted a narrative synthesis only[10,12-16].

3.4.3. Methodological Quality

The critical appraisal results for each of the seven systematic reviews are summarised in Table 3.1. Six out of seven systematic reviews were of high quality and only one was of medium quality as per the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses[32]. The minimum number of criteria met was six and the maximum was nine, out of 11. Criteria 2-5, relating to inclusion criteria, search strategy, and study appraisal, were met by all included systematic reviews. Only one systematic review, however, stated that the likelihood of publication bias had been assessed (criteria 9). No reviews were excluded on the basis of methodological quality criteria.

3.4.4. Intervention Characteristics

3.4.4.1. Type

Five systematic reviews examined the effects of exercise intervention only[10-14], while two systematic reviews included trials examining exercise in combination with nutritional intervention[15,16].

In regards to the exercise interventions, 33 trials included multi-component exercises involving resistance, balance, flexibility and aerobic exercises. Fifteen trials examined the effects of resistance exercise only[10-14]. One trial examined resistance exercise with an additional component of motion exercise[13] and one trial assessed balance only[11]. Another trial examined the effect of a horse riding simulator[10], while another used sit-to-stand exercises with the help of an electronic device called GrandStandTM[11,13]. Three trials performed personalised exercise without providing further information on the type of exercise[11].

Three trials in two systematic reviews[15,16] evaluated the effects of exercise in combination with a nutritional approach. One trial examined the effects of resistance exercise combined with protein supplementation of 30g per day[15]. Another trial examined multi-component exercise, including resistance, aerobic, and balance exercises combined with nutrition (without details of the nutritional supplement)[15], and another trial looked at exercise combined with fruit and dairy products[16].

3.4.4.2. Frequency

Six systematic reviews reported on the frequency of exercise interventions with a range of 1-7 exercise sessions per week[10-14,16]. The majority of the systematic reviews (n=3) reported a frequency of 2-3 times per week[10,13,14]. Other systematic reviews reported frequencies of 2-5 sessions per week[16], 3-7 sessions per week[12], and 1-7 sessions per week. One systematic review did not provide any information on frequency[15]. The mean exercise frequency was 3.0 ± 1.5 times per week.
The length of the exercise sessions was stated in five systematic reviews, and ranged between 10 to 90 minutes each session, with a mean of 52.0 ± 16.5 mins[10-12,14,16]. Two systematic reviews did not provide any information on the length of the exercise sessions[13,15].

3.4.4.3. Duration

All seven systematic reviews reported on the duration of the exercise interventions. The total duration of the interventions ranged from 5 to 72 weeks with a mean of 22.7 ± 17.7 weeks. The majority of systematic reviews (n=4) reported a minimum duration of 2.5 months[10,12,14,16]. One systematic review reported a minimum duration of 12 weeks[15], while two other systematic reviews reported shorter durations of 5 to 6 weeks[11,13]. The maximum duration of exercise interventions ranged between 9, 12 and 18 months.

3.4.4.4. Intensity

The intensity of the exercise interventions was reported in two systematic reviews[12,14] and ranged from 2-3 times of 8-12 repetitions at 85-100% 1RM (repetition maximum), as well as 30-80% 1RM and 60-80% 1RM for resistance exercises. The intensity of aerobic exercises ranged from 15 minutes at 65–70% of VO2max (equivalent to 80% of maximum heart rate in older adults of 65 years) and 3-5 minutes at 85–90% VO2max (equivalent to 90-95% maximum heart rate in older adults of 65 years) to 6-8 points on a 10-point perceived exertion scale. Personalised intensity, and low, medium and high intensity were discussed without further definition. Three systematic reviews did not include any information on intensity[13,15,16] and two systematic reviews stated either low to high intensity or low versus high intensity without any further information[11,14].

3.4.5. Effects on Physical Function

3.4.5.1. Muscle Strength

Muscular strength was measured using knee extension and flexion for lower limb strength, and grip strength and shoulder strength for upper limb strength. Strength exercises included progressive resistance training alone or with Thera bands, as well as a variation of concentric, isometric and eccentric knee-extension exercises.

Four systematic reviews[12,13,15,16] involving 15 relevant trials and 1395 participants evaluated the impact of exercise interventions on muscular strength. Eleven trials (75.6%; n=1055 participants) showed a positive impact on muscular strength using multi-component exercises (n=5 trials),12,16 resistance exercises (n=5 trials)[12,13,15,16] and multi-component exercises in combination with nutrition (no details stated) (n=1 trial)[15]. Four trials (24.4%; n=340 participants) failed to show improvements in muscular strength using multi-component exercises (n=2 trials)[12,13], strength and motion exercises (n=1 trial)[13], as well as resistance exercises in combination with protein supplementation of 30g per day (n=1 trial)[15].

With regards to the overall effect, multi-component exercises, including resistance training, as well as resistance exercises on their own, seemed to be most effective in improving muscular strength (Table 3.2). The exercises were performed 2-5 times per week for 20-90 minutes each session for a duration of 2.5-9 months. The intensity of the resistance training ranged from 40-70% 1RM using 6-12 repetitions and 1-3 sets.12 Trials that did not show any improvements of muscular strength did not provide any information on intensity. An overview of the extracted data is presented in Table 3.3.

3.4.5.2. Gait Speed

Gait speed was measured using 2.4, 3, 4, 5, 6, 10 and 400 meter tests; normal, rapid and maximal gait speed; as well as the 6MWT.

Five systematic reviews[10-12,14,16] involving 34 trials (n=4017 participants) included gait speed as an outcome measure. However, only 13 trials (40.5%; n=1626) out of three systematic reviews reported on the effects on gait speed as an individual outcome. The remaining two systematic reviews included gait speed as part of their mobility and physical performance assessments and did not report on gait speed specifically.

Ten trials (31.1%; n=1250 participants) showed a positive impact on gait speed using multi-component exercises (n=7 trials)[12,14,16] and resistance exercises (n=3 trials)[12,14]; while three trials (9.4%; n=376 participants) failed to show improvements in gait speed using multi-component exercises (n=3 trials)[11,12,14].

With regards to the overall effect, multi-component and resistance exercises on their own seemed to be most effective in improving gait speed. The exercises were performed 2-5 times per week for 20-90 minutes per session over 2.5-18 months. The intensity for the resistance exercises ranged from 1-3 sets of 6-8 repetitions at 70% 1RM12 to less specific information stating low, moderate and high intensity without further details[14].

3.4.5.3. Mobility

Mobility was measured by chair rise & stand, as well as the Timed Up & Go Test (TUG) alone or in combination with gait speed. Six systematic reviews[10-14,16] including 36 trials (n=4791 participants) reported on mobility as an outcome.

Nineteen trials (52.8%; n=2545 participants) showed a positive effect on mobility using multi-component exercises (n=9 trials)[10-13,16], resistance exercises (n=6 trials)[10-12], personalised training (n=3 trials)[11] and resistance exercises combined with range of motion exercises (n=1 trial)[13]. However, 17 trials (47.2%; n=2246 participants) failed to show any improvement using multi-component exercises (n=10 trials)[11,13,14], resistance exercises (n=4 trials)[11,14,16], GrandStand™ based exercises (n=1 trial)[11,13], the horse riding simulator (n=1 trial)[10] or balance exercises (n=1 trial)[11].

With regards to the overall effect, the results were inconclusive and suggested that only personalised exercises seemed to consistently be effective in improving mobility. However, a sufficient number of trials showed positive effects on mobility using multi-component exercises (n=9 trials; 1205 participants) and resistance exercises (n=6 trials; 391 participants) to suggest that these interventions might also be of benefit. The exercises were performed 1-7 times per week for 26-90 minutes per session and over a period of 5 weeks to 18 months. The intensity for resistance exercises was 60-80% 1RM using 6-10 repetitions and 1-3 sets[10,12], as well as personalised intensity without further details[11].

3.4.5.4. Balance

Five systematic reviews[10,12-14,16] including 24 trials (n=2552 participants) reported on balance as an outcome. However, only 13 trials (54.2%, n=1630 participants) reported on the effects of exercise on balance as an individual outcome measure. How balance was assessed was not stated.

Nine trials (46.0%; n=1174 participants) showed a positive effect on balance using multi-component exercises (n=8)[10,12,13,16] and resistance exercise (n=1).16 Four trials (17.9%; n=456 participants) failed to show improvements in balance using multi-component (n=1 trial)[13], resistance (n=1 trial)[14], resistance combined with a range of motion (n=1 trial)[13] or GrandStand™ based exercise (n=1 trial)[11,13].

With regards to the overall effect, multi-component exercises seemed to be most effective in improving balance. The exercises were performed from 3 times per day to 3 times per week for 20-75 minutes each session for a duration of 2.5 weeks to 18 months. The intensity ranged from 3 times of 8-12 repetitions at 85-100% 1RM for resistance exercise, and 15 mins at 65-70% VO_2max and 3-5 mins at 85–90% VO_2max for aerobic exercise[10].

3.4.5.5. Physical Performance

Physical performance was measured using the Physical Performance Test (PPT), the Tinetti Performance-Oriented Mobility Assessment (POMA) and the MacArthur Battery.

All seven included systematic reviews including 27 trials (n=3765 participants) reported on physical performance as an outcome measure.

Twenty-two trials (81.5%, n=3067 participants) showed positive effects on physical performance using multi-component (n=16 trials)[10-12,14,16], resistance (n=4 trials)[10,11,16], personalised (n=1 trial)[11] and balance exercises (n=1 trial)[11]. Five trials (18.3%; n=698 participants) reported in three systematic reviews[11,13,15] failed to show improvements in physical performance following multi-component (n=1 trial)[13], resistance (n=1 trial)[11], GrandStand™ based (n=1 trial)[11,13] and personalised exercises (n=1 trial)[11], as well as exercise combined with protein supplementation (n=1 trial)[15].

With regards to the overall effect, multi-component exercises, resistance exercises on their own, as well as balance exercises, appeared to be the most effective in improving physical performance. The exercises were performed between 1 and 5 times per week for 20-90 minutes each session and over a period of 2.5-18 months. The intensity ranged from 2-3 times of 8-12 repetitions at 85-100% 1RM for resistance exercise; 15 minutes at 65-70% VO_2max and 3-5 minutes 85-90% VO_2max, as well as 6-8 points on a 10-point perceived exertion scale for aerobic exercise. Exercises conducted at a personalised intensity, as well as low, medium and high intensity did not provide any further details[10,11].

3.4.6. Compliance, Dropout Rates and Safety

Five[10-12,14,16] of the seven systematic reviews reported on compliance and dropout rates. Dropouts were defined as the number of randomised participants having no post intervention measurements. One systematic review, including eight relevant trials, reported dropout rates from 4% to 32%[14]. Two other systematic reviews, including 23 relevant trials, only assessed whether the dropout rate was below or above 15%. Seventeen trials had less than a 15% dropout rate, while six had higher dropout rates without providing further information[11,12]. As part of their methodological quality assessment, Daniels et al.[16] determined whether the compliance in the trials was acceptable. Out of seven relevant trials, four demonstrated meaningful compliance. Two trials did not provide any data about compliance and another was not compliant. In the systematic review of Theou et al.,[10] eight out of 13 relevant trials included information regarding exercise compliance; however, specific information was not available. Additionally, five of these trials reported on adverse events, stating that no adverse events had occurred in the intervention group, or, if they had, they were similar to the control group, demonstrating that exercise is a safe intervention for frail older people[10].

3.5. Discussion

Key findings suggest that studies should follow a consistent definition of frailty to clearly identify the target population group and investigate the effects of different exercise types, alone or in combination with nutritional interventions on physical function parameters in frail older adults. Studies should also provide sufficient information and report on frequency, intensity, and duration of exercise so that more specific recommendations for frail older people can be made.

This umbrella review summarised the evidence from seven systematic reviews including 58 relevant trials and involving 6,927 participants. The majority of the included trials examined mobility (n=36 trials), followed by physical performance (n=27 trials), gait speed (n=13 trials), muscle strength (n=15 trials) and balance (n=12 trials).

Multi-component exercise interventions can currently be recommended for pre-frail and frail older adults to improve muscular strength, gait speed, balance and physical performance, including resistance, aerobic, balance, and flexibility tasks. Resistance training was also suggested to be beneficial in particular for improving muscular strength, gait speed and physical performance and should be considered as part of a multi-component exercise intervention. Other types of exercise were not sufficiently studied and their effectiveness is yet to be established. Exercise combined with nutritional interventions was also comparatively little studied and results were mixed.

Most of the systematic reviews stated an average frequency of 2-3 times per week for 10-90 minutes per exercise session. The total duration of the interventions ranged from 5 to 72 weeks, with the majority of the reviews reporting a minimum duration of 2.5 months (mean 22.7 ± 17.7 weeks). The intensity of the exercise interventions ranged from 30-80% 1RM to 2-3 times of 8-12 repetitions at 85-100% 1RM for resistance exercise; 15 minutes at 65-70% VO_2max and 3-5 minutes at 85-90% VO_2max, as well as 6-8 points on a 10-point perceived exertion scale for aerobic exercise.

3.5.1. Type and Effects of Exercise Interventions

The current exercise recommendations for healthy older adults aged 65 years and older include a combination of aerobic (150 minutes of moderate intensity or 75 minutes of vigorous intensity per week) and resistance training (at least twice per week)[34]. The results of this umbrella review extend these recommendations and suggest that multi-component exercises, including a combination of resistance, aerobic, flexibility, and balance exercises, are effective in improving physical function parameters, such as strength, gait speed, balance and physical performance, in older adults who are frail or at-risk of frailty. The extended recommendations agree with recent published literature that suggests that pre-frail and frail older adults should aim to meet the current recommendations for healthy older adults but should participate in a multi-component exercise program that includes resistance, aerobic, balance and flexibility exercises[35].

Bray et al.[35] also suggest a focus on resistance exercises, including lower extremity muscle groups for pre-frail older adults and longer aerobic exercise sessions for frail older adults. The results of this umbrella review support the observation that an important element of multi-component exercise interventions is resistance training. For three out of four physical function parameters (strength, gait speed, physical performance), resistance training made a positive difference. This concurs with Cadore et al.[36] who conducted a systematic review on the effects of exercise interventions in frail older adults and reported that resistance training (either alone or as part of a multi-component exercise program) revealed greater strength gains in physical frail older adults than multi-component exercise interventions without resistance training. However, the participants' setting was not stated, and therefore no definite comparisons to the results of this umbrella review can be made.

The effects of exercise interventions on mobility were inconclusive as both multi-component and resistance exercises resulted in mixed results. Other types of exercise were not sufficiently studied and their effectiveness is yet to be established. Only personalised exercises tailored for the individual frail older adult seemed to increase mobility consistently. A possible reason for the inconclusive results across the trials included in this umbrella review could also be variations in the use of the TUG which is an assessment tool for mobility. It has been reported that TUG scores can be affected by several circumstances, like the use of an assistive device or the height of the chair[37]. Another reason why the TUG could have been a major reason for the inconclusive results is that mobility was also assessed by gait speed which increased in the majority of the trials using multi-component interventions and resistance training. It is suggested that future trials should use an additional test to the TUG and examine the effectiveness of other potential exercise types further.

Numerous studies have demonstrated substantial benefits of protein supplementation in combination with resistance exercise in healthy older adults[38]. However, few studies have been conducted in frail older adults and those that have been undertaken have yielded conflicting results on the benefits of protein in combination with exercise on physical function parameters[39-41]. This umbrella review also found mixed results in studies that combined exercise with nutritional interventions. Inconclusive findings might be due to a low number of studies and heterogeneous study designs, with some study samples being too small or others providing insufficient doses of nutrition or administering the nutritional supplements on different timings. One systematic review confirmed that the timing of nutritional intervention before or after exercise should be explored in further clinical trials, as basic studies suggest there may be time-sensitive factors that influence the outcome of nutrition intervention in association with exercise[15]. More studies are needed before recommendations for frail older adults can be made related to nutrition and exercise in combination.

3.5.2. Frequency

This umbrella review supports current literature that suggests an optimal frequency of 2-3 times per week (mean 3.0 ± 1.5 times per week; range 1-7 weekly) for multi-component exercise interventions involving pre-frail and frail older adults[35,36]. Bray et al.[35] suggest that less than two times per week would likely not improve physical function parameters and more than three exercise sessions per week could cause some pre-frail and frail older adults to become over trained and lose interest. Nevertheless, whenever possible, pre-frail and frail older adults should be encouraged to increase their exercise frequency to at least three exercise sessions per week[42].

3.5.3. Duration

The duration of the exercise sessions noted in this umbrella review ranged from 10-90 minutes (mean of 52.0 ± 16.5 mins). One of the systematic reviews suggested that the optimal duration for exercise sessions was 45-60 minutes for pre-frail older adults and 30-45 minutes for frail older adults[10]. This observation agrees with recently published literature that suggests a total duration of multi-component exercise sessions of up to 60 minutes for pre-frail older adults (20 mins resistance, 10 mins aerobic, 20 mins balance, 10 mins flexibility) and up to 45 minutes for frail older adults (10 mins resistance, 20 mins aerobic, 8 mins balance, 7 mins flexibility)[35]. The appropriate duration depends on frailty status, age and consistency of exercise participation[35]. Exercise sessions may start at lower durations but should progress to the recommended levels[36].

3.5.4. Intensity

The intensity of exercise was reported in only two systematic reviews and was of higher intensity than the recommendations in the literature. When using heart rate as an indicator for intensity, according to current guidelines, aerobic exercises should be performed at 70-75% of older people’s maximal heart rate[43]. The intensity in this umbrella review was reported to be between 80-95% of the maximum heart rate.

Another quantifiable measure of intensity is the Borg scale, a scale that allows a rating of perceived exertion (RPE). A RPE between 12 and 14 (somewhat hard) is reported to be the optimal intensity range for frail and pre-frail adults36 which is equivalent to 3-4 on the 10-point Borg scale[35]. Recent literature does recommend that pre-frail and frail older adults should eventually progress to a reasonably moderate-vigorous intensity[8], working toward the upper end of the RPE scale[35]. The intensity found in this umbrella review was reported to be higher, 6-8 points on a 10-point perceived exertion scale. It should be noted that many older adults are using medications that might influence their heart rates. When using heart rate as a measurement for exercise intensity, therefore, measurements should be adjusted.

Resistance exercises should be performed using an estimated percentage of the 1RM starting with three sets of 8-12 repetitions at an intensity of 20-30% 1RM and progressing to 80% of 1RM[36] or beyond (if appropriate)[35] as high-intensity resistance training appears to be more effective than low-intensity training[44]. Another progression strategy could be higher repetitions (12-15) at a lower intensity (55% of 1RM) to build up muscular endurance, and progress to fewer repetitions (4-6) at a greater intensity (>80% of 1RM) to maximise muscular strength[35]. The recommended level of exercise is in agreement with the results of this umbrella review, which states an intensity of 8-12 repetitions at 85-100% 1RM, as well as resistance exercises performed at 30-80% and 60-80% 1RM.

3.6. Strengths and Limitations

The strengths of this umbrella review include the comprehensiveness of the search strategy, the currency of the studies and the large number of RCTs and participants representing the effects of exercise interventions on physical function parameters in community-dwelling frail older adults.

A limitation of this umbrella review was the heterogeneity of RCTs in the included systematic reviews due to different types of exercise interventions and outcome parameters. However, predefined inclusion and exclusion criteria aimed to minimise this heterogeneity. Further, there was not enough evidence to draw any conclusions about the effectiveness of other types of exercise resulting in only limited recommendations focusing on multi-component and resistance interventions only.

Another limitation was the lack of consensus in the definition of frailty and the use of various criteria to define frailty. A consistent definition of frailty would help to ensure a more uniform target population, allowing for a more rational examination of the effects of exercise interventions on the status of an individual’s frailty.

The intensity of exercise interventions was reported in only two systematic reviews, which makes conclusions in regards to this exercise characteristic difficult. Systematic reviews should provide sufficient information and report on frequency, intensity, duration and type of exercise so that more specific recommendations for frail older people can be made.

3.7. Conclusion

To the best of our knowledge, this is the first umbrella review examining the effects of exercise interventions on physical function parameters in community-dwelling frail older adults. The review sought to determine the most effective exercise interventions for improving physical well-being in this group. The results compiled from the systematic reviews indicated that pre-frail and frail older adults should participate in a multi-component exercise program, including in particular resistance training, as well as aerobic, balance and flexibility exercises. However, other types of exercise interventions have not been sufficiently studied and their effectiveness is yet to be established. Nevertheless, to optimise the exercise interventions and improve physical function, an optimal combination of intensity, duration and frequency is crucial, as well as gradual increases in these characteristics. Multi-component interventions should be performed up to three times per week for 45-60 minutes per exercise session at a moderate to high intensity aiming to progress to “somewhat hard” on the Borg scale for aerobic exercises and ≥80% of 1RM for resistance exercises for a duration of at least 2.5 months.

3.7.1. Implications for Practice

Evidence suggests that multi-component exercise interventions, including in particular, resistance training, as well as aerobic, balance and flexibility exercises, are an effective strategy to improve physical function (i.e., strength, gait speed, balance, physical performance) in pre-frail and frail older adults. However, other types of exercise interventions might also be effective but have not been sufficiently studied yet to draw any conclusions. Nevertheless, an optimal combination of frequency, duration and intensity is crucial to ensuring a positive response in physical function. Frail older people should not only gradually increase the frequency of their exercise from once or twice per week up to at least three times per week, but also increase the intensity and duration of their exercise. Multi-component intervention programs should be promoted more actively amongst older adults to increase their participation in exercise and to tackle frailty in the community.

3.7.2. Implications for Research

Future research should adopt a consistent definition of frailty to clearly identify the target population and investigate the effects of other exercise types, alone or in combination with nutritional interventions on physical function in frail older adults. Also, systematic reviews should provide sufficient information and report on frequency, intensity, duration and type of exercise so that more specific recommendations for frail older people can be made. Furthermore, compliance and dropout rates need to be reported consistently across studies so that exercise interventions for frail older people can be optimised.

Investigations into the management of the proposed increase in intensity, frequency and duration over time are required, as is research into how to monitor the quality of exercise interventions. Results of these investigations would assist in the optimisation of exercise interventions for frail older adults.

3.8. References

1. Australian Bureau of Statistics, Australian Demographic Statistics 2014 [updated June 2014]. Available from: http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/126E319BBCA7E237CA257DB1001620B4/$File/31010_jun%202014.pdf.
2. Bierman AS. Functional Status: The Sixth vital sign. J Gen Intern Med 2001;16:785-86.
3. Australian Institute for Health and Welfare, Australia's Health 2016. Available from: http://aihw.gov.au/WorkArea/DownloadAsset.aspx?id=60129555788, p. 226.
4. Nash KCM. The effects of exercise on strength and physical performance in frail older people: A systematic review. Rev Clin Gerontol 2012;22(4):274-85.
5. Chang SF, Lin PL. Frail phenotype and mortality prediction: a systematic review and meta-analysis of prospective cohort studies. Int J Nurs Stud 2015;52(8):1362-74.
6. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56.
7. Bendayan M, Bibas L, Levi M, Mullie L, Forman DE, Afilalo J. Therapeutic interventions for frail elderly patients: part II. Ongoing and unpublished randomized trials. Prog Cardiovasc Dis 2014;57(2):144-51.
8. Paterson DHJ, Gareth R.; Rice, Charles L. Ageing and physical activity: evidence to develop exercise recommendations for older adults. Can J Public Health 2007; 98 Suppl 2:S69-S108.
9. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-23.
10. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res 2011;2011:569194.
11. de Vries NM, van Ravensberg CD, Hobbelen JSM, Olde Rikkert MGM, Staal JB, Nijhuis-van der Sanden MWG. Effects of physical exercise therapy on mobility, physical functioning, physical activity and quality of life in community-dwelling older adults with impaired mobility, physical disability and/or multi-morbidity: A meta-analysis. Ageing Res Rev 2012;11(1):136-49.

12. de Labra C, Guimaraes-Pinheiro C, Maseda A, Lorenzo T, Millan-Calenti JC. Effects of physical exercise interventions in frail older adults: a systematic review of randomized controlled trials. BMC Geriatr 2015;15:154.

13. Clegg AP, Barber SE, Young JB, Forster A, Iliffe SJ. Do home-based exercise interventions improve outcomes for frail older people? Findings from a systematic review. Rev Clin Gerontol 2012;22(1):68-78.

14. Chin A Paw MJM, Van Uffelen JGZ, Riphagen I, Van Mechelen W. The functional effects of physical exercise training in frail older people: A systematic review. Sports Med 2008;38(9):781-93.

15. Cruz-Jentoft AJ, Landi F, Schneider SM, Zúñiga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: A systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing 2014;43(6):48-759.

16. Daniels R, van Rossum E, de Witte L, Kempen GI, van den Heuvel W. Interventions to prevent disability in frail community-dwelling elderly: a systematic review. BMC Health Serv Res 2008;8:278.

17. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56.

18. van Lummel RC, Walgaard S, Pijnappels M, Elders PJ, Garcia-Aymerich J, van Dieen JH, et al. Physical Performance and Physical Activity in Older Adults: Associated but Separate Domains of Physical Function in Old Age. PLoS One 2015;10(12):e0144048.

19. Lee PH, Lee YS, Chan DC. Interventions targeting geriatric frailty: A systemic review. J Clin Gerontol Geriatr 2012;3(2):47-52.

20. American College of Sports Medicine, Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, Skinner JS. American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 2009;41(7):1510-30.

21. Jadczak AD, Makwana N, Luscombe-Marsh ND, Visvanathan R, Schultz TJ. Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol. JBI Database System Rev Implement Rep 2016;14(9):93-102.

22. Bouillon K, Kivimaki M, Hamer M, Sabia S, Fransson EI, Singh-Manoux A, et al. Measures of frailty in population-based studies: an overview. BMC Geriatr 2013;13:64.

23. Steverink N, Slaets J, Schuurmans H, M VL. Measuring frailty: developing and testing of the Groningen Frailty Indicator (GFI). Gerontologist 2001;41(1):236-7.

24. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficits as a proxy measure of aging. ScientificWorldJournal 2001;1:323-36.

25. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173(5):489-95.

26. Kanauchi M, Kubo A, Kanauchi K, Saito Y. Frailty, health-related quality of life and mental well-being in older adults with cardiometabolic risk factors. Int J Clin Pract 2008;62(9):1447-51.

27. Gobbens RJ, van Assen MA, Luijkx KG, Wijnen-Sponselee MT, Schols JM. The Tilburg Frailty Indicator: psychometric properties. J Am Med Dir Assoc. 2010;11(5):344-55.

28. Gill TM, Baker DI, Gottschalk M, Peduzzi PN, Allore H, Byers A. A program to prevent functional decline in physically frail, elderly persons who live at home. N Engl J Med 2002;347(14):1068-74.

29. Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. Age Ageing 2006;35(5):526-9.

30. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Cawthon PM, Stone KL, et al. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Arch Intern Med 2008;168(4):382-9.

31. Sanford AM, Orrell M, Tolson D, Abbatecola AM, Arai H, Bauer JM, et al. An international definition for "nursing home". J Am Med Dir Assoc 2015;16(3):181-4.

32. The Joanna Briggs Institute, Joanna Briggs Reviewers' Manual 2014: Methodology for JBI Umbrella Reviews. In: The Joanna Briggs Institute. Adelaide 2014.

33. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. Int J Surg 2010;8(5):336-41.

34. Taylor D. Physical activity is medicine for older adults. Postgrad Med J 2014;90(1059):26-32.

35. Bray NW, Smart RR, Jakobi JM, Jones GR. Exercise prescription to reverse frailty. Appl Physiol Nutr Metab 2016;41(10):1112-6.

36. Cadore EL, Rodriguez-Manas L, Sinclair A, Izquierdo M. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. Rejuvenation Res 2013;16(2):105-14.

37. Schoene D, Wu SM, Mikolaizak AS, Menant JC, Smith ST, Delbaere K, et al. Discriminative ability and predictive validity of the timed up and go test in identifying older people who fall: systematic review and meta-analysis. J Am Geriatr Soc 2013;61(2):202-8.

38. Finger D, Goltz FR, Umpierre D, Meyer E, Rosa LH, Schneider CD. Effects of protein supplementation in older adults undergoing resistance training: a systematic review and meta-analysis. Sports Med 2015;45(2):245-55.

39. Björkman MP, Finne-Soveri H, Tilvis RS. Whey protein supplementation in nursing home residents. A randomized controlled trial. Eur Geriatr Med 2012;3(3):161-6.

40. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2012;13(8):713-9.

41. Rosendahl E, Lindelof N, Littbrand H, Yifter-Lindgren E, Lundin-Olsson L, Haglin L, et al. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: a randomised controlled trial. Aust J Physiother 2006;52(2):105-13.

42. Liu CK, Fielding RA. Exercise as an intervention for frailty. Clin Geriatr Med 2011;27(1):101-10.

43. Ehsani AA, Spina RJ, Peterson LR, Rinder MR, Glover KL, Villareal DT, et al. Attenuation of cardiovascular adaptations to exercise in frail octogenarians. J Appl Physiol (1985) 2003;95(5):1781-8.

44. Seynnes O, Fiatarone Singh MA, Hue O, Pras P, Legros P, Bernard PL. Physiological and functional responses to low-moderate versus high-intensity progressive resistance training in frail elders. J Gerontol A Biol Sci Med Sci 2004;59(5):503-9.

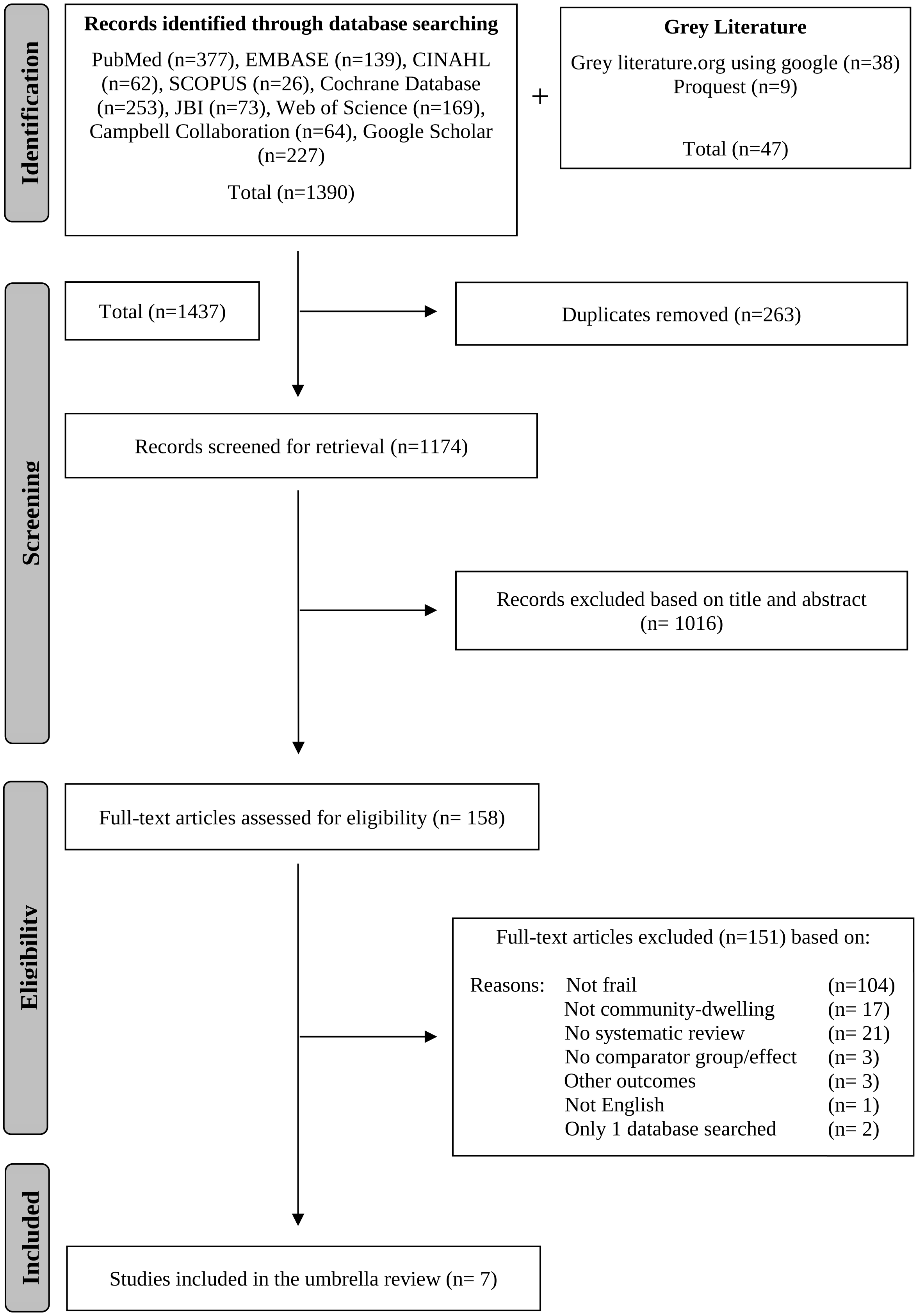


Figure 3.1: PRISMA flow chart[33]

Table 3.1: Assessment of methodological quality

Systematic Review	1	2	3	4	5	6	7	8	9	10	11	N	%	Quality
Chin 2008[14]	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	8/11	72.7	High
Clegg 2012[13]	Y	Y	Y	Y	Y	N	Y	Y	U	Y	Y	9/11	81.8	High
Cruz-Jentoft 2014[15]	N	Y	Y	Y	Y	U	U	N	N	Y	Y	6/11	54.5	Medium
Daniels 2008[16]	Y	Y	Y	Y	Y	Y	Y	Y	U	U	Y	9/11	81.8	High
De Labra 2015[12]	Y	Y	Y	Y	Y	Y	U	Y	N	U	Y	8/11	72.7	High
De Vries 2012[11]	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	9/11	81.8	High
Theou 2011[10]	N	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	9/11	81.8	High

Y – criteria met **N – criteria not met** **U- unclear**
0-33% low quality **34-66% medium quality** **≥67% high quality**

Table 3.2: Effects on physical function parameters

Outcome **Intervention**	**Muscle Strength**	**Gait Speed**	**Mobility**	**Balance**	**Physical Performance**
MCT*	5 trials (n=548) ↑ 2 trials (n=192) - ✓	7 trials (n=887) ↑ 3 trials (n=376) - ✓	9 trials (n=1205) ↑ 10 trials (n=1482) – X	8 trials (n=1102) ↑ 1 trial (n=61) – ✓	16 trials (n=2370) ↑ 1 trial (n=61) - ✓
Resistance Training	5 trials (n=311) ↑ 1 trial (n=86) - ✓	3 trials (n=363) ↑ ✓	7 trials (n=391) ↑ 4 trials (n=602) – X	1 trial (n=72) ↑ 2 trials (n=329) - X	4 trials (n=436) ↑ 1 trial (n=21) - ✓
Balance Training			1 trial (n=73) - X		1 trial (n=73) ↑ ✓
Grand Stand™			1 trial (n=68) - X		1 trial (n=68) – X
Personalised Training			3 trials (n=847) ↑ ✓		1 trial (n=188) ↑ 1 trial (n=486) - X
Horse Riding Simulator			1 trial (n=21) – X		
RT + Protein	1 trial n=62 – X				1 trial (n=62) – X
MCT + Nutr	1 trial n=96↑ ✓				

***MCT: Multi-component training including resistance, aerobic, balance and flexibility exercises**
RT: Resistance training Nutr: Nutrition ✓ : Overall increase X : Overall no effect ↑: Effect -: No effect
The overall decision whether an intervention is effective or not was based on the total number of participants across the trials

Table 3.3: Data extraction of included systematic reviews

Systematic Review	Studies	Participants	Intervention	Characteristics	Outcomes	Findings/Effects
Chin et al.[14]	8 out of 20 trials	956 out of 2515 Mean age 80.5 Community & Frail	6 x MCT 2 x RT	2.5-9 months 2-3 x weekly 45-90mins per session Intensity low-high	Gait Mobility Balance PP	MCT: ↑ gait, PP, 1x NE RT: ↑ gait
Clegg et al.[13]	5 out of 6 trials	799 out of 987 Mean Age 82.8 Community & Frail	2 x MCT 1 x RT 1 x RT & Motion 1 x GrandStand™	1.5–18 months 3-7 x weekly Intensity not stated	Strength Gait Mobility Balance	MCT: ↑ balance, mobility, 1x NE RT: ↑ strength RT & Motion: ↑ mobility GrandStand™: NE
Cruz-Jentoft et al.[15]	3 out of 19 trials	249 out of 1453 Mean Age 81.0 Community & Frail	1 x RT 1 x RT & Protein 1 x MCT & NUTR	3–9 months Frequency not stated Intensity not stated	Strength PP	RT: ↑ strength RT & Protein: NE MCT & NUTR: ↑ strength
Daniels et al.[16]	7 out of 10 trials	837 out of 1191 Mean Age 80.0 Community & Frail	4 x MCT 2 x RT 1 x EX & NUTR	2.5–18 months 2-3 x weekly 45-75mins per session Intensity not stated	Strength Gait Mobility Balance PP & FC	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, balance, PP EX & NUTR: ↑ FC
De Labra et al.[12]	5 out of 9 trials	562 out of 1067 Mean Age 80.6 Community & Frail	4 x MCT 1 x RT	2.5–12 months 2–5 x weekly 20–90mins per session 30–80% 1RM	Strength Mobility Balance	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, gait, mobility
De Vries et al.[11]	18 out of 18 trials	2580 out of 2580 Age range 60-85 Community & Frail	9 x MCT 4 x RT 1 x Balance 1 x GrandStand™ 3 x Personalised	1.25–18 months 1-7 x weekly 10-90mins per session Intensity low vs high	Gait Mobility PP	MCT: ↑ gait, mobility, PP RT: ↑ mobility, PP Balance: ↑ PP GrandStand™: NE Personalised: ↑ mobility, PP
Theou et al.[10]	13 out of 75 trials	1010 out of 4915 Mean Age 80.3 Community & Frail	8 x MCT 4 x RT 1 x Horse Simulator	2.5–18 months 2-3 x weekly 10-60mins per session 6-8 on 10-point scale 60–80% & 85-100% 1RM	Gait Mobility Balance PP	MCT: ↑ gait, balance, mobility, PP RT: ↑ mobility, PP Horse Simulator: NE

MCT: Multi-component training; RT: Resistance training; EX: Exercise; NUTR: Nutrition; PP: Physical performance; FC: Functional capacity; NE: No effects; ↑: Increase

3.9 Appendix I: Search strategies

PubMed (pubmed.gov)

Search on 02/09/2016

Search	Query
#1	Aged [MH] OR Elder* [all] OR Older [all]
#2	Frail* [all] OR Functionally Impair* [all]
#3	systematic[sb] OR review[pt]
#4	Exercise [MH] OR Exercis* [all] OR Physical Activity
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

EMBASE

Search	Query
#1	Aged/syn OR Elder* OR Older
#2	Frail* OR ‘Functionally impaired’ OR ‘functional impairment’ OR ‘functional impairments’
#3	‘systematic review’/SYN OR ‘meta analysis’/SYN
#4	Exercise/SYN OR ‘Physical Activity’
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

CINAHL

Search	Query
#1	(MH "Frail Elderly") OR (MH "Aged") OR TI Aged OR AB Aged OR TI Elder* OR AB Elder*OR TI Older OR AB Older
#2	TI Frail* OR AB Frail* OR TI Functional* OR AB Functional*
#3	(MH "Systematic Review") OR (MH "Meta Analysis") ORTI “systematic review*” OR TI “meta analysis” OR TI metaanalysis OR AB “systematic review*” OR AB “meta analysis” OR AB metaanalysis
#4	TI Exercis* OR TI “Physical Activity” OR AB “Physical Activity”
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Scopus

Search	Query
#1	Aged OR Elder* OR Older
#2	Frail* OR Functionally Impair*
#3	“systematic review*” OR “meta analysis” OR metaanalysis
#4	Exercis* OR “Physical activity”
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Cochrane Database of Systematic Reviews, JBI Database of Systematic Reviews and Implementation Reports, Web of Sciences, Campbell Collaboration Library of Systematic Reviews

Search	Query
#1	Aged OR Elder* OR Older
#2	Frail* OR Functionally Impair*
#3	systematic review OR meta analysis OR metaanalysis
#4	Exercis* OR Physical activity
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Google Scholar and Grey Literature

Search	Query
#1	Older Exercise Physical Activity Review (with all of the words)
#2	aged OR elder OR frail OR functional impairment OR systematic review OR meta analysis OR metanalysis OR Exercise Physical Activity (with at least one of these words)
#3	#1 AND #2
Limited to 1990 and English language	

ProQuest Dissertations and Theses

Search	Query
#1	Aged OR Elder OR Older
#2	Frail OR Functionally Impair*
#3	systematic review OR meta analysis
#4	Exercise OR Physical activity
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Appendix II: Verification of review eligibility

VERIFICATION OF REVIEW ELIGIBILITY - INCLUSION CRITERIA

AUTHOR AND YEAR	
JOURNAL	
TITLE	
NAME/CODE OF REVIEWER	
Design: The article is/contains a systematic review with or without meta-analysis Yes	
Review Type: For effectiveness reviews, a comparator group is utilised Yes	
Participants: Participants of interested are older people aged 60 years and over, identified as pre-frail, frail or at-risk of frailty in title, abstract or text and living in the community	 Yes Yes Yes
Interventions: Interventions of interest are exercise interventions, alone or combined with other interventions Yes	
Outcomes: Outcomes of interest are: muscular strength, gait ability including gait speed and gait performance, balance and mobility Yes	
IF YOU HAVE NOT ANSWERED YES TO ALL OF THE ABOVE QUESTIONS, YOU SHOULD EXCLUDE THE STUDY. IF YOU ANSWERED YES TO ALL, PLEASE CONTINUE.	

Appendix III: Details of Included Reviews

	1. Chin et al.[14]	2. Clegg et al.[13]
Databases searched	PubMed, EMBASE, CENTRAL	Medline, AMED, CINAHL, The Cochrane Library, EMBASE, PSYCHINFO, PEDro
Range of included studies	2000-2005	1995-2007
Total number of studies/total relevant	20 trials / 8 trials	6 trials / 5 trials
Total number of participants/total relevant	2515 / 956 Female 62.2%	987 / 799 Female 75.5%
Heterogeneity$	Not calculated	Not calculated
Setting	Community-dwelling	Community-dwelling
Age	Mean age 80.5 years	Mean age 82.8 years
Intervention	6 x Multi-component (MCT) 2 x Resistance (RT)	2 x Multi-component (MCT) 1 x Resistance (RT) 1 x Strength & motion 1 x GrandStand™
Characteristics	Frequency 2-3 x weekly of 45-90 mins Duration 2.5–9 months Intensity 1x low intensity 2x moderate intensity 1x high intensity 4x Intensity not stated	Frequency 3-7 x weekly Duration 6 weeks–18 months Intensity not stated
Intervention setting	2 x Home-based 3 x Centre-based 1 x Centre & home-based 2 x Not stated	Home-based
Control	3 x Home-based exercise 4 x Exercise - no setting stated 1 x Usual care	Not stated
Outcomes	Gait Mobility (TUG & Chair rise/stand) Balance (BBS & other tests) Physical Performance (PP)	Strength Gait Mobility Balance
Effect size	MCT: ↑ gait, PP, 1x no effect RT: ↑ gait	MCT: ↑ balance, mobility, 1x NE RT: ↑ strength RT & Motion: ↑ mobility GrandStand™ no effect
Type of studies	RCTs	RCTs
Analyses	Narrative synthesis	Narrative synthesis
Confidence intervals	Not calculated	Not calculated
P value	Not calculated	Not calculated
Follow-up	10 weeks–9 months	Not stated

	3. Cruz-Jentoft et al.[15]	4. Daniels et al.[16]
Databases searched	PubMed, Dialogue	PubMed, CENTRAL, CINAHL
Range of included studies	2005 – 2012	1998 – 2005
Total number of studies/total relevant	19 trials / 3 trials	10 trials / 7 trials
Total number of participants/total relevant	1453 / 249 Female 62.7%	1191 / 837 Female: No information provided
Heterogeneity[$]	Not calculated	Not calculated
Setting	Community-dwelling	Community-dwelling
Age	Mean age 81 years 1 trial > 75 years	Mean age 80.0 years
Intervention	1 x Resistance (RT) 1 x Resistance + protein 1 x Multi-component + nutrition	4 x Multi-component (MCT) 2 x Resistance (RT) 1 x Exercise + nutrition (fruit + diary product)
Characteristics	Frequency not stated Duration 3–9 months Intensity 3 x not stated	Frequency 2-3 x weekly of 45-75 mins Duration 2.5–18 months Intensity not stated
Intervention setting	Not stated	1 x Home-based 4 x Home & centre-based supervised 2 x Centre-based
Control	1 x Home based low intensity 1 x No intervention 1 x Not stated	4 x No intervention 3 x Usual care
Outcomes	Strength Physical Performance (PP)	Strength Gait Mobility Balance Physical Performance (PP) Functional/aerobic capacity (FC)
Effect size	RT: ↑ strength RT & Protein: no effect MCT & NUTR: ↑ strength	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, balance, PP EX & NUTR: ↑ FC
Type of studies	RCTs	RCTs
Analyses	Narrative synthesis	Narrative synthesis
Confidence intervals	Not calculated	Not calculated
P value	> 0.05 in 2 trials	Not calculated
Follow-up	Not stated	2.5 -18 months

	5. De Labra et al.[12]	6. De Vries et al.[11]
Databases searched	PubMed, Web of Science, The Cochrane Library	PubMed, CINAHL, EMBASE, PEDro, The Cochrane Library
Range of included studies	2005 – 2015	1998 – 2010
Total number of studies/total relevant	9 trials / 5 trials	18 trials / 18 trials
Total number of participants/total relevant	1067 / 562 Female 75.3%	2580 / 2580 Female: No information provided
Heterogeneity[$]	Not calculated	Mobility exercise vs non I^2 9% Mobility intensity/duration I^2 0% PP exercise vs non I^2 27% PP intensity: I^2 67% dura: I^2 83%
Setting	Community-dwelling	Community-dwelling
Age	Mean age 80.6 years	Age range: 60-85 years
Intervention	4 x Multi-component (MCT) 1 x Resistance (RT)	9 x Multi-component (MCT) 4 x Resistance (RT) 1 x Balance 3 x Personalised/not stated 1 x GrandStand™
Characteristics	Frequency 2-5 x weekly of 20-90mins Duration 2.5-12 months Intensity 30-80% 1RM	Frequency 1-7x weekly of 10--90mins Duration 5 weeks–18 months Intensity: low vs high without definition
Intervention setting	1 x Home-based 4 x Not stated	2 x Centre-based 5 x Home-based 2 x Home & centre-based supervised 4 x Centre vs home 5 x Not stated
Control	Not stated	10 x No intervention 4 x Home-based; 4 x Not stated
Outcomes	Strength Mobility Balance & Physical Performance (PP)	Gait Mobility Physical Performance (PP)
Effect size	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, gait, mobility Small to very small effect size	Mobility EX vs no EX: SMD: 0.18 Intensity SMD: -0.05 Duration SMD -0.09 short duration SMD 0.00 long duration PP EX vs no EX: SMD: 2.93 Intensity SMD: 0.22 Duration SMD 0.13/0.38 short SMD 0.26 long
Type of studies	RCTs	RCTs
Analyses	Narrative Synthesis	Meta-analysis + Narrative synthesis
Confidence intervals	Not calculated	Mobility EX vs no EX: CI: 0.05-0.30 Intensity CI: -0.25 – 0.15 Duration: CI:-0.35 – 0.18 short CI: -0.32 – 0.32 long PP EX vs no EX: CI:2.50 – 3.36 Intensity: CI:-0.17 – 0.62 Duration: CI:-0.34 – 0.61 short CI: -0.48 – 1.25 short CI: -0.35-0.87 long
P value	Not calculated	Not calculated
Follow-up	2.5 - 12 months	5 weeks -18 months

	7. Theou et al.[10]
Databases searched	Medline, EMBASE, PSYCHINFO, CINAHL, Scopus, AgeLine, ERIC, SPORTDiscus
Range of included studies	1998 – 2008
Total number of studies/total relevant	75 trials / 13 trials
Total number of participants/total relevant	4915 / 1010 Female 70.0%
Heterogeneity$	Not calculated
Setting	Community-dwelling
Age	Mean age 80.3 years
Intervention	8 x Multi-component (MCT) 4 x Resistance (RT) 1 x Horse riding simulator
Characteristics	Frequency 2-3 x weekly 10-60mins Duration 10 weeks – 36 weeks Intensity 1 trail: 6-8 on 10-point scale 2 trials: 3 x 8-12 repetitions at 85-100% 1RM 1 trial: 60 – 80% 1RM
Intervention setting	2 x Home-based 3 x Centre-based supervised 8 x Not stated
Control	Not stated
Outcomes	Gait Mobility Balance Physical Performance (PP)
Effect size	Not stated for community-dwelling separately MCT: ↑ gait, balance, mobility, PP RT: ↑ mobility, PP Horse Simulator: no effect
Type of studies	RCTs
Analyses	Narrative synthesis
Confidence intervals	Not calculated
P value	Not calculated
Follow-up	Not stated

Chapter 4

The Perspectives of Pre-frail and Frail Older People on Being Advised About Exercise: A Qualitative Study

Summary

Encouraging frail older people to take up exercise is crucial in the management of frailty. However, research specifically investigating frail older people's experiences of being advised about exercise and their opinions regarding who should advise them, and where, is sparse. The study aimed to explore pre-frail and frail older peoples' perspectives in relation to being advised about exercise and their perceptions of the GP's role in promoting exercise for older people.

Semi-structured interviews were conducted with 12 community-dwelling older (median age 83 years) participants screened pre-frail or frail using the FRAIL Screen. Their attitudes towards exercise, the advice received, their access to relevant information and their perceptions of the GP's role in promoting exercise were explored. Thematic analysis was used to analyse data.

The majority of participants had a positive attitude towards exercise and many participants indicated a preference for being advised firstly by their GP and then other health care professionals. Participants living in the community reported difficulties in accessing information on exercise and indicated that local governments and GP practices should promote exercise for older people more actively. Participants living in retirement villages, however, reported having access to relevant information and being encouraged to participate in exercise.

This research identified a gap in current practice, demonstrating that GPs, health care providers, and local governments should promote exercise for older people more actively. Convincing health professionals to encourage regular exercise among their older patients would provide an opportunity to avoid and manage frailty in this population.

This research has formed the basis of a research paper peer-reviewed and published in the Journal Family Practice (Appendix 3 including Statement of Authorship).

4.1. Background

Exercise is considered to be the most effective strategy for the prevention, treatment and postponement of frailty, a prevalent geriatric syndrome observed in clinical practice[1]. Frailty is defined as a "clinically recognisable state of increased vulnerability resulting from age-associated decline in reserve and function"[2]. It includes clinical indicators, such as deficit accumulation, fatigue, sedentary behaviour, weight loss, and physical function impairment[2,3], and is associated with increased hospitalisations, disability, loss of independence, and reduced quality of life[4,5].

One of the most commonly used frameworks of frailty is the frailty phenotype by Fried *et al.* (2001)[6] which uses a physiological approach to categorise adults into robust (0 indicators), pre-frail (1-2 indicators) and frail (≥3 indicators) based on the accumulation of the following five physical conditions: unintentional weight loss, exhaustion, slow walking speed, weakness and low physical activity. The prevalence of frailty is reported to be 10.7% in community-dwelling older people and it is estimated that by 2050, four million Australians will be either pre-frail or frail[7].

Frailty is a dynamic syndrome that is treatable and reversible[8], and a critical component in its treatment is exercise[1]. Exercise helps to increase and restore muscle strength and improve overall physical function. Greater strength and mobility allow for greater independence and an enhanced quality of life[1,8,9]. Promoting physical activity programs for community-dwelling pre-frail and frail older adults and generally encouraging older people to take up exercise are critical in managing frailty[10,11].

Although the benefits of exercise are well known, the uptake of exercise in older people is poor[12,13]. Barriers to exercise amongst older people include health issues (e.g. pain), environmental factors (e.g. lack of transportation), lack of knowledge, and the lack of physician advice[14].

Costello *et al.* (2013) conducted focus groups with 31 independent-living, non-frail older adults and confirmed that general practitioners (GPs) play an important role in promoting exercise for older people. However, older adults perceived their exercise conversations with their GP as inadequate, and it was suggested that health care providers, including GPs, should take collective responsibility for encouraging older people to take up exercise[15].

In regards to the frail population, Broderick *et al.* (2015) investigated the perceptions of 29 frail older adults in order to determine their exercise motivation and behaviour. The study results indicate that family members and social support networks involving friends and peers are critical motivators of exercise activity among frail older people. However, social support networks decline as frailty increases, and family members may not only motivate, but also limit frail older people in their physical activities in an effort to protect them[16].

Research specifically investigating frail older people's experiences of being advised about exercise and their opinions regarding who should advise them, and where, is sparse. By better understanding frail older people's preferred source of exercise advice, researchers can ensure that community-based education and awareness programs are not only appropriately composed, but that the information is made available through the most appropriate sources. The aims of this study were to (1) understand the perspectives of community-dwelling older people who are pre-frail or frail in relation to being advised about exercise and to (2) explore their experiences in regards to any advice provided by their GP.

4.2. Methods

4.2.1. Participants and Procedures

Participants were recruited from The Queen Elizabeth Hospital (TQEH), the Queen Elizabeth Specialist Centre (QE Specialist Centre) and the Geriatrics Training and Research with Aged Care Centre (G-TRAC Centre) in Adelaide, South Australia, Australia. Potential participants were asked by their TQEH geriatricians (affiliated with the researchers' department) during a scheduled consult if they were interested in participating in this study. Interested individuals were then referred to a researcher (ADJ) who provided more information about the study, confirmed interest and performed initial eligibility screening on-site following the consult, or over the phone before enrolling them into the study and scheduling an interview.

Participants aged 75 years and older, living in the community and screened pre-frail or frail using the FRAIL Screen[17] were included in this study. The FRAIL Screen represents the Fried frailty phenotype[6] and includes five questions about fatigue, resistance, ambulation, illness, and weight loss. It categorises individuals into pre-frail (1-2 deficits), frail (≥3 deficits) or robust (0 deficits). Participants with a medical history of dementia or who were unable to communicate in English were excluded from the study.

4.2.2. Interviews and Study Questionnaires

Semi-structured interviews were held at the Basil Hetzel Institute, an adjacent research centre of TQEH, the G-TRAC Centre, or at the participant's home, depending on the participant's preference. ADJ conducted face-to-face interviews with all participants, each lasting approximately one hour. The interviews included 16 semi-structured questions asking about participants' previous exercise experiences, their perspectives on receiving advice on exercise, their access to relevant information and their experiences with their GPs. The interviews were audio recorded and transcribed. The transcript of the first interview was reviewed by a member of the research team (JD) to assess ADJ's interview technique for gathering quality data. Participants' five-year mortality risk was determined using the Charlson Comorbidity Index[18], and current physical activity levels were assessed using the Physical Activity Level in the Elderly (PASE) questionnaire[19]. Demographic information, recorded in a separate questionnaire, included age, gender, nationality, education, income level and participation in regular exercise.

4.2.3. Data Analysis

Participants' characteristics and demographic information were analysed using descriptive statistic methods. The interviews were analysed using thematic analysis[20]. ADJ transcribed the audio recorded interviews, reread the transcripts to ensure familiarity and coded the transcripts line by line using an inductive approach[21]. Codes were then collated and categorised into potential themes, gathering all data relevant to each theme before refining the themes and generating clear definitions for each specific theme. The coding framework, the codes and themes were then discussed with a member of the research team (JD) and a scholarly report of the analysis was prepared[20]. *NVivo* Version 10 software was used to manage data analysis. Quotations are provided in this paper to support the themes. Data saturation was reached when there was enough information to replicate the study and new information were not obtained by interviewing additional participants[22].

4.3. Results

4.3.1. Participants' Characteristics

Seventeen potential participants were referred to ADJ and screened for eligibility. Three decided not to participate, another felt too unwell and another was neither pre-frail nor frail according to the FRAIL Screen[17]. The selected participants provided written informed consent and were advised that participation was voluntary.

Twelve participants (eight female and four male) were interviewed. By the 9th interview, data saturation was reached as it was noted that participants' responses to the interview questions were repetitive. Recruitment was therefore ceased after the 12th interview. The median age of the participants was 83 years with a range of 76 to 91 years. Ten participants were pre-frail and two participants were frail. The most common deficits on the FRAIL

Screen included feeling fatigued (n=6) and currently having more than five illnesses simultaneously (n=5). Eleven participants had a low five-year mortality risk according to the Charlson Comorbidity Index. Six participants reached the current physical activity recommendations for older people according to the PASE questionnaire, considering their age and gender. Demographic data revealed a lower income and a prevalence of men in the non-active group. However, there were no differences in age, education, frailty status, and five-year mortality risk between active and non-active participants (Table 4.1).

4.3.2. Themes

Four themes emerged from the data (Figure 4.1): older peoples' attitudes towards exercise; their difficulties in accessing information on exercise; the crucial role of GPs and health care professionals in promoting exercise; and the missing or limited advice on exercise provided by GPs.

4.3.3. Attitudes, Barriers and Enablers of Exercise

The majority of participants (10 out of 12) reported a positive attitude towards exercise and physical activity programs, commenting on the importance of exercise and its benefits in older age, irrespective of their physical activity status (PASE). Being physically active in the past did not correlate with participants' attitudes towards exercise reported during the interviews.

Participants perceived multiple barriers to participation in exercise. These included family commitments (especially for women whose role as carer may override self-care, hobbies or other activities), physical limitations (pain and illness), transportation and seasonal climate (cold weather and darkness common during winter months in South Australia).

> *We just couldn't cope with the cold and both of us stopped exercising and got stuck inside. (#10)*

Enablers for exercise included exercising with their partner, social aspects, and rehabilitation or health care services, such as physiotherapy after hip replacement, where participants recognised the benefits of exercise in form of improvements in physical function and mobility.

> *I was in hospital (hip operation) and then I went to rehabilitation. I had physiotherapy there every day. I really should have started those exercises straight away. (#4)*

In regards to enjoyable and preferred aspects of physical activity programs, participants reported a preference for smaller classes with a variety of gentle, but challenging and beneficial, exercises tailored for their individual health, including strength and balance tasks. Half of the participants (6 out of 12) were engaged in regular exercise, participating in a structured exercise program.

4.3.4. Access to Information on Exercise and Physical Activity Programs

Both active and non-active participants living in the community felt that information relating to opportunities for exercise in the community was insufficient. They suggested that the local government should be more engaged in promoting physical activity programs for older people.

> *The government should send out brochures to older people. They should get something in every suburb, like through the council. (#8)*
>
> *I don't see any advertisement (for exercise or physical activity programs) [...] and I have been to the local library and places like that [...], but I've never seen something […]. I just don't know where to get information. (#6)*

All participants living in retirement villages (3 out of 12) revealed that they had greater access to exercise information and physical activity programs due to the services provided in their villages.

> *Before I came here (retirement village) I had no idea where to go, I had no idea that people even went to exercise classes; you've never heard of it. (#12)*

The majority of participants (9 out of 12) preferred brochures with information, including the health benefits of exercise in older age and available physical activity programs in the community. They also commented on their preference for personal advice from someone with a positive attitude.

4.3.5. Role of GPs and Health Care Professionals in Promoting Exercise

Health care professionals appear to play a key role in the promotion of exercise for older people, especially when patients receive health care services like physiotherapy or rehabilitation. Five participants reported that they received information on exercise opportunities during these services, and four of these participants continued with exercise after completing their treatment.

> *I had physiotherapy [...] and he gave me some exercises […] which I still do. And they (rehabilitation centre) said there are also other exercise classes you can get involved if you like. (#8)*

However, half of the participants (6 out of 12) indicated a preference for being advised on exercise initially by their GPs as they see them regularly, and the GP is aware of their medical conditions, and is the primary referrer to health care services.

> *Initially the doctor as he knows in what condition you are and what you are able to do. (#5)*
>
> *At first point I would have thought […], it is our GP. Older people go to see their physicians naturally. So it is first the GP. (#10)*

Family members were also reported to have significant influence.

> *My daughter, she was the one that encouraged me to go to Pilates. (#4)*

Three participants did not nominate a particular individual as the most important adviser, instead, stating that 'someone who knows about it' should advise them about exercise, two participants stated that health care professionals should advise initially, and one participant did not answer the question. Active participants did not differ from non-active participants in their opinions as to who should advise them on exercise.

4.3.6. Advice on Exercise Provided by GPs

Even though participants perceived that GPs play a key role in promoting exercise for older people, the majority of participants (11 out of 12; both active and non-active) reported no (n=6) or only limited (n=5) recollection of exercise advice being provided during consults. Advice was defined as limited if the GP suggested walking without giving detailed information on the frequency, duration or intensity, or did not refer the individual to health care professionals or available physical activity programs.

However, participants consistently expressed faith in their GPs and said that they would appreciate and follow their advice on exercise.

> *I would do it (exercise) if my GP would say it. (#1)*
>
> *When the GP would say do this or this (exercises), yes, I would dare it. (#5)*

Participants also suggested that GPs should promote exercise and physical activity programs more actively.

> *If the doctor would have something to hand to you. A notice of who to see and what you could do (#5).*

One participant received information from their GP after taking the initiative and asking about available physical activity programs.

> *I want to go to an exercise class, do you know any where? And he said, yes I do, you are going to need my referral […]. They are very good, they have classes for falls and balance and all that kind of stuff, and strength. So I went down there for quite a few years. (#12)*

4.4. Discussion

Three key findings emerged from this study. Firstly, data analysis indicated that pre-frail and frail older people had mostly positive attitudes towards exercise, irrespective of their current physical activity status. Secondly, half of the participants indicated a preference for being advised on exercise initially by their GP, but only one participant could recollect getting advice. Thirdly, participants received information on exercise and available physical activity programs mainly through allied health care services (i.e. physiotherapy, rehabilitation) and their retirement villages while participants living outside of retirement villages or those not receiving any allied health services reported a lack of exposure to exercise and available physical activity programs. The important role of retirement villages in successfully encouraging physical activity among older adults emerged as an unexpected finding.

The mostly positive attitudes towards exercise amongst the pre-frail and frail older adults reported in this study are consistent with findings in other studies showing that older adults hold positive attitudes towards exercise[23-25]. However, findings that report negative attitudes towards exercise amongst inactive older adults were not supported by this study as most of the inactive participants also reported positive attitudes[24-26]. These findings might be due to participants who have a more positive attitude being more likely to consent to an interview about exercise. This bias has been reported previously, for example by Rich & Rogers (2001), who used a survey to examine older adults' attitudes towards exercise and mainly received responses from adults who were likely to exercise[25]. However, the positive attitudes of non-exercisers provide an opportunity to coax more pre-frail and frail older people into physical activity.

Attitudes towards GPs confirmed the results of other studies that have noted that older adults are more likely to accept health advice from GPs compared to any other age group[27]. Older adults tend to be in regular contact with their GPs, who are not only aware of their medical conditions and limitations, but also the primary referrers to health care services[13-15]. The fact that half of the participants indicated a preference for being advised about exercise firstly by their GP underlines the important role that GPs play. GPs should capitalise on older people's positive attitudes towards exercise and their readiness to follow their advice by promoting exercise and available physical activity programs more actively, especially amongst those who do not receive any therapy services. A shared-decision making mode' where GPs collaborate with patients on treatment options and exercise strategies should be the ultimate goal rather than being paternalistic by merely telling patients what to do[28].

However, exercise advice provided by physicians is reported to be rare[29] and not specific[9], which aligns with the findings of this study where only one participant recollected receiving adequate information on exercise and being referred to an exercise program. It is suggested that specific advice, including the type, frequency, intensity and duration of exercise, can lead to a greater increase in physical activity amongst older people than general advice with no specifics on where to go and what to do[30].

Education and awareness programs tailored to GPs could be introduced to inform and encourage them to advise their older patients about available physical activity programs or to refer patients to allied health care experts more frequently, as a lack of knowledge is reported to be the main reason GPs do not advise their patients about exercise[31]. The Enhanced Primary Care Program (currently active in Australia), for example, allows supported referrals to exercise physiologists and represents a unique opportunity to tackle frailty.

Difficulty in accessing information on exercise for older people has been reported previously, as well as the need for health care providers and local communities to promote exercise for older people more actively[32]. This study underlines this need and has identified clearly the difficulty in accessing information related to exercise and available physical activity programs for community-dwelling pre-frail and frail older people living outside of retirement villages.

Data from this study revealed that retirement villages and their associated services appear more successful in promoting exercise, as all of the participants in this study who were living in a retirement village received information on exercise and available physical activity programs. There might be a health promotion strategy to be learnt from the retirement villages which local governments could use to integrate pre-frail and frail older people into community-based physical activity programs. Furthermore, since brochures related to exercise and physical activity programs were recorded as being the most popular source of information by participants in this study, local communities could strategically send out brochures to their older residents to promote available physical activity programs and encourage participation.

Health care services also play a crucial role in encouraging older people to take up exercise as evidenced by the comments from participants in this study. These tertiary services provided information about available physical activity programs, and the majority (four out of five participants) continued with exercise after treatment. Health care services, like physiotherapy, could therefore be seen as an opportunity to introduce pre-frail and frail older people to physical activity programs, as it has been reported before that rehabilitation or exercise programs in a recovery setting impact positively on older people's exercise beliefs[16].

4.4.1. Limitations and Future Studies

Recruiting community-dwelling frail older people to the study at the time of a geriatric consultation proved difficult due to the presence of severe medical conditions resulting in participants feeling too fatigued to be interviewed and declined to participate. This resulted in the recruitment of mostly pre-frail older adults, with the majority (nine out of twelve) scoring only one deficit on the FRAIL Screen. The fact that participants were recruited from geriatric clinics only, were mostly pre-frail, English speaking and had an average level of education, limits the generalisability of the study results. Including more frail older adults with different cultural and educational backgrounds may have led to more diverse opinions in relation to exercise and being advised about exercise. Regarding sample size and data saturation, the sample size of qualitative studies depends more on the data in terms of richness and thickness rather than on sample size[22]. Twelve participants were sufficient as data saturation was reached after interviewing the 9th participant. Further, half of the participants were active (PASE), despite being pre-frail or frail suggesting that additional tools are required to identify pre-frail and frail older adults.

The fact that our recruitment method was successful in recruiting pre-frail but not frail participants requires reflection and future studies should allow more time and resources for recruitment, target more frail individuals (with scores of ≥2 on the FRAIL Screen), and explore why GPs are reluctant to give advice or refer patients to exercise programs.

4.5. Conclusion

The results of this study suggest that GPs should capitalise on older people's positive attitudes towards exercise and their readiness to follow the GP's advice by promoting exercise and available physical activity programs more actively. Additionally, tertiary health care services, like rehabilitation and therapy services, should also be seen as an opportunity where pre-frail and frail older people could be linked long-term into exercise programs. Retirement villages with health promotion strategies are a resource from which the wider community can learn. Further research into health promotion strategies used in retirement villages would be of interest as well as to explore why GPs are reluctant to give advice or refer patients to exercise programmes. The findings suggest that to facilitate exercise in pre-frail and frail older people further effort to inform and promote exercise is vital.

4.6. References

1. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381(9868):752-62.
2. Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27(1):1-15.
3. Cesari M, Landi F, Vellas B, Bernabei R, Marzetti E. Sarcopenia and physical frailty: two sides of the same coin. Front Aging Neurosci 2014;6:192.
4. Clark BC, Manini TM. Functional consequences of sarcopenia and dynapenia in the elderly. Curr Opin Clin Nutr Metab Care 2010;13(3):271-6.
5. Weiss CO. Frailty and Chronic Diseases in Older Adults. Clin Geriatr Med 2011;27(1):39-52.
6. Fried, L.P., Tangen, C.M., Walston, J., et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56.
7. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 2012;60(8):1487-92.
8. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-23.
9. Taylor D. Physical activity is medicine for older adults. Postgrad Med J 2014;90(1059):26-32.

10. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 2012;380(9838):247-57.
11. Australian Institute of Health and Welfare 2014. Australia's health 2014.
12. Franco MR, Tong A, Howard K, Sherrington C, Ferreira PH, Pinto RZ, et al.. Older people's perspectives on participation in physical activity: a systematic review and thematic synthesis of qualitative literature. Br J Sports Med 2015;49(19):1268-76.
13. Rantanen T. Promoting mobility in older people. J Prev Med Public Health 2013;46 Suppl 1:S50-4.
14. Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. Prev Med 2004;39(5):1056-61.
15. Costello E, Leone JE, Ellzy M, Miller TA. Older adult perceptions of the physicians' role in promoting physical activity. Disabil Rehabil 2013;35(14):1191-8.
16. Broderick L, McCullagh R, White EB, Savage E, Timmons S. Perceptions, Expectations, and Informal Supports Influence Exercise Activity in Frail Older Adults. SAGE Open 2015;5(2):1-10.
17. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, *et al.*. Frailty consensus: a call to action. J Am Med Dir Assoc 2013;14(6):392-7.
18. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40(5):373-83.
19. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. J Clin Epidemiol 1993;46(2):153-62.
20. Joffe H, Yardley L. Content And Thematic Analysis. Research methods for clinical and health psychology: Sage Publications Ltd; 2004: 56-68.
21. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology 2006;3(2):77-101.
22. Fusch PI, Ness LR. A re We There Yet? Data Saturation in Qualitative Research. The Quality Report 2015;20(9):1408-1416.
23. Archer T, Fredriksson A, Schütz E, Kostrzewa RM. Influence of physical exercise on neuroimmunological functioning and health: Aging and stress. Neurotox Res 2011;20(1):69-83.

24. Lee C. Attitudes, knowledge, and stages of change: a survey of exercise patterns in older Australian women. Health Psychol 1993;12(6):476-80.
25. Rich SC, Rogers ME. Stage of exercise change model and attitudes toward exercise in older adults. Percept Mot Skills 2001;93(1):141-4.
26. Courneya KS. Understanding readiness for regular physical activity in older individuals: an application of the theory of planned behavior. Health Psychol 1995;14(1):80-7.
27. Whitlock EP, Orleans CT, Pender N, Allan J. Evaluating primary care behavioral counseling interventions: an evidence-based approach. Am J Prev Med 2002;22(4):267-84.
28. Charles C, Gafni A, Whelan T. Decision-making in the physician-patient encounter: revisiting the shared treatment decision-making model. Soc Sci Med 1999; 49(5):651-61.
29. Glasgow RE, Eakin EG, Fisher EB, Bacak SJ, Brownson RC. Physician advice and support for physical activity: results from a national survey. Am J Prev Med 2001;21(3):189-96.
30. Kerse N, Elley CR, Robinson E, Arroll B. Is physical activity counseling effective for older people? A cluster randomised, controlled trial in primary care. J Am Geriatr Soc 2005;53(11):1951-6.
31. Forman-Hoffman V, Little A, Wahls T. Barriers to obesity management: a pilot study of primary care clinicians. BMC Fam Pract 2006;7:35.
32. Bethancourt HJ, Rosenberg DE, Beatty T, Arterburn DE. Barriers to and facilitators of physical activity program use among older adults. Clin Med Res 2014;12(1-2):10-20.

Table 4.1: Participants' health and demographic characteristics collected during the interviews

Characteristic	**Total participants (n=12)**	**Active participants PASE (n=6)**	**Non-active participants PASE (n=6)**
Age (Median)	83 (range 76-91 years)	83 (range 76-91 years)	83 (range 76-90 years)
Gender	8 females 4 males	5 females 1 male	3 females 3 males
FRAIL Screen	10 pre-frail 2 frail	5 pre-frail 1 frail	5 pre-frail 1 frail
Charlson Comorbidity Index	11 low 5-year mortality risk 1 high 5-year mortality risk	6 low 5-year mortality risk 0 high 5-year mortality risk	5 low 5-year mortality risk 1 high 5-year mortality risk
Income	8 Low 3 Average 1 High	3 Low 2 Average 1 High	5 Low 1 Average 0 High
Highest education	2 Primary School 5 Secondary School 4 Technical College 1 University	0 Primary School 4 Secondary School 2 Technical College 0 University	2 Primary School 1 Secondary School 2 Technical College 1 University
Nationality	8 Australian 3 European 1 Asian	5 Australian 1 European 0 Asian	3 Australian 2 European 1 Asian
Participation in exercise program	6 yes 6 no	5 yes 1 no	1 yes 5 no

PASE: Physical Activity Scale for the Elderly
Income per year: low (< $25,000), average ($25,000-$45,000), high (> $45,000)

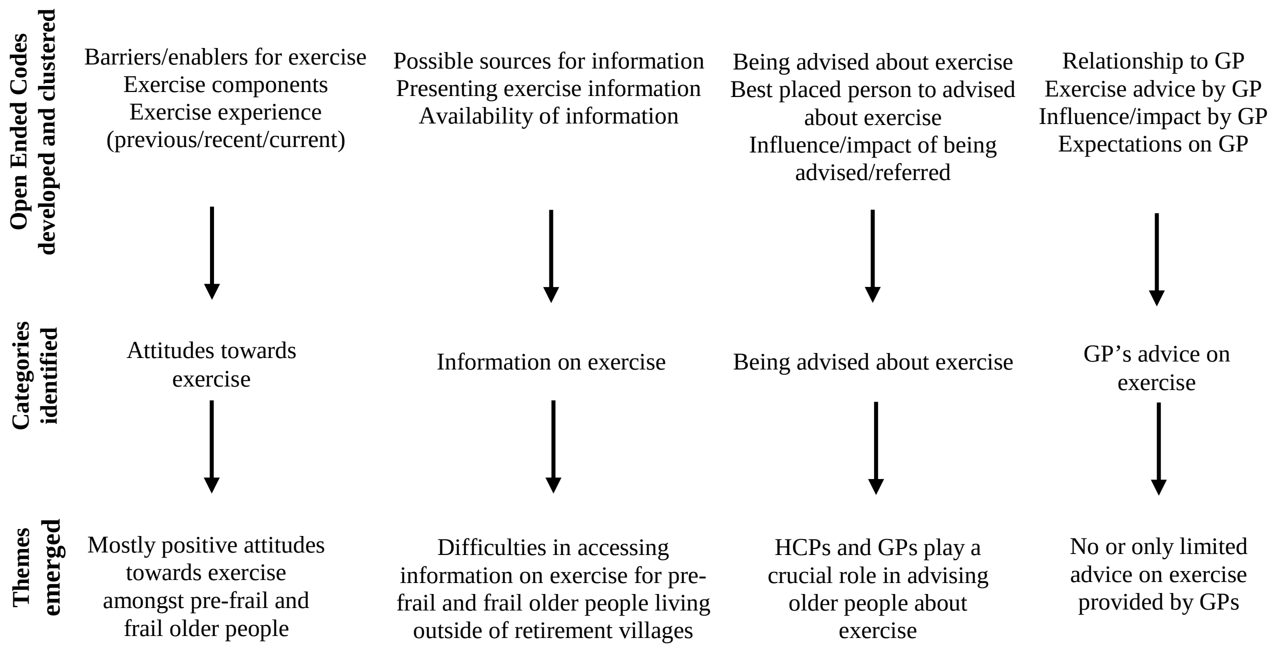


Figure 4.1: Data analyses and development of themes

Chapter 5

Medical Students’ Perceptions of the Importance of Exercise and Their Perceived Competence in Prescribing Exercise to Older People

Summary

Medical practitioners have the potential to increase older peoples’ participation in exercise by providing advice on exercise or prescribing exercise. However, physicians often cite a lack of education during medical school as a barrier to prescribing exercise.

The aim of this study was to determine the effects of a 4.5-week geriatric medicine course on 5th year medical students’ perceived importance and competence in prescribing exercise to older people.

The modified Exercise and Physical Activity Competence Questionnaire was administered to 81 students before and after the course. Scores ranged from 1 to 6. One open-ended question about perceived barriers to exercise prescription was added.

Students’ perceptions of the importance of designing an exercise prescription ($p=0.038$), determining the training heart rate ($p=0.021$), determining the body mass index ($p>0.001$), referring an older person to an exercise program ($p>0.001$) and identifying age-related limitations ($p=0.029$) improved significantly after the course. Students’ self-perceived competence improved significantly across all items ($p>0.001$). Barriers to exercise prescription included lack of: knowledge (57%), patient compliance (39%) and time (33%).

Given our ageing demographic and the benefits of exercise in older people, the improvement of medical teaching programs is a critical strategy in building the future capacity of our medical workforce, thus equipping them with the necessary skills and knowledge to motivate and counsel older people to participate in exercise.

This research has formed the basis of a research paper peer-reviewed and published in the Australasian Journal of Ageing (Appendix 4 including Statement of Authorship).

5.1. Background

Exercise is a key intervention when managing the health of older people. It contributes to healthy ageing and is important in preventing health complications and maintaining independence[1]. Exercise has demonstrated benefits for controlling and ameliorating numerous age-related diseases and chronic health conditions[2]. Regular exercise is reported to help maintain and restore muscle strength, improve balance and physical performance, prevent the loss of independence, reduce the risks of falls and fractures, thus contributing to enhanced quality of life[1-3].

Although the benefits of exercise are well known, the uptake of exercise in older people is poor. Participation in exercise decreases as people age, with 45% of people aged over 65 years and 75% of people aged 75 years and older not meeting their respective recommended levels of physical activity[4]. On the whole, globally, people are increasingly sedentary and sedentary behaviour is thought to contribute to health complications and premature deaths[5,6]. Older people report that health issues, environmental barriers, a lack of personal knowledge and also a lack of doctor's advice are the main reasons for not participating in adequate exercise[7].

Doctors are, therefore, an integral member of any healthcare team and have a role to play in encouraging older people to exercise[8,9]. They can do this by increasing awareness of the importance of exercise, allaying fears, helping to overcome perceived barriers and by providing direction as where to go and what to do[10]. Exercise advice provided in prescription form, including the type of activity, frequency, intensity and duration following a medication prescription format has been shown to be acceptable and effective in increasing older peoples' physical activity levels[9.11]. Doctors may be able to undertake a basic prescription with general advice and encouragement prior to referral to allied health experts, such as exercise physiologists and physiotherapists who have expertise in prescribing tailored exercise programs.

Despite the efficacy of exercise prescription, doctors' rarely focus on the need for exercise when recommending treatment, with only one-third of physicians recommending exercise to their patients[12]. A commonly cited reason for doctors not prescribing exercise or counselling about physical activity is due to the lack of training during medical school[13]. Recent studies confirm that 44% of medical schools in the UK are not teaching the government recommended guidelines for physical activity[14] and that over half of doctors trained in the United States do not receive formal education relating to exercise[15].

In this context, a cross sectional study conducted by Vallance et al.[16] investigated undergraduate medical students' perceived competence in prescribing exercise. This research confirmed that medical students' perceived that it was important to prescribe exercise, but only demonstrated moderate competence in completing an exercise prescription[16]. It is important to note that the survey was not specifically about exercise prescription for older people, but was designed to investigate perceived importance and competence in relation to exercise prescription for healthy adults and the response rate was only 27%.

Nevertheless, Jones et al.[17] and Conroy et al.[18] confirmed that specific exercise courses during medical school significantly increase medical students' beliefs in regards to the importance of exercise and their confidence and ability to counsel healthy adults about exercise. It is anticipated that a specific exercise curriculum, including lectures in medical school, could contribute to medical students' competence and confidence by ensuring that they understand the benefits of this treatment modality, are more enthusiastic in promoting exercise, and can and do offer counselling to encourage the uptake of exercise[17,18]. However, targeted research investigating the impact of medical school teaching programs in relation to exercise prescription for older people is sparse.

The aims of this present study, therefore, were to (1) determine the level of importance that 5th year medical students attribute to exercise and their perceived competence in prescribing exercise to older people, and (2) to examine whether the current 4.5-weeks geriatric medicine course improves medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise.

5.2. Methods

5.2.1. Participants and Procedures

All 5th Year medical students (a six year undergraduate program) from the University of Adelaide at the Queen Elizabeth Hospital (TQEH) campus in 2015 were invited to participate in this study. An independent researcher administered questionnaires at the commencement and end of the course. Students provided informed consent and were advised that participation was voluntary. All returned questionnaires were confidentially kept in an envelope and processed after the students had completed their course.

5.2.2. Geriatric Medicine Course

The University of Adelaide Geriatric Medicine Course is a 4.5 weeks course (Table 5.1) and is a core component of the 5th Year undergraduate medical teaching program. There are six rotations per annum of between 12 to 14 students per rotation. Students are allocated to four teaching campuses - three metropolitan hospitals and a rural clinical school. The clinical course is delivered differently at the four campuses.

In the TQEH program, there are no specific tutorials focused on exercise prescription, although medical students have exposure to therapy programs, including a compulsory visit to a community based exercise class where the students interview older people about their participation in exercise and present this to their tutor. Students are also encouraged to read or revise the current physical activity guidelines for older people and an online article about the effects of multifactorial interventions on frailty as part of their self-directed learning. Students are aware that any part of the course can be assessed.

5.2.3. Study Questionnaires

The questionnaire included questions to record the students' demographic information, medical students' current physical activity levels (introduced in the third rotation), previous exposure to a geriatric medicine course, their perceptions of the importance of exercise and their perceived competence in prescribing exercise, as well as perceived barriers to exercise prescription faced by medical practitioners in clinical practice.

Medical students' physical activity levels were assessed using the Leisure Score Index (LSI) from the Godin Leisure Time Exercise Questionnaire (GLTEQ), as personal exercise habits are said to correlate positively with physical activity counselling practices[19]. The GLTEQ consists of two questions, however, only question one was applied in the present study to determine the amount of physical activity[20,21].

Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise were assessed using the Exercise and Physical Activity Competence Questionnaire (EPACQ). The EPACQ includes six fundamental skills related to exercise prescription and assesses the importance of being able to prescribe exercise, as well as perceived competence in prescribing exercise, according to self-evaluation[22]. Medical students indicated their responses on a six point Likert scale ranging from 0 (not important or competent) to 6 (very important or competent). The EPACQ was adapted to be relevant to exercise in older people and modified to include four additional items relating to the risks and benefits of exercise, referral to an exercise program and age-related limitations.

Perceived barriers to exercise prescription faced by medical practitioners in clinical practice were assessed via an open ended question asking the students *In your opinion, what are potential barriers faced by doctors in prescribing exercise for their older patients in everyday practice?*

5.2.4. Statistical Analyses

IBM *SPSS Statistics* Version 21 (SPSS Inc., Chicago IL) was used to perform the statistical analyses. Associations between a previous attendance of a geriatric medicine course and perceived importance and competence were determined using point biserial correlation. Associations between students' physical activity levels and perceived importance and competence were determined using the Pearson correlation coefficient. A paired t-test was used to determine the difference between responses before and after the course. Descriptive data is presented as mean ± standard deviation (SD). The significance level (alpha) was set at 0.05. Responses to the open ended question were coded, categorised and underwent an interrater reliability check conducted by an independent researcher[23].

5.3. Results

5.3.1. Participants

Eighty-one 5th Year medical students attended the Geriatric Medicine Course in 2015 and participated in the study. One student did not complete the importance part of the EPACQ and two other students missed one item in the competence questionnaire. 53% (i.e. 43 out of 81 students) were female. The mean age was 23.4 ± 1.5 years. Twenty-five (31%) students had previously attended a geriatric medicine elective course. Medical students' physical activity levels were available only for 53 students due to the late introduction of this question (i.e. in third rotation). Thirty-seven (70%) students were active and met the current physical activity recommendations for healthy adults.

5.3.2. Perceived Importance and Competence in Prescribing Exercise

Analysis revealed that perceived importance of exercise for older people correlated positively with previous attendance of a geriatric medicine course ($p=0.040$; $r=0.23$). There was no correlation between previous attendance of a geriatric medicine course and perceived competence in prescribing exercise to older people ($p=0.079$). There was also no significant correlation between students' personal physical activity levels and their perceived importance ($p=0.860$) or competence ($p=0.960$) in prescribing exercise to older people.

Overall, the medical students perceived exercise for older people to be important (4.8 ± 0.7) but reported only moderate competence (3.0 ± 0.6) in prescribing exercise to older people in responses to the initial EPACQ.

Following their participation in the course, the overall perception of the importance of exercise for older people increased significantly ($p<0.001$) from being important (4.8 ± 0.7) to being highly important (5.0 ± 0.6). Students' perceptions of the importance of designing an exercise prescription ($p=0.038$), determining the training heart rate ($p=0.021$), determining the body mass index ($p<0.001$), as well as referring an older person for an exercise program ($p=0.001$) and identifying age-related limitations ($p=0.029$) improved significantly. Overall perceived competence in prescribing exercise for older people increased significantly ($p<0.001$) from feeling moderately competent (3.0 ± 0.6) to feeling competent (4.4 ± 0.6). Students' perceived competence improved significantly across all ten skills listed in the EPACQ ($p<0.001$).

The largest mean score improvements were shown in the perceived competence of referring an older person to an exercise program (by 2.0 ± 1.4; from 2.6 ± 1.2 to 4.6 ± 1.0), designing an exercise prescription (by 2.0 ± 1.2; from 1.8 ± 0.9 to 3.8 ± 1.1), and determining the nutritional needs of an older person (by 2.0 ± 1.3; from 2.0 ± 1.0 to 4.0 ± 1.1). However, five of the ten competence skills listed in the EPACQ remained below the competence score of 4.0.

Descriptive statistics for both perceived importance and competence in prescribing exercise to older people before and after a geriatric medicine course are shown in Tables 2 and 3.

5.3.3. Perceived Barriers to Exercise Prescription

Seventy-five (93%) students responded to the open-ended question. The barrier to exercise prescription most commonly noted was lack of knowledge (n=43; 57%), including not being aware of available exercise programs and not having the skills to prescribe exercise for older people. Twenty-nine (39%) students identified a lack of patient compliance. Twenty-five (33%) students identified a lack of time as a barrier to exercise prescription in clinical practice. Twelve (16%) students stated that a patient's personal and physical limitations could potentially be a barrier to exercise prescription. Seven (9%) students stated that other health care professionals might be more qualified to prescribe exercise to older people. Six

(8%) students stated that a doctor's perception of the importance of exercise might negatively affect their counselling practice.

5.4. Discussion

To the best of our knowledge, this is the first study that specifically examines the effects of a geriatric medicine course on senior medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people.

Three key findings emerged from the study. Firstly, results indicated that senior medical students perceive exercise for older people as important, although they only feel moderately competent to prescribe exercise to older people. Secondly, the geriatric medicine course attended by the medical students contributed to an improved perception of the importance of exercise and self-perceived competence in prescribing exercise to older people. This second finding was further supported by the fact that there was a correlation between previous exposure to geriatric medicine as an elective and perceived importance, indicating that medical students who previously attended a geriatric medicine course perceive exercise for older people to be more important than students who didn't attend a geriatric medicine course. Thirdly, it was confirmed that students perceive that a lack of knowledge acts as the main barrier to prescribing exercise.

The findings in this study are consistent with the findings of Vallance et al.[16] who determined that 1st to 4th Year medical students perceive exercise related prescription to be important (score 4.43 on the EPACQ 6-point Likert-scale) while demonstrating only moderate competence (score 3.45 on the EPACQ 6-point Likert scale) in completing an exercise prescription. Vallance et al.[16] and Frank et al.[24] observed that medical students in 3rd and 4th Year indicate lower perceived importance of exercise than 1st and 2nd Year students. We were unable to determine whether the same phenomenon existed at our medical school as we only included 5th Year students in our study. Furthermore, we had not investigated if there were differences across our teaching campuses.

Even if senior medical students perceive exercise for older people as important, they only feel moderately competent in prescribing it. The pre-course perceived competence scores (mean 3.01 on a 6-point scale) in this study were lower than the results of Vallance et al.[16]. The lower perceptions of competence in prescribing exercise to older people might demonstrate that among senior medical students exercise and exercise prescription for older people are perceived to be more complex than exercise prescriptions for healthy or younger adults.

The significant impact of the geriatric medicine course on 5th Year medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people is consistent with the results from other studies. For example, specific exercise courses during medical school have been shown to significantly increase medical students' beliefs in the importance of exercise and their confidence and ability to counsel healthy adults about exercise[17,18]. Jones et al.[17], for example, investigated the positive effects of just four lectures about exercise medicine on medical students' confidence about advising patients on exercise, while Conroy et al.[18] investigated the impact of a 28-hour course in preventive medicine and nutrition on medical students' ability to assess and counsel about exercise. Although the geriatric medicine course in this study had no specific tutorial focused on exercise prescription, the results of the study indicate that components of the course, such as the interaction with older people who exercise, a visit to a community-based exercise class, reading material related to the physical activity guidelines and the effects of exercise on frailty through self-directed learning, significantly affected medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people. However, the perceived competence scores remained low after the geriatric medicine course and therefore more can be done. Specific tutorials with regards to assessments and exercise prescription for older people are needed to increase medical students' confidence and understanding of exercise prescription for older people. By better understanding the concept of exercise prescription, medical students will be better positioned to encourage and reinforce older people to begin and continue with an exercise program. It is also envisaged that as a direct result of this better understanding, graduating doctors are more likely to refer older patients to allied health professionals, such as exercise physiologists or physiotherapists who have expertise in exercise prescription. Working as a team and in partnership with the older person, an effective exercise program is more likely to be achieved.

Barriers to exercise prescription identified by students were similar to those identified by Kennedy and Meeuwisse[25] who investigated barriers to exercise counselling by family physicians, as well as Forman-Hoffman et al.[13] who investigated barriers to counselling obese patients about exercise by primary care physicians. Lack of knowledge and the lack of education during medical school were cited as the main barriers to exercise prescription and our study confirmed this. Therefore, strengthening the undergraduate program, as well as providing for continuing professional development, are possibly two interventions that could translate to improved participation in exercise by older people. The hypothesis is that graduating doctors with improved knowledge and greater confidence are more likely to prescribe exercise, which could result in a larger number of older people being motivated to participate in exercise programs.

The limitations of the present study include the reliance on self-reporting and the fact that the study was conducted at only one teaching campus.

5.5. Conclusion

This study provides first hand evidence that a geriatric medicine course for senior medical students results in improved perceptions of the importance of exercise and greater perceived competence in prescribing exercise to older people. However, half of the competency skills remained low after the course, suggesting that there is an opportunity to improve the course by including specific tutorials on exercise prescription. We hypothesise that this will lead to better self-perceived competence scores amongst medical students, and we plan to investigate this theory in the future. The provision of such evidence might help other academics argue for teaching space relating to this topic in the undergraduate medical student curriculum. Considering our ageing population and the benefits of exercise in older people, such as better health and greater independence, there is an imperative that medical teaching programs assign time and provide the resources necessary to ensure that our graduating doctors are equipped to motivate and counsel older people to participate in exercise.

5.6. References

1. Taylor, D., Physical activity is medicine for older adults. Postgrad Med J 2014;90:26-32.
2. Clegg, A., Young, J., Iliffe, S., Rikkert, M.O., and Rockwood, K., Frailty in elderly people. Lancet 2013;381: 52-62.
3. Gill, T.M., Gahbauer, E.A., Allore, H.G., and Han, L., Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166:418-23.
4. Hallal, P.C., Andersen, L.B., Bull, F.C., et al., Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 2012;380:247-57.

5. WHO, Global health risks: mortality and burden of disease attributable to selected major risks. Geneva: World Health Organization (WHO), 2009.
6. Xue, Q.L., The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27:1-15.
7. Schutzer, K.A. and Graves, B.S., Barriers and motivations to exercise in older adults. Prev Med 2004;39:1056-61.
8. Franco, M.R., Tong, A., Howard, K., et al., Older people's perspectives on participation in physical activity: a systematic review and thematic synthesis of qualitative literature. Br J Sports Med 2015;49:1268-1276.
9. Lawton, B.A., Rose, S.B., Elley, C.R., et al., Exercise on prescription for women aged 40-74 recruited through primary care: two year randomised controlled trial. BMJ 2008;337:a2509.
10. Andersen, R.E., Blair, S.N., Cheskin, L.J., and Bartlett, S.J., Encouraging patients to become more physically active: the physician's role. Ann Intern Med 1997;127:395-400.
11. Phillips, E.M. and Kennedy, M.A., The exercise prescription: a tool to improve physical activity. PM R 2012;4:818-25.
12. Glasgow, R.E., Eakin, E.G., Fisher, E.B., Bacak, S.J., and Brownson, R.C., Physician advice and support for physical activity: results from a national survey. Am J Prev Med 2001;21:189-96.
13. Forman-Hoffman, V., Little, A., and Wahls, T., Barriers to obesity management: a pilot study of primary care clinicians. BMC Fam Pract 2006; 7: 35.
14. Weiler, R., Chew, S., Coombs, N., Hamer, M., and Stamatakis, E., Physical activity education in the undergraduate curricula of all UK medical schools: are tomorrow's doctors equipped to follow clinical guidelines? Br J Sports Med 2012;46:1024-1026.
15. Cardinal, B.J., Park, E.A., Kim, M., and Cardinal, M.K., If Exercise is Medicine(R), Where is Exercise in Medicine? Review of U.S. Medical Education Curricula for Physical Activity-Related Content. J Phys Act Health 2014;12:1336-1343.
16. Vallance, J.K., Wylie, M., and MacDonald, R., Medical students' self-perceived competence and prescription of patient-centered physical activity. Prev Med 2009;48:164-166.

17. Jones, P.R., Brooks, J.H., and Wylie, A., Realising the potential for an Olympic legacy; teaching medical students about sport and exercise medicine and exercise prescribing. Br J Sports Med 2013;47:1090-1094.
18. Conroy, M.B., Delichatsios, H.K., Hafler, J.P., and Rigotti, N.A., Impact of a preventive medicine and nutrition curriculum for medical students. Am J Prev Med 2004;27:77-80.
19. Lobelo, F., Duperly, J., and Frank, E., Physical activity habits of doctors and medical students influence their counselling practices. Br J Sports Med 2009;43:89-92.
20. Godin, G. and Shephard, R.J., A simple method to assess exercise behavior in the community. Can J Appl Sport Sci 1985;10:141-146.
21. Godin, G., The Godin-Shephard Leisure-Time Physical Activity Questionnaire. Health & Fitness Journal of Canada 2011;4:18-21.
22. Connaughton, A.V., Weiler, R.M., and Connaughton, D.P., Graduating medical students' exercise prescription competence as perceived by deans and directors of medical education in the United States: implications for Healthy People 2010. Public Health Rep 2001;116:226-234.
23. Joffe, H. and Yardley, L., Content And Thematic Analysis. In: Research methods for clinical and health psychology. Sage Publications Ltd.,2004;56-68.
24. Frank, E., Galuska, D.A., Elon, L.K., and Wright, E.H., Personal and clinical exercise-related attitudes and behaviors of freshmen U.S. medical students. Res Q Exerc Sport 2004;75:112-121.
25. Kennedy, M.F. and Meeuwisse, W.H., Exercise counselling by family physicians in Canada. Preve Med 2003;37:226-232.
26. Tam, K.L., Chandran, K., Yu, S., Nair, S., and Visvanathan, R., Geriatric medicine course to senior undergraduate medical students improves attitude and self-perceived competency scores. Australas J Ageing 2014;33:E6-E11.
27. Australian Society for Geriatric Medicine. Australas J Ageing 2006;25:218-222.

Table 5.1: University of Adelaide Geriatric Medicine 2015 curriculum (adapted from Tam et al.[26])

Tutorials (tutors)	Time commitment (total 28.5 hours)
The topics for the tutorials and the clinical exposure are based on recommendations by the Australian and New Zealand Society for Geriatric Medicine position statement[27]	
Introduction & orientation, distribution of course materials (geriatrician)	0.5 hours
Rehabilitation, Transition Care, Discharge Options, and Day Therapy Services (geriatrician)	1 hour
Falls (geriatrician)	1 hour
Urinary incontinence in older people (geriatrician)	1 hour
Polypharmacy and iatrogenesis (geriatrician)	1 hour
Depression in older people (psychogeriatrician)	1.5 hours
Cognition (geriatrician)	4 hours
Dementia	
Delirium	
Capacity assessment and legal directives	
Management of behavioural and psychological symptoms of dementia and acute agitation	
Caring for Patients with Dementia (Alzheimer's Australia Consultant)	3 hours
Nutrition in older people (geriatrician)	1 hour
Osteoporosis and bone health (geriatrician)	1 hour
Parkinson's disease in older people (geriatrician)	1 hour
Pharmacology in elderly (clinical pharmacist)	1 hour
Oral health in older people (dentist)	1 hour
Management of dysphagia and dysphasia (speech therapist)	1 hour
Physiotherapy assessments, role in Geriatric Medicine and Discharge Planning (physiotherapist)	1 hour
Occupational therapy functional, safety & cognitive assessments, discharge planning (occupational	1 hour
therapist)	1 hour
Malnutrition and Nutritional Supplements in elderly (Dietician)	1 hour
Elder abuse (Aged Rights Advocacy Service)	1 hour
Advance care planning, respecting patient choices (specialist nurse)	2.5 hours
Aged Care Assessment Programs & Community Services (geriatrician & Domiciliary Care Service)	1 hour
Campbelltown Keep Fit Class for elderly (Exercise Professional)	1 hour
Student presentation & discussions regarding exercise history from consumers (geriatrician & psychologist); Physiology of aging – Brief notes and headings provided to guide student in their study	Self-directed learning
Clinical attachments with preceptors (geriatrician) - 2 blocks of 2 week clinical attachments (1 preceptor for each 2 week block) End of rotation assessments (MCQs- 50 questions 60 minutes to answer; OSCE- 10 stations 10 minutes per station with immediate feedback included) Student Grading for rotation: MCQ 25%; OSCE 25%; 1st Preceptor assessment 25%; 2nd Preceptor assessment 25%, OSCE: Objective structured clinical examination, MCQ: Multiple choice question	

Table 5.2: Medical students' perceived importance in being able to prescribe exercise for older people

Skills		**n**	**Minimally important**		**Moderately important**		**Important**		**Pre-course Post-course**	**Difference (pre - post)**	**P-value**
			n	**(%)**	**n**	**(%)**	**n**	**(%)**	**Mean (SD)**	**Mean (SD)**	
1. Conducting a physical examination to approve an exercise program	pre	81	3	(4)	14	(17)	64	(79)	5.0 (1.0)	0.0 (0.1)	0.913
	post	80	1	(1)	4	(5)	75	(94)	5.0 (0.9)		
2. Determining the maximum heart rate for an older person	pre	81	7	(9)	47	(58)	27	(33)	4.1 (1.2)	0.1 (0.1)	0.295
	post	80	5	(6)	18	(23)	57	(71)	4.2 (1.1)		
3. Calculating the training heart range for an older person	pre	81	9	(11)	46	(57)	26	(32)	4.0 (1.1)	0.3 (0.1)	0.021*
	post	80	5	(6)	12	(15)	63	(79)	4.3 (1.0)		
4. Determining the body mass index for an older person	pre	81	4	(5)	21	(26)	56	(69)	4.7 (1.0)	0.6 (0.1)	<0.001*
	post	80	-	-	1	(1)	79	(99)	5.3 (0.7)		
5. Determining the daily caloric and nutritional needs of an older person	pre	81	3	(4)	18	(22)	60	(74)	5.0 (1.0)	0.2 (0.1)	0.053
	post	80	1	(1)	2	(3)	77	(96)	5.2 (0.8)		
6. Designing an exercise prescription for an older person	pre	81	9	(11)	27	(33)	45	(56)	4.4 (1.2)	0.3 (0.1)	0.038*
	post	80	9	(11)	2	(3)	69	(86)	4.7 (1.2)		
7. Explaining the benefits of exercise to an older person	pre	81	-	-	8	(10)	73	(90)	5.4 (0.7)	0.1 (0.1)	0.300
	post	80	-	-	-	-	80	(100)	5.5 (0.6)		
8. Explaining the risks of exercise to an older person	pre	81	1	(1)	12	(15)	68	(84)	5.2 (0.8)	0.2 (0.1)	0.122
	post	80	-	-	-	-	80	(100)	5.4 (0.6)		
9. Referring an older person to an exercise program	pre	81	2	(3)	19	(23)	60	(74)	5.0 (1.0)	0.3 (0.1)	0.001*
	post	80	-	-	2	(3)	78	(97)	5.3 (0.7)		
10. Identifying age-related limitations to exercise that may exist in older people	pre	81	1	(1)	20	(25)	60	(74)	5.0 (0.9)	0.2 (0.1)	0.029*
	post	80	-	-	1	(1)	79	(99)	5.2 (0.7)		
Overall mean score	pre	**81**							**4.8 (0.7)**	**0.2 (0.1)**	**0.001***
	post	**80**							**5.0 (0.6)**		

SD= standard deviation, skills rated on a scale from 1 (not important) to 6 (very important), score ≥ 4 indicates importance

Minimally important = < 2.0 Moderately important = 2.01 – 3.99 Important = ≥ 4

Data collected January - October 2015 from University of Adelaide 5th year medical students

Table 5.3: Medical students' perceived competence in prescribing exercise for older people

Skills		**n**	**Minimally competent n (%)**	**Moderately competent n (%)**	**Competent n (%)**	**Pre-course Post-course Mean (SD)**	**Difference (pre - post) Mean (SD)**	**P-value**
1. Conducting a physical examination to approve an exercise program	pre	81	57 (70)	23 (28)	1 (1)	2.1 (1.0)	1.6 (1.1)	<0.001*
	post	81	12 (15)	15 (19)	54 (67)	3.7 (1.0)		
2. Determining the maximum heart rate for an older person	pre	81	36 (44)	29 (36)	16 (20)	3.0 (1.4)	0.9 (1.3)	<0.001*
	post	81	13 (16)	14 (17)	54 (67)	3.9 (1.2)		
3. Calculating the training heart range for an older person	pre	81	58 (72)	19 (24)	4 (5)	2.1 (1.2)	1.2 (1.4)	<0.001*
	post	81	21 (26)	28 (35)	32 (40)	3.3 (1.2)		
4. Determining the body mass index for an older person	pre	81	4 (5)	24 (30)	53 (65)	4.7 (1.3)	0.8 (1.3)	<0.001*
	post	80	- -	2 (3)	78 (98)	5.5 (0.7)		
5. Determining the daily caloric and nutritional needs of an older person	pre	81	61 (75)	19 (24)	1 (1)	2.0 (1.0)	2.0 (1.3)	<0.001*
	post	81	12 (15)	10 (12)	59 (73)	4.0 (1.1)		
6. Designing an exercise prescription for an older person	pre	81	63 (78)	17 (21)	1 (1)	1.8 (0.9)	2.0 (1.2)	<0.001*
	post	81	12 (15)	11 (14)	58 (72)	3.8 (1.1)		
7. Explaining the benefits of exercise to an older person	pre	81	1 (1)	37 (46)	43 (53)	4.5 (0.9)	0.9 (1.0)	<0.001*
	post	81	- -	- -	81 (100)	5.4 (0.7)		
8. Explaining the risks of exercise to an older person	pre	80	12 (15)	46 (58)	22 (28)	3.8 (1.1)	1.2 (1.2)	<0.001*
	post	81	- -	5 (6)	76 (94)	5.0 (0.9)		
9. Referring an older person to an exercise program	pre	81	39 (48)	35 (43)	7 (9)	2.6 (1.2)	2.0 (1.4)	<0.001*
	post	81	3 (4)	8 (10)	70 (86)	4.6 (1.0)		
10. Identifying age-related limitations to exercise that may exist in older people	pre	81	16 (20)	50 (62)	15 (19)	3.4 (1.1)	1.5 (1.3)	<0.001*
	post	81	- -	2 (3)	79 (98)	4.9 (0.7)		
Overall mean score	pre	**81**				**3.0 (0.6)**	**1.4 (0.7)**	**<0.001***
	post	**81**				**4.4 (0.6)**		

SD= standard deviation, skills rated on a scale from 1 (not competent) to 6 (very competent), score ≥ 4 indicates competence

Minimally competent = < 2.0 Moderately competent = 2.01 – 3.99 Competent = ≥ 4

Data collected January - October 2015 from University of Adelaide 5th year medical students

Chapter 6

Educating Medical Students in Counselling Older Adults About Exercise: The Impact of a Physical Activity Module

Summary

Exercise courses during medical school contribute to medical students' confidence in promoting physical activity to their patients. However, there is still a lack of uniform physical activity education across medical school curricula to equip medical students with the necessary skills and knowledge to counsel their patients about exercise.

The aim of this study was to determine the effects of a 1.5-hour physical activity module including a one-hour exercise tutorial combined with a 30-minute practical counselling session on senior medical students' perceptions of the importance of exercise and their perceived competence in advising older people about exercise.

The modified Exercise and Physical Activity Competence Questionnaire (EPACQ) was administered before and after a 4.5-week Geriatric Medicine Course. Scores ranged from 1 (not important or competent) to 6 (very important or competent). The independent T-Test and repeated-measures ANOVA was used to determine differences between intervention and control group.

Medical students' perceived exercise-related skills to be highly important (score ≥ 4) in both the intervention (4.85 ± 0.37) and control group (4.78 ± 0.67), pre-course. The overall perceived importance could not be significantly increased by the physical activity module ($p=0.082$). The physical activity module, however, improved medical students' perceived competence in six out of ten exercise-related skills, and increased their overall perceived competence in counselling older people about exercise ($p<0.001$).

This study proves that little teaching space is needed to impact positively on medical students' exercise counselling abilities. We hope that this research will inform medical curriculum development at universities for the benefit of older people.

This research has formed the basis of a research paper peer-reviewed and accepted for publication in the Journal of Frailty and Aging (Appendix 5 including Statement of Authorship).

6.1. Background

Exercise helps to maintain and restore muscle strength, and reduce the risk of falls and fractures in older people. Frailty, a geriatric syndrome prevalent in clinical practice, as well as falls and fractures threaten the independence of older people, and contribute to a reduced quality of life[2-4]. Older people prefer to live in their own homes for as long as possible[5]. Therefore, any strategy that might help older people achieving their goals should be actively supported.

Educational programs that ensure that graduating doctors are better placed to promote the uptake of exercise by older people might be one such strategy. Furthermore, with the ageing population, more comprehensive geriatric education programs in medical schools are required if a skilled medical workforce able to cater to the needs of older citizens is to be developed[6]. And because older people tend to hold their doctors in high regard, doctors must play a key role in educating older patients about the importance of exercise, and encourage them to participate in physical activity (PA) programs[2,7].

In spite of its importance, exercise is not meaningly included in many undergraduate medical curricula[8]. A recent review of US medical curricula, for example, suggests that over half of the medical students trained in the United States receive no formal education about exercise[9]. Similar findings have also been noted in the United Kingdom[8]. Many doctors, not surprisingly, cite the lack of education during medical school as the main barrier for them not counselling their patients about exercise[10].

Even when it is included in the curricula, there is a gap in the delivery of exercise-oriented courses. A recent evaluation of PA training in the curricula of Australian medical schools revealed that while most medical schools report including PA training in their curricula, the quality of content is variable, with key topics, such as the national strength recommendations missing[11]. We know that there is considerable heterogeneity in teaching methods, duration and placement within medical school curricula with regards to PA training[12]. Research evidence as to what works and what does not is limited, especially where it relates to older individuals.

We have previously reported that a dedicated 4.5-week geriatric medicine course for senior medical students improved students' perception of the importance of prescribing exercise to older people[13]. In relation to their perceived competence, however, although improvements were noted across all PA counselling-related skills, students still perceived not being competent in performing half of the listed skills following the course.

As a result of this findings, we introduced a PA module including a one hour exercise tutorial combined with a 30 minute practical counselling session. The aim of this study was to determine the effect of this course improvement on medical students' perceived importance and competence in advising older people about exercise.

6.2. Methods

6.2.1. Participants

All University of Adelaide 5th year medical students taking part in the Queen Elizabeth Hospital (TQEH) Geriatric Medicine course in 2015 (control group) and 2016 (intervention group) were invited to participate in this study. The Geriatric Medicine Course is a 4.5 week core component course of the 5th year medical teaching program and includes six rotations of 12 to 14 medical students per annum, resulting in approximately 80 students per year. We previously described the structure of the Geriatric Medicine Course in 2015[13].

Students were advised that participation was voluntary and provided informed consent. The study received ethics approval from the University of Adelaide Human Research Ethics Committee (ethics approval number H-2015-001).

6.2.2. Physical Activity Module

In 2015, there were no specific tutorials focused on exercise prescription, although medical students did have access to therapy programs, including a community based exercise class with the opportunity to interview older people about their exercise experience. Students were also encouraged to read the current exercise recommendations for older people and a research article on the effects of multi-component exercise interventions on frailty.

In 2016, a one hour tutorial was introduced to the course by an exercise physiologist and researcher at TQEH. The tutorial included topics relevant to exercise and older people, and was based on information and tools provided by Exercise is Medicine, a global health initiative managed by the American College of Sports Medicine (ACSM). The Exercise is Medicine initiative focuses on motivating health care professionals to include exercise when discussing treatment options with their patients[14]. Core components of the one hour tutorial included information and tools on:

- How to assess the physical activity level of an older patient
- How to do a safety screening and identify risk factors
- How to motivate an older patient and determine their readiness to change

- How to write an exercise prescription
- How to provide medical clearance for exercise programs

Students had the opportunity to use the provided tools following a community-based exercise class, counsel the older participants about PA, and present their results to their tutors. The content of the PA module in this study is displayed in Figure 6.1.

6.2.3. Study Questionnaires

Study questionnaires were handed out pre- and post-course. All returned forms were kept in a sealed envelope and only opened after the students had finished their course.

The study questionnaire included medical students' date of birth, gender, current physical activity level, and previous attendance of a geriatric medicine course.

The physical activity levels were assessed using the Godin Leisure Time Exercise Questionnaire[15,16]. The Exercise and Physical Activity Competence Questionnaire (EPACQ) was used to examine medical students' perceived importance and competence in prescribing exercise to older people[17]. The EPACQ is a self-evaluation questionnaire including six skills related to exercise prescription with responses being graded on a Likert scale ranging from 1 (not important or competent) to 6 (very important or competent)[17]. A score of ≥4 indicated perceived competence or importance and was considered as satisfactory. The EPACQ was modified to address older people and four additional items were included in relation to the risks and benefits of exercise, the referral to exercise and the identification of age-related limitations.

6.2.4. Statistical Analyses

IBM SPSS Statistics Version 24 was used to perform the statistical analyses. Associations between a previous attendance of a geriatric medicine course and perceived importance and competence were determined using point biserial correlation. Associations between students' personal physical activity levels and perceived importance and competence were determined using the Pearson correlation coefficient. The independent T-test and repeated-measures ANOVA was used to determine differences between the intervention group and control group pre- and post-course. Descriptive data is presented as mean ± standard deviation (SD). The significance level was set at $\alpha \leq 0.05$.

6.3. Results

6.3.1. Participants

The questionnaire was administered to 161 5th year medical students in 2015 (control group [CG]; n=81) and 2016 (intervention group [IG]; n=80). The mean age was 23.4±1.45 years and 52.5% of the students (n=84) were female. Over one-third of the students (n=52; 32.5%) had previously attended a geriatric medicine elective course and the majority of the students (n=103; 78.6%) were active according to the physical activity recommendations for healthy adults. Baseline characteristics between the two cohorts were no different except for the CG reported feeling more competent in explaining the risks (p=0.046) and benefits (p=0.023) of exercise to an older person compared to the IG (Table 6.1).

6.3.2. Students' Perceived Importance in Prescribing Exercise to Older People

The previous attendance of a geriatric medicine course correlated positively (p=0.040; r=0.23) with medical students' perceived importance of being able to prescribe exercise to older people in the CG. No correlations could be found in the IG. There was also no significant correlation between students' personal physical activity levels and their perceived importance in either CG or IG.

Before the course, overall students' perceived importance of being able to prescribe exercise to older people was high (score ≥4) in both the IG (4.85±0.37) and the CG (4.78±0.67). In regards to the proportion of the students, 91.3% (n=73 out of 80) of the IG and 88.9% (n=72 out of 81) of the CG perceived the PA related skills as important (score ≥4).

The PA module significantly improved medical students' perceived importance in nine out of ten skills, while only five out of ten skills significantly improved in the CG (Table 6.2).

Compared to the initial geriatric course, the PA module presented to the IG only significantly improved the perceived importance of determining the maximal heart rate of an older person (IG 4.75±1.06 vs CG 4.19±1.09; p=0.040).

However, there was an upward trend for medical students' perceived importance in being able to conduct a physical examination (IG 5.32±0.83 vs CG 5.03±0.92; p=0.056), explain the benefits of exercise (IG 5.53±0.70 vs CG 5.46±0.59; p=0.087), as well as medical students' overall perceived importance (IG 5.25±0.28 vs CG 5.02±0.57; p=0.082).

After the amended course in 2016, 96.3% of the IG (n=77 out of 80) perceived PA-related skills in advising older people about exercise as important (score ≥4), exactly the same percentage as the CG (n=78 out of 81). This was an increase of 5.0% (n=4) in the IG and 7.4% (n=6) in the CG.

6.3.3. Students' Perceived Competence in Prescribing Exercise to Older People

No correlations could be found between medical students' perceived competence and their previous attendance of a geriatric medicine course or their personal physical activity levels for students in either the IG or the CG.

Before the course, overall medical students' perceived competence in prescribing exercise to older people was low (score <4) in both, IG (2.94±0.96) and CG (3.00±0.64). Only 5.0% (n=4 out of 80) of the students in the IG and 9.9% (n=8 out of 81) of the students in the CG perceived themselves as being competent (score ≥4) in advising older people about exercise.

The initial geriatric medicine course in the CG, as well as the PA module in the IG, significantly improved medical students' perceived competence across all ten skills (Table 6.3). However, despite these significant improvements, medical students in the CG still did not feel competent in performing half of the skills listed in the EPACQ (score <4), while students attending the PA module perceived themselves to be competent across all domains (score ≥4).

Compared to the initial geriatric course in the CG, the PA module significantly improved the students' perceived competence in six out of ten skills (p>0.050), as well as their overall perceived competence (p<0.001). There was also an upward trend for medical students 'perceived competence in explaining the risks of exercise (IG 5.01±0.76 vs CG 4.98±0.92; p=0.065) to an older person.

After the course in 2016, containing the PA module, 97.5% (n=78 out of 80) of the students in the IG perceived themselves as being competent (score ≥4) in advising older people about exercise, an increase of 92.5% (n=74). Among the CG, 81.5% (n=66 out of 81) of the students perceived themselves being competent (score ≥4), an increase of 71.6% (n=58).

6.4. Discussion

The key finding from this study is that a short 1.5 hour PA module introduced to senior medical students, including a one hour exercise tutorial combined with a 30 minute practical counselling session increased medical students' perceived competence in prescribing exercise to older people.

The fact that PA training during medical school has a positive effect on medical students' perceived competence and confidence in advising their patients about PA has been shown for almost three decades[12,18,19]. A recent systematic review examining the effects of PA training in medical school education confirmed positive changes in students' attitudes toward PA, their PA counselling knowledge and skills, and their confidence to counsel. However, a considerable heterogeneity of teaching methods, duration, and placement within the curriculum was noted and weak research designs limited an optimal evaluation of effectiveness (i.e., few pre-/post-intervention, and/or control comparisons)[12].

This study used an exercise theory tutorial combined with a practical session to not only provide the students with information about the background of PA counselling, but to also offer them practical experience to increase their confidence in advising older people about exercise. Similar teaching methods have been used effectively by other studies, like Mohler et al. (2010) and Bass et al. (2004)[20,21]. In regards to the content of the PA module, it was based on the Exercise is Medicine initiative, which includes quick and simple tools for health care professionals to assist with exercise prescription, as well as behavioural strategies and steps to ensure patients receive the most effective and personalised advice[14]. Similar content, including the 5 A's (ask, advise, assess, assist, arrange) of the behavioural change model for chronically ill patients[22], for example, has also proved effective in other studies[12,23].

In regards to the effectiveness of shorter PA interventions, Mohler et al. (2010) demonstrated that a two hour mandatory interactive educational offering improved medical students' attitudes and awareness of the importance of healthy ageing using an end-of-session evaluation form that was developed for the purpose of the study. The PA training included two theory sessions on PA combined with two counselling sessions between the students and a mentor[20]. Bass et al. (2004) confirmed that a two hour interactive lecture and two 15 minute PA counselling practices with a patient significantly improved first year medical students' knowledge, attitudes and confidence in PA counselling using a 13 item pre- and post-knowledge questionnaire that was developed for the purpose of the study[21]. In contrast, the present study did not only provide students a practical counselling session with older participants, but also distributed a validated pre- and post-questionnaire that had been used in several studies before[17,24,25]. Our study has, however, only assessed for perceived competence and it remains to be determined if actual competence is improved through this course. It also remains to be determined if this perception is sustained and if it truly translates into changed clinical practice.

This study provides evidence using a rigorous study design (pre/post survey and control group) that only a small teaching space (1.5 hours) is needed to significantly improve medical students’ perceived competence in prescribing exercise to older people. Considering the curriculum space for PA training in medical schools across Australia, for example, which was reported to be between 5.0 and 12.3 hours[11], the implementation of a short PA module as described in this study may be feasible.

The limitations of this study were that the survey was conducted at only one teaching campus and at one university, and so the results may not be generalisable.

6.5. Conclusion

Considering the benefits of exercise to older people, medical curricula need to ensure quality teaching content on this topic so that the needs of older people in our ageing society can be better met. This study provides evidence that a 1.5 hour PA module presented to senior medical students improves their perceived competence in counselling older people about exercise. It is important that this research is replicated elsewhere to confirm generalisability. Future research should focus on the effectiveness of such programs in improving competency and sustaining these improvements to ensure changed clinical practice in the long term.

6.6. References

1. Exercise is Medicine. Healthcare Providers' Action Guide [PDF]. Indianapolis: American College of Sports Medicine; 2017 [cited 2017/30/5]. Available from: http://www.exerciseismedicine.org/assets/page_documents/Complete%20HCP%20Action%20Guide.pdf
2. Taylor D. Physical activity is medicine for older adults. Postgrad Med J 2014;90(1059):26-32.
3. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381(9868):752-62.
4. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-23.
5. Elwyn G, Williams M, Roberts C, Newcombe RG, Vincent J. Case management by nurses in primary care: analysis of 73 'success stories'. Qual Prim Care 2008;16(2):75-82.

6. Lucchetti AL, Lucchetti G, de Oliveira IN, Moreira-Almeida A, da Silva Ezequiel O. Experiencing aging or demystifying myths? - impact of different "geriatrics and gerontology" teaching strategies in first year medical students. BMC Med Educ 2017;17(1):35.
7. Lawton BA, Rose SB, Elley CR, Dowell AC, Fenton A, Moyes SA. Exercise on prescription for women aged 40-74 recruited through primary care: two year randomised controlled trial. BMJ 2008;337:a2509.
8. Weiler R, Chew S, Coombs N, Hamer M, Stamatakis E. Physical activity education in the undergraduate curricula of all UK medical schools: are tomorrow's doctors equipped to follow clinical guidelines? Br J Sports Med 2012;46(14):1024-6.
9. Cardinal BJ, Park EA, Kim M, Cardinal MK. If Exercise is Medicine, Where is Exercise in Medicine? Review of U.S. Medical Education Curricula for Physical Activity-Related Content. J Phys Act Health 2015;12(9):1336-43.
10. Forman-Hoffman V, Little A, Wahls T. Barriers to obesity management: a pilot study of primary care clinicians. BMC Fam Pract 2006;7:35.
11. Strong A, Stoutenberg M, Hobson-Powell A, Hargreaves M, Beeler H, Stamatakis E. An evaluation of physical activity training in Australian medical school curricula. J Sci Med Sport 2017;20(6):534-8.
12. Dacey ML, Kennedy MA, Polak R, Phillips EM. Physical activity counseling in medical school education: a systematic review. Med Educ Online 2014;19:.24325.
13. Jadczak AD, Tam KL, Yu S, Visvanathan R. Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people. Australas J Ageing 2017; doi: 10.1111/ajag.12412. [Epub ahead of print].
14. American College of Sports Medicine. Exercise is Medicine 2017 [30 May 2017]. Available from: http://www.exerciseismedicine.org/.
15. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. Can J Appl Sport Sci 1985;10(3):141-6.
16. Godin G. The Godin-Shephard Leisure-Time Physical Activity Questionnaire. Health & Fitness Journal of Canada 2011;4(1):5.
17. Connaughton AV, Weiler RM, Connaughton DP. Graduating medical students' exercise prescription competence as perceived by deans and directors of medical education in the United States: implications for Healthy People 2010. Public Health Rep 2001;116(3):226-34.

18. Young A, Gray JA, Ennis JR. 'Exercise medicine': the knowledge and beliefs of final-year medical students in the United Kingdom. Med Educ 1983;17(6):369-73.
19. Jones PR, Brooks JH, Wylie A. Realising the potential for an Olympic legacy; teaching medical students about sport and exercise medicine and exercise prescribing. Br J Sports Med 2013;47(17):1090-4.
20. Mohler MJ, D'Huyvetter K, Tomasa L, O'Neill L, Fain MJ. Healthy aging rounds: using healthy-aging mentors to teach medical students about physical activity and social support assessment, interviewing, and prescription. J Am Geriatr Soc 2010;58(12):2407-11.
21. Bass Iii PF, Stetson BA, Rising W, Wesley GC, Ritchie CS. Development and Evaluation of a Nutrition and Physical Activity Counseling Module for First-Year Medical Students. Med Educ Online 2004;9(1):4359.
22. Glasgow RE, Emont S, Miller DC. Assessing delivery of the five 'As' for patient-centered counseling. Health Promot Int 2006;21(3):245-55.
23. Trilk JL, Phillips EM. Incorporating 'Exercise is Medicine' into the University of South Carolina School of Medicine Greenville and Greenville Health System. Br J Sports Med 2014;48(3):165-7.
24. Vallance JK, Wylie M, MacDonald R. Medical students' self-perceived competence and prescription of patient-centered physical activity. Prev Med 2009;48(2):164-6.
25. Lamarche K, Vallance J. Prescription for physical activity a survey of Canadian nurse practitioners. Can Nurse 2013;109(8):22-6.

Table 6.1: Medical students' baseline characteristics pre-course

Characteristic	**Intervention Group (n=80)**	**Control Group (n=81)**	**P-Value IG vs CG**
Age	23.39 ± 1.43	23.37 ± 1.48	0.917
Gender	41 ♂ (51.2%)	43 ♂ (53.0%)	0.881
Previous Course	n=27 (33.7%)	n=25 (30.9%)	0.657
Physical Active	n=60 (75.0%)	n=43 (81.1%)[1)]	0.551
Overall Importance	4.85 ± 0.37	4.78 ± 0.67	0.737
Conducting a physical examination	5.01 ± 0.80	5.01 ± 0.98	0.997
Determining the maximum heart rate	4.22 ± 1.14	4.05 ± 1.15	0.391
Calculating the training heart range	4.22 ± 1.15	3.95 ± 1.13	0.124
Determining the body mass index	4.92 ± 0.85	4.74 ± 1.02	0.224
Determining the nutritional needs	5.08 ± 0.88	5.03 ± 1.05	0.622
Designing an exercise prescription	4.69 ± 1.14	4.44 ± 1.28	0.160
Explaining the benefits of exercise	5.23 ± 0.77	5.38 ± 0.70	0.195
Explaining the risks of exercise	5.18 ± 0.82	5.24 ± 0.83	0.607
Referring an older person to a exercise	4.90 ± 0.88	4.99 ± 1.01	0.496
Identifying limitations to exercise	5.09 ± 0.72	5.05 ± 0.89	0.829
Overall Competence	2.94 ± 0.96	3.00 ± 0.64	0.870
Conducting a physical examination	2.13 ± 0.93	2.10 ± 1.00	0.856
Determining the maximum heart rate	3.09 ± 1.44	3.00 ± 1.41	0.695
Calculating the training heart range	2.23 ± 1.21	2.09 ± 1.15	0.452
Determining the body mass index	4.77 ± 1.22	4.73 ± 1.28	0.731
Determining the nutritional needs	2.25 ± 1.13	2.04 ± 0.99	0.200
Designing an exercise prescription	1.78 ± 0.93	1.85 ± 0.95	0.653
Explaining the benefits of exercise	4.10 ± 1.13	4.48 ± 0.96	0.023*
Explaining the risks of exercise	3.43 ± 1.10	3.78 ± 1.06	0.046*
Referring an older person to exercise	2.44 ± 1.23	2.62 ± 1.25	0.375
Identifying limitations to exercise	3.15 ± 1.06	3.43 ± 1.15	0.112

[1)]data was only available for 53 students; *significant ($p \leq 0.05$)

Table 6.2: Effects of a physical activity module on medical students' importance

EPACQ Item	**Intervention Group (n=80)**		**Important n (%)**	**Control Group (n=81)**		**Important n (%)**	**P-Value IG vs CG**
Conducting a physical examination to approve exercise	Pre	5.01 ± 0.80	74 (92.5)	Pre	5.01 ± 0.98	75 (92.3)	0.056
	Post	5.32 ± 0.83	75 (93.8)	Post	5.03 ± 0.92	75 (92.3)	
	Change	0.3 ± 1.0		Change	0.0 ± 1.0		
	P-Value	0.005*		P-Value	0.913		
Determining the maximum heart rate for an older person	Pre	4.22 ± 1.14	57 (71.3)	Pre	4.05 ± 1.15	57 (70.4)	0.040*
	Post	4.75 ± 1.06	70 (87.5)	Post	4.19 ± 1.09	57 (70.4)	
	Change	0.5 ± 1.3		Change	0.1 ± 1.2		
	P-Value	<0.001*		P-Value	0.295		
Calculating the training heart range for an older person	Pre	4.22 ± 1.15	57 (71.3)	Pre	3.95 ± 1.13	56 (69.1)	0.238
	Post	4.77 ± 1.01	70 (87.5)	Post	4.28 ± 1.04	63 (77.8)	
	Change	0.6 ± 1.3		Change	0.3 ± 1.2		
	P-Value	<0.001*		P-Value	0.021*		
Determining the body mass index for an older person	Pre	4.92 ± 0.85	76 (95.0)	Pre	4.74 ± 1.02	72 (88.9)	0.931
	Post	5.52 ± 0.70	78 (97.5)	Post	5.33 ± 0.74	79 (97.5)	
	Change	0.6 ± 1.0		Change	0.6 ± 1.2		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the caloric needs of an older person	Pre	5.08 ± 0.88	75 (93.8)	Pre	5.03 ± 1.05	73 (90.1)	0.656
	Post	5.24 ± 0.72	78 (97.5)	Post	5.26 ± 0.83	77 (95.1)	
	Change	0.2 ± 0.9		Change	0.2 ± 1.1		
	P-Value	0.107		P-Value	0.053		
Designing an exercise prescription for an older person	Pre	4.69 ± 1.14	68 (85.0)	Pre	4.44 ± 1.28	63 (77.8)	0.123
	Post	5.32 ± 0.76	77 (96.3)	Post	4.76 ± 1.26	69 (85.2)	
	Change	0.6 ± 1.2		Change	0.3 ± 1.4		
	P-Value	<0.001*		P-Value	0.038*		
Explaining the benefits of exercise to an older person	Pre	5.23 ± 0.77	75 (93.8)	Pre	5.38 ± 0.70	80 (98.8)	0.087
	Post	5.53 ± 0.70	77 (96.3)	Post	5.46 ± 0.59	80 (98.8)	
	Change	0.3 ± 0.9		Change	0.1 ± 0.8		
	P-Value	0.002*		P-Value	0.300		
Explaining the risks of exercise to an older person	Pre	5.18 ± 0.82	75 (93.8)	Pre	5.24 ± 0.83	79 (97.5)	0.163
	Post	5.51 ± 0.68	77 (96.3)	Post	5.39 ± 0.62	80 (98.8)	
	Change	0.3 ± 0.8		Change	0.2 ± 0.9		
	P-Value	<0.001*		P-Value	0.122		
Referring an older person to an exercise program	Pre	4.90 ± 0.88	73 (91.3)	Pre	4.99 ± 1.01	74 (91.4)	0.647
	Post	5.28 ± 0.75	76 (95.0)	Post	5.33 ± 0.72	78 (96.3)	
	Change	0.4 ± 0.9		Change	0.3 ± 0.9		
	P-Value	<0.001*		P-Value	0.001*		
Identifying age-related limitations to exercise in an older person	Pre	5.09 ± 0.72	76 (95.0)	Pre	5.05 ± 0.89	78 (96.3)	0.890
	Post	5.32 ± 0.76	76 (95.0)	Post	5.26 ± 0.74	79 (97.5)	
	Change	0.2 ± 0.8		Change	0.2 ± 0.9		
	P-Value	0.013*		P-Value	0.029*		
Overall importance	Pre	4.85 ± 0.37	73 (91.3)	Pre	4.78 ± 0.67	72 (88.9)	0.082
	Post	5.25 ± 0.28	77 (96.3)	Post	5.02 ± 0.57	78 (96.3)	
	Change	0.4 ± 0.6		Change	0.2 ± 0.1		
	P-Value	<0.001*		P-Value	0.001*		

Table 6.3: Effects of a physical activity module on medical students' competence

EPACQ Item	**Intervention Group (n=80)**		**Competent n (%)**	**Control Group (n=81)**		**Competent n (%)**	**P-Value IG vs CG**
Conducting a physical examination to approve exercise	Pre	2.13 ± 0.93	6 (7.5)	Pre	2.10 ± 1.00	9 (11.1)	0.001*
	Post	4.39 ± 0.94	68 (85.0)	Post	3.73 ± 0.97	54 (66.7)	
	Change	2.3 ± 1.2		Change	1.6 ± 1.1		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the maximum heart rate for an older person	Pre	3.09 ± 1.44	31 (38.8)	Pre	3.00 ± 1.41	30 (37.0)	<0.001*
	Post	4.94 ± 0.94	74 (92.5)	Post	3.91 ± 1.24	54 (66.7)	
	Change	1.8 ± 1.6		Change	0.9 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Calculating the training heart range for an older person	Pre	2.23 ± 1.21	11 (13.8)	Pre	2.09 ± 1.15	9 (11.1)	<0.001*
	Post	4.71 ± 0.92	73 (91.3)	Post	3.27 ± 1.18	32 (39.5)	
	Change	2.5 ± 1.4		Change	1.2 ± 1.4		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the body mass index for an older person	Pre	4.77 ± 1.22	67 (83.8)	Pre	4.73 ± 1.28	66 (81.5)	0.889
	Post	5.51 ± 0.75	76 (95.0)	Post	5.49 ± 0.72	78 (96.3)	
	Change	0.7 ± 1.3		Change	0.8 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the caloric needs of an older person	Pre	2.25 ± 1.13	14 (17.5)	Pre	2.04 ± 0.99	9 (11.1)	0.747
	Post	4.11 ± 1.07	60 (75.0)	Post	3.96 ± 1.07	59 (72.8)	
	Change	1.9 ± 1.2		Change	1.9 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Designing an exercise prescription for an older person	Pre	1.78 ± 0.93	4 (5.0)	Pre	1.85 ± 0.95	5 (6.2)	<0.001*
	Post	5.10 ± 0.81	76 (95.0)	Post	3.81 ± 1.14	58 (71.6)	
	Change	3.3 ± 1.2		Change	2.0 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Explaining the benefits of exercise to an older person	Pre	4.10 ± 1.13	54 (67.5)	Pre	4.48 ± 0.96	67 (82.7)	0.056
	Post	5.34 ± 0.64	78 (97.5)	Post	5.38 ± 0.66	81 (100.0)	
	Change	1.2 ± 1.2		Change	0.9 ± 1.0		
	P-Value	<0.001*		P-Value	<0.001*		
Explaining the risks of exercise to an older person	Pre	3.43 ± 1.10	34 (42.5)	Pre	3.78 ± 1.06	52 (64.2)	0.065
	Post	5.01 ± 0.76	76 (95.0)	Post	4.98 ± 0.92	76 (93.8)	
	Change	1.6 ± 1.4		Change	1.2 ± 1.2		
	P-Value	<0.001*		P-Value	<0.001*		
Referring an older person to an exercise program	Pre	2.44 ± 1.23	15 (18.8)	Pre	2.62 ± 1.25	18 (22.2)	0.003*
	Post	5.10 ± 0.80	76 (95.0)	Post	4.60 ± 1.05	70 (86.4)	
	Change	2.7 ± 1.4		Change	2.0 ± 1.4		
	P-Value	<0.001*		P-Value	<0.001*		
Identifying age-related limitations to exercise in an older person	Pre	3.15 ± 1.06	31 (38.8)	Pre	3.43 ± 1.15	40 (49.4)	0.032*
	Post	5.10 ± 0.72	78 (97.5)	Post	4.94 ± 0.74	79 (97.5)	
	Change	1.9 ± 1.3		Change	1.5 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Overall competence	Pre	2.94 ± 0.96	4 (5.0)	Pre	3.00 ± 0.64	8 (9.9)	<0.001*
	Post	4.93 ± 0.42	78 (97.5)	Post	4.40 ± 0.62	66 (81.5)	
	Change	2.0 ± 0.8		Change	1.4 ± 0.7		
	P-Value	<0.001*		P-Value	<0.001*		

Physical Activity Module (1.5 hours)

Exercise Tutorial (60mins)

"Exercise is Medicine" Guide[1] (40mins)
Step 1: Ask about physical activity level
Step 2: Screen to determine level of risk
Step 3: Customise advice
Step 4: Refer and Prescribe
Step 5: Provide information

Additional Information (20 mins)
Common exercise terms & expressions
Medical clearance for PA programs
Graded Exercise Test (GXT)

Counselling Session (30mins)

Counselling Participants (20 mins)
Medical history including chronic conditions, physical limitations and medications

Exercise advice using "Exercise is Medicine" guide and tools

Students' Presentation (10 mins)
Medical history
Exercise advice

Figure 6.1: Content of the physical activity module

Chapter 7

The Feasibility of Standardised Geriatric Assessment Tools and Physical Exercises in Frail Older Adults

Summary

Geriatric assessment tools are applicable to the general geriatric population; however, their feasibility in frail older adults is yet to be determined.

The study aimed to determine the feasibility of standardised geriatric assessment tools and physical exercises in hospitalised frail older adults.

Various assessment tools including the FRAIL Screen, the Charlson Comorbidity Index, the SF-36, the Trail Making Test (TMT), the Rapid Cognitive Screen, the Self Mini Nutritional Assessment (MNA-SF) and the Lawton iADL as well as standard physical exercises were assessed using observational protocols.

The results suggest that the FRAIL Screen, MNA-SF, Rapid Cognitive Screen, Lawton iADL and the physical exercises were deemed to be feasible with only minor comprehension, execution and safety issues. The TMT was not considered to be feasible and the SF-36 should be replaced by its shorter form, the SF-12.

In order to ensure the validity of these findings a study with a larger sample size should be undertaken.

This research has formed the basis of a research paper peer-reviewed and published in the Journal of Frailty and Aging (Appendix 6 including Statement of Authorship).

7.1. Background

Frailty is defined as a "clinically recognisable state of increased vulnerability resulting from age-associated decline in reserve and function"[1]. It includes clinical indicators, such as deficit accumulation, fatigue, sedentary behaviour, weight loss, and physical function impairment[1]. Frailty is associated with a higher risk of disability, hospitalisation, cognitive impairment and reduced quality of life[2]. It is estimated that by 2050, four million people in Australia will be either pre-frail or frail[3].

However, frailty is a dynamic syndrome that is treatable and reversible[4]. Exercise interventions are considered to be the most effective strategy for preventing, treating and delaying frailty[5]. Exercise is beneficial in increasing muscle mass, improving physical function, mobility and cognition in frail older adults, it also contributes to maintaining independence and quality of life[5]. Frail older adults are more vulnerable to stressors (i.e. illnesses or falls) compared to healthy older adults, which makes tailored interventions and the use of appropriate geriatric assessment tools crucial in the management of their condition.

Geriatric assessment tools are applicable to the general geriatric population; however, their feasibility in frail older adults is yet to be determined.

The aim of this study was to determine the feasibility of standardised geriatric assessments and standard physical exercises in hospitalised pre-frail and frail older adults.

7.2. Methods

7.2.1. Participants and Recruitment

Patients from the Geriatric Evaluation and Management Unit (GEMU) at the Queen Elizabeth Hospital in Adelaide, South Australia, aged ≥ 65 years, screened pre-frail or frail on the FRAIL Screen[6] were included in this study. Patients who were not able to communicate in English and/or were diagnosed with a significant cognitive impairment were excluded from the study. Written informed consent was obtained. Ethics approval was sought from the Central Adelaide Local Health Network Ethics Committee (HREC/16/TQEH/10). Recruitment, screening and data collection were performed on three consecutive days in the patient's room.

7.2.2. Assessment Tools and Physical Exercises

The assessment battery included seven standardised geriatric tools including the FRAIL Screen[6], Charlson Comorbidity Index (CCI)[7], 36-Item Short Form Health Survey (SF-36)[8], Trail Making Test (TMT)[9], Rapid Cognitive Screen (RCS)[10], Self Mini Nutritional Assessment (MNA-SF)[11], and the Lawton Instrumental Activities of Daily Living (Lawton iADL)[12] as well as standard physical exercises based on the LIFE study[13] comprising mobility, strength, balance, and flexibility (Appendix 1).

The feasibility was assessed using observational protocols recording time and any prohibitive issues encountered during the assessments (Appendix 2).

7.2.3. Data Analysis

Descriptive statistics in IBM SPSS Statistics Version 21 were used to analyse demographic information. Issues observed during the assessments were collated, categorised and summarised.

7.3. Results

103 patients were considered for this study. 38 patients were excluded due to not being able to communicate in English and/or having a significant cognitive impairment. 65 patients were approached. 19 patients were not interested and declined to participate. One patient was not screened as pre-frail or frail and 15 patients withdrew prior to the assessments due to illness, time issues or being discharged from hospital. The sample size included 30 patients (9 males; 30% and 21 females; 70%) with a mean age of 85.37 ± 5.71 years (Table 7.1).

7.3.1. Assessment Tools

Areas of difficulty included comprehension, execution and completion issues (Table 7.2). Comprehension issues were defined as “issues relating to the phrasing of questions and/or instructions”. Execution issues were defined as “any problems which impedes the completion or smooth progression through the assessments”.

Comprehension issues were observed with the FRAIL Screen, the CCI and the SF-36. In regards to the FRAIL Screen, 14 participants (47%) did not know whether they had more than five illnesses and seven participants (23%) could not calculate 5% of their weight. Participants were also unsure about the meaning of the terms “fatigue” (n=5; 17%) and “one flight of stairs” (n=2; 7%). In regards to the CCI, 13 participants (43%) had problems understanding the medical terminology used in the CCI. In relation to the SF-36, eight participants (27%) thought the questions were repetitive.

Issues with execution were observed with the SF-36, the RCS and the TMT. In relation to the SF-36, 16 participants (53%) commented that too many answers were offered, and seven participants (23%) commented that the SF-36 was too long. Participants with visual problems (n=3; 10%), and those with tremors and unsteady hands (n=2; 7%) found the RCS and TMT difficult to complete. In addition, seven participants (28%) had difficulties differentiating between the numeral 1 and letter I on the provided TMT sheet and eight participants (32%) were confused by the test.

Completion issues were mainly observed with the TMT where the majority of participants (n=15; 60%) were not able to complete part B of the test which involves the connection of numbers and letters in a logical order.

7.3.2. Physical Exercises

Areas of difficulty included safety, execution and equipment issues (Table 7.2). Safety issues were defined as “any issues that might include a risk for the patients”. Execution issues were defined as “any problems which impedes the completion or smooth progression through the exercises”. Equipment issues were defined as” any issues observed with the materials used”.

In terms of safety, five participants (19%) were unstable with the “sit to stand” and seven participants (28%) had difficulties in attempting the “tandem stand” and the “one leg stand” safely.

In regards to execution, 13 participants (46%) had difficulties with the mobility tasks due to stiff joints, limb oedema or pain. Three participants (11%) had difficulties isolating ankles and muscle groups to execute the mobility and strength exercises correctly and five participants (19%) had difficulties executing the flexibility tasks due to shoulder pain or arm slings.

Equipment issues were observed in two participants (7%) who found it difficult to control the elastic exercise band with their feet while doing the “bicep curls”, and three other participants (11%) found it difficult to tie the elastic band around their thigh for the “hip abduction” due to decreased coordination, tremors and rheumatoid arthritis (Table 7.2).

7.4. Discussion

Three key findings emerged from this study. Firstly, the SF-36 was considered to be too long, affecting completion rates and should be replaced by its shorter form, the SF-12. Secondly, the TMT was not considered to be feasible as the majority of participants was not able to complete the test. And thirdly, safety and appropriate equipment are key factors in exercise programs for frail older adults.

7.4.1. Assessment Tools

In regards to the FRAIL Screen, the findings suggest that questions regarding quantifying illnesses and bodyweight would be more reliably answered by examining patient's medical records which applies for the CCI as well. Issues with comprehension could lead to different interpretations influencing the outcomes of these tools. Providing unambiguous explanations for medical terms could help to reduce the possible heterogeneity in the answers. The Lawton iADL and the MNA-SF, on the other hand, were brief and easy to perform, proving the tools' feasibility for use with frail older adults. The RCS has previously been found to be valid, brief and easy to perform[10]. The results of this study confirm these findings, as the tool was found to be quick and acceptable to all study participants. The SF-36 has been used in a variety of populations, including the older age group[14]. However, there remain acknowledged issues, such as lower item completeness in disadvantaged age groups, which includes older people[14]. This study suggests a shorter questionnaire, such as the SF-12, that might be more accurate for use with frail older adults. The TMT is a sensitive instrument that tests for cognitive impairment associated with dementia[9]. Despite its clear usefulness, various issues identified in this study indicate that other or additional neuropsychological assessment tools might be useful.

7.4.2. Physical Exercises

The main barriers to older people participating in exercise are fear of falling, physical ailments and inertia, confirming that safety is a key factor in the feasibility of exercise programs in older people[15]. The results of this study confirm that it might be necessary to consider walking aids, especially in participants who are unstable on their feet and want to perform the exercises at home. Home-based exercises are considered to be effective in improving physical function in frail older people[5]. However, safety is crucial in reducing the risk of adverse events. Further, many participants in this study experienced stiff joints, limb oedema or pain confirming that physical limitations and co-morbidities affecting physical movement and vision are other key issues that could limit the successful execution of exercise programs. Regarding equipment, issues can be expected in the use of elastic bands. Using the own body weight or dumbbells could be an alternative.

7.5. Conclusion

This study suggests that geriatric assessment tools need to be amended in relation to being brief and comprehensible. Alternative or additional tools for neuropsychological assessments should be considered to accommodate the frail population's physical and mental limitations. This study also indicated that in order to optimise the exercise programs for frail older adults adjustments to the exercises should be made, especially in regards to safety and adequate equipment.

7.6. References

1. Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27(1):1-15.
2. Weiss CO. Frailty and Chronic Diseases in Older Adults. Clin Geriatr Med 2011;27(1):39-52.
3. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 2012;60(8):1487-1492.
4. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-423.
5. Liu CK, Fielding RA. Exercise as an intervention for frailty. Clin Geriatr Med 2011;27(1):101-110.
6. Morley JE, Vellas B, van Kan GA, et al. Frailty consensus: a call to action. J Am Med Dir Assoc 2013;14(6):392-397.
7. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40(5):373-383.
8. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992;30(6):473-483.
9. Salthouse TA. What cognitive abilities are involved in trail-making performance? Intelligence 2011;39(4):222-232.

10. Malmstrom TK, Voss VB, Cruz-Oliver DM, et al. The Rapid Cognitive Screen (RCS): A Point-of-Care Screening for Dementia and Mild Cognitive Impairment. J Nutr Health Aging 2015;19(7):741-744.
11. Kaiser MJ, Bauer JM, Ramsch C, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging 2009;13(9):782-788.
12. Graf C. The Lawton Instrumental Activities of Daily Living (IADL) Scale. Medsurg Nurs 2009;18(5):315-316.
13. Cesari M, Vellas B, Hsu FC, et al. A Physical Activity Intervention to Treat the Frailty Syndrome in Older Persons-Results From the LIFE-P Study. J Gerontol A Bio Sci Med Sci. 2015:70(2):216-222.
14. Bartsch LJ, Butterworth P, Byles JE, Mitchell P, Shaw J, Anstey KJ. Examining the SF-36 in an older population: analysis of data and presentation of Australian adult reference scores from the Dynamic Analyses to Optimise Ageing (DYNOPTA) project. Qual Life Res 2011;20(8):1227-1236.
15. Lees FD, Clarkr PG, Nigg CR, Newman P. Barriers to exercise behavior among older adults: a focus-group study. J Aging Phys Act 2005;13(1):23-33.

Table 7.1: Cut-off criteria and participants' characteristics

Assessments	Cut-Off Criteria	n	(%)
FRAIL Screen	1-2 pre-frail	7	(23%)
	≥ 3 frail	23	(77%)
Charlson Comorbity Index	≤ 3 low mortality risk	21	(70%)
	4-5 moderate mortality risk	3	(10%)
	≥ 6 high mortality risk	6	(20%)
Lawton iADL	7-8 independent	11	(37%)
	4-6 moderately dependent	12	(40%)
	0-3 highly dependent	6	(20%)
Rapid Cognitive Screen	8-10 normal	7	(23%)
	6-7 mildly impaired	8	(27%)
	0-5 dementia	10	(33%)
MNA Short Form	12-14 normal	4	(13%)
	8-11 at-risk	14	(47%)
	0-7 malnourished	11	(37%)

Table 7.2: Issues encountered with geriatric assessment tools and physical exercises

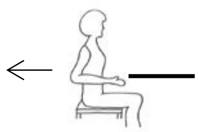
Assessment tools	**Total n**	**Time (mins ± SD)**	**Comprehension n (%)**	**Execution n (%)**	**Completion n (%)**
FRAIL Screen	30	1:46 ± 0:43	14 (47%)	-	-
Charlson Comorbidity Index	30	2:53 ± 1:04	13 (43%)	-	-
SF-36	30	14:37 ± 5:06	8 (27%)	23 (77%)	-
Lawton iADL	30	3:43 ± 2:00	-	-	-
Rapid Cognitive Screen	29	4:27 ± 2:14	-	5 (17%)	-
Trail Making Test	25	5:36 ± 2:37	-	20 (80%)	15 (60%)
MNA-SF	30	2:30 ± 1:01	-	-	-
Physical exercises	**Total n**	**Time (mins ± SD)**	**Safety n (%)**	**Execution n (%)**	**Equipment n (%)**
Mobility	28	2:08 ± 0:29	-	13 (46%)	-
Strength	27	5:15 ± 0:56	5 (19%)	3 (11%)	5 (19%)
Balance	25	1:24 ± 0:36	7 (28%)	-	-
Flexibility	27	0:34 ± 0:06	-	5 (19%)	-

7.7. Appendix 1

Warm-Up/Mobility

Shoulder circles	Wrist circles	Ankle circles
		

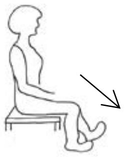
Strength

Task	Explanation
	**KNEE EXTENSION** Sit comfortably in your chair. Extend your foot out in front of you, hold for up to 2 seconds, and return to the starting position in a slow, controlled manner.
	**SIT TO STAND USING ARMS** Move forward in your chair. Place your feet slightly apart on the floor. Use your arms on the arm rest to push up and move from sitting to standing slowly. Return to your seat in a slow, controlled manner.
	**HIP ABDUCTION** Sit up straight. Place loop around thighs and secure with your hands. Slowly open your thighs against the resistance of the loop.
	**HIP ADDUCTION** Sit up straight. Place a pillow or soft ball between your thighs and secure with your hands. Slowly squeeze your thighs together against the resistance of pillow or ball
	**BICEP CURL** Sit comfortably in your chair. Fix one end of the theraband under your feet or the chair. Keeping your elbow close to your side, lift the theraband up to your shoulder, and return to the starting position in a slow, controlled manner.
	**SEATED ROW** Sit comfortably in your chair. Hold the theraband out in front of you. Pull the theraband towards your body, extending your elbows back behind you, squeezing your shoulder blades together, and return to the starting position in a slow, controlled manner
	**HEEL / TOE RAISE** Stand comfortably behind your chair. Stand up on your toes, hold for up to 5 seconds, and return to the starting position in a slow, controlled manner. Lift your toes up towards your knees, and return to the starting position in a slow, controlled manner.

Balance

Task	Explanation
	**TANDEM STAND** Stand up tall and look ahead. Place one foot directly in front of the other so your feet form a straight line. Hold position for 5 seconds and place the foot behind in front.
	**ONE LEG STAND** Stand up tall and look ahead. Stand on one leg and try to hold this position for 5 seconds. Stand on the other leg and repeat the exercise.

Flexibility

Task	Explanation
	**LEG FLEXIBILITY** Sit comfortably in your chair. Extend one foot out in front of you and lean with upright upper body towards your extended leg. Hold this position for 5 seconds and repeat with other leg.
	**ARM LIFT** Sit comfortably in your chair. Lift one arm slowly and as high as possible. Hold this position for 5 seconds and repeat the exercise with the other arm.

Appendix 2

Feasibility Protocol for Assessment Tools

Patient ID:___________ **Date: ____/____/______**

	Time	Language Issues, Execution Problems , Other Issues
Demographic Information		
FRAIL Screen		
Comorbidity Questionnaire		
SF-36		
Lawton iADL		
Rapid Cognitive Screen		
Trail Making Test		
MNA-SF		

Feasibility Protocol for Exercises

Patient ID:___________ **Date: ____/____/______**

	Time	Safety Issues, Execution Problems, Other Issues
Warm-Up/ Mobility **- Shoulder Circles** **- Wrist Circles** **- Ankle Circles**		
Strength 1 **(name exercise)**		
Strength 2 **(name exercise)**		
Strength 3 **(name exercise)**		
Strength 4 **(name exercise)**		
Strength 5 **(name exercise)**		
Balance, **Tandem Stand**		
Balance, **One Leg Stand**		
Flexibility, **Leg Flexibility** **Arm Lift**		

Chapter 8

The EXPRESS Study: EXercise and PRotein Effectiveness Supplementation Study Supporting Autonomy in Community Dwelling Frail Older People: Study Protocol for a Randomised Controlled Pilot and Feasibility Study

Summary

Research has repeatedly demonstrated that exercise has a positive impact on physical function, and is beneficial in the treatment of physical frailty. However, an even more effective strategy for managing physical frailty might be the combination of multicomponent exercise with the intake of high-quality protein supplements, but the efficacy remains unclear for older adults who are already pre-frail and frail.

The aim was to examine the feasibility of recruiting frail older adults to participate in a trial designed to determine the potential effects of a six month exercise and nutrition intervention on physical function. The feasibility objectives included frail older peoples' compliance, the safety and tolerability of the trial, the estimation of estimates to aid sample size calculation, and the potential efficacy. Primary outcomes included gait speed, grip strength and physical performance. Secondary outcomes included frailty status, muscle mass, nutritional intake, physical activity levels, cognitive performance and quality of life.

This study will provide much needed insight into the feasibility of recruiting and retaining frail older adults into community-based intervention programs, while providing knowledge relating to the safety, tolerability and benefits of a combined exercise and protein supplement program designed to halt or reverse the transition of physical frailty in the community. If shown to be effective, this strategy could be included in best practice clinical guidelines for community-dwelling older adults who are pre-frail or frail.

This research has formed the basis of a research protocol peer-reviewed and published in BMC Pilot and Feasibility Studies (Appendix 7 including Statement of Authorship).

8.1. Background

Globally, the number of people aged 65 years and older is expected to triple over the next 30 years[1,2]. In Australia, it is estimated that approximately 10 million people will be aged over 65 years by 2050[3]. A common geriatric syndrome associated with ageing is frailty[4]. Frailty is defined as a "clinically recognisable state of increased vulnerability resulting from age- associated decline in reserve and function"[2] and results in increased morbidity, including disability, loss of independence, increased hospitalisations and reduced quality of life[5,6]. While frailty is measured using different scales, one of the most commonly used instruments is the Fried Frailty Index[7], which defines frailty according to a physical phenotype consisting purely of physical components. This construct of a physical phenotype is regarded as being distinct from disability or co-morbidity, and hence, the Frailty Index is considered to be highly predictive of future decline in physical health.

Due to the appreciation of the Fried Frailty Index as a relatively easy tool with which to determine whether a person is physically frail, there have been a number of studies that have described the prevalence of this phenotype in different regions around the world. The Survey of Health, Aging and Retirement in Europe (SHARE) surveyed older adults across Europe and Israel using the Fried criteria[7], and the prevalence of frailty was reported to be 17% (range 5.8% in Switzerland to 27.3% in Spain)[8]. Data from a longitudinal cohort of Australian women using similar frailty criteria reported the same prevalence of pre-frail and frail[9] and, by 2050, this is estimated to represent four million Australians[10]. These data provide impetus for the development of strategies that can be used to either halt or reverse the transition of physical frailty and the manifestation of poor health outcomes. Otherwise, increasing poor health and healthcare costs among this population cannot be mitigated[2,11].

While physical frailty appears to be reversible when early intervention is provided[7.9] there remains a lack of consensus regarding the management of older people who are frail or have complex health conditions. Evidence indicates that exercise is critical in managing many of the physiological changes that occur as individuals' age[4,12]. Exercise interventions, particularly those that include resistance training, have the potential to prevent, delay and reverse frailty[13]. For example, numerous studies have demonstrated that exercise maintains and restores one or more health parameters including muscle strength, bone integrity, balance and physical function in study populations that include older people who were relatively healthy (i.e. those without a clinical diagnosis)[14], and those classified as frail according to a variety of methods[12,15]. However, the strength of the evidence from meta-analyses regarding the benefits of exercise for frail older people was limited by the fact that many of the studies reviewed included small and heterogeneous study populations. Few studies have simultaneously measured markers of muscle mass, strength, and function; the type of control activity used as the comparator for an exercise intervention has been highly variable; and the compliance to programs has not been well reported. In addition, a study of 151 community-living pre-frail and frail older adults in Singapore showed that improvements in frailty status and a variety of biomarkers of physical frailty were largely comparable for the nutrition, physical, cognitive and combined treatments and all resulted in greater improvement compare with the control (i.e. standard care from health and aged care services in combination with a placebo nutritional supplements. However, while there were no statistically significant differences between the nutrition, physical, cognitive and combined treatments, the improvements in all measured domains where greatest with the physical and combined groups[16]. Accordingly, more studies are needed to identify feasible exercise programs, alone and in combination with other treatments, for community-dwelling pre-frail and frail older adults.

With respect to the nutritional management of pre-frail and frail older people, very few studies have been conducted to determine the effects of protein supplements, either on their own, or in combination with exercise. Numerous studies have demonstrated substantial benefits of protein supplementation in combination with resistance exercise in healthy older adults[17,18]. However, only three studies have been conducted in frail older adults and have yielded conflicting results for the benefits of protein on muscle mass and markers of strength and mobility[19,20,21]. One study reported increased mobility, but no increase in skeletal muscle mass or strength when consuming additional protein[19], while another showed that protein supplements do not increase the effects of high-intensity functional exercise[21]. Yet another concluded that resistance training, when combined with protein intake, did lead to increased muscle mass compared to resistance training alone[20]. Discrepant findings are likely to be the results of differences in study protocols and participants, with some study samples being too small, while others provided insufficient protein or administered the protein as a single bolus dose, or did not control for differences in background diet.

In addition to the aforementioned limitations of previous research conducted in the ageing field, another major issue are the varied tools used to identify pre-frail and frail older adults. There remains little agreement regarding the diagnostic test accuracy of any of the simple, common diagnostic tests for community-dwelling people. Although interest in the FRAIL Screen is increasing for a number of reasons, this quick, simple screening tool does not require measurements by health professionals and has been validated in various populations across the globe[22-14]. It includes five questions about fatigue, resistance, ambulation, illness, and weight loss, representing the phenotypic definition for frailty[7]. The FRAIL Screen can be completed in 15 seconds. The brevity and simplicity make it useful as a screening tool for implementation in primary care, and it is said to be capable of detecting changes in frailty bi-directionally, and thus may be useful in monitoring for change[22].

Given the incompleteness of our knowledge relating to the efficacy of protein supplements in combination with exercise interventions on physical function in people aged 65 years and older, and who are recognised as pre-frail/frail, more information is required. Without a fuller understanding of the effects of a supplement-exercise regimen on frail community-dwelling older adults, it will continue to be difficult, if not impossible, to successfully manage their condition.

8.2. Methods

The primary aim of this six month study is to report on the feasibility of recruiting frail adults aged 65 years and older using the FRAIL screen (e.g. source, speed, etc.) and retaining them for the entire six month intervention (e.g. compliance, safety, tolerability etc.).

The feasibility objectives will include the recruitment of pre-frail and frail older people from the community using several recruitment channels, how well pre-frail and frail older people comply with the exercise and nutritional components of the intervention, their completion of the baseline, 3 and 6 month assessments, and the safety and tolerability of the intervention. This information will be used to estimate the sample size required for the main trial and the potential efficacy of the main trial.

In addition, the study aims to determine the effects of exercise in combination with a protein supplement. The supplement will be either a (a) commercially available high-quality whey protein supplement or (b) a control supplement which is a commercially available lower-quality rice protein. Changes in response to exercise in combination with either the low or high quality protein supplement will be determined by measurements of the:

- primary outcomes, including gait speed, grip strength and physical performance, and
- secondary outcomes, including frailty status, muscle mass, quality of life, nutritional intake, cognitive performance and physical activity levels.

The primary and secondary outcomes listed above will potentially be used in the main trial after their feasibility is confirmed in this pilot trial.

8.2.1. Study Design

A randomised, parallel, control pilot study will be conducted in a community setting. Participants will be assessed at baseline, at three months and at six months. Participants will be able to withdraw from the study at any time and will have their final assessments completed within one week of withdrawal.

8.2.2. Participants

Participants will be eligible for this study if they are aged 65 years and older, able to converse in English, live in the community, and are identified as being pre-frail (i.e. have a score ≥1 but <3 out of 5) or frail (i.e. have a score ≥3 out of 5) using the FRAIL Screen[22], including the following five questions:

- Are you fatigued?
- Do you have difficulties walking up one flight of steps?
- Are you unable to walk at least one block?
- Do you have more than five illnesses?
- Have you lost more than 5% of your weight in the past 6 months?

Participants with dementia (i.e. score 5 or less out of 10) as per the Rapid Cognitive Screen[25], severe renal impairment (eGFR <30 mmol/L) and those unable to comply with the exercise or nutrition study protocol will be excluded.

8.2.3. Recruitment

Participants will be recruited through social media (e.g. Facebook), public seminars, local newspapers, radio and television advertising, as well as flyers displayed in newsletters and the halls of collaborative aged care services, medical centres, GP practices and the Queen Elizabeth Hospital in Adelaide, South Australia, Australia. The flow of participants through the study will be captured as per the CONSORT statement and as depicted in Figure 8.1.

8.2.4. Randomisation and Blinding

The study coordinator will enrol eligible participants into the study and send a participant's identification number to the study biostatistician who will randomise the participants to one of the two study arms using a stratification system to ensure that an approximately equal numbers of men and women, aged (<80 and >80 years), and who are pre-frail (score ≥1 but <3 out of 5) and frail (score ≥3 out of 5), are allocated to each arm. The biostatistician will then notify the dietician on the allocated arm prior to the start of the intervention. The participants, as well as the study co-ordinator and research staff performing the study assessments, will be blinded to the two different types of protein supplements until the end of the trial.

8.2.5. Exercise Intervention

The exercise intervention will be undertaken by all participants who will be supervised by trained exercise physiologists. The exercise regimen includes one centre-based group exercise and two home-based exercise sessions, in addition to walking twice a week. During holiday periods or periods of illness, centre-based exercise can be missed, but participants will be asked to do an additional home-based exercise session if possible. These flexible approaches to the exercise regimen will be recorded.

The exercise prescription is based on the LIFE study, a physical activity intervention for community-dwelling frail older people conducted in the USA[26]. Multi-component exercises incorporating strength, balance, aerobics and flexibility were selected from the LIFE Study and modified for this pilot intervention. Strength exercises will be performed using own body weight, elastic exercise bands and ankle weights. The aerobic modality will be performed using walking exercise. The balance modality will include at least two balance tasks and the flexibility modality will include upper- and lower extremities. Exercises that are safe and that can be executed in a sitting or safe standing position will be prescribed for the home-based-exercise program. Additional exercises that may require more supervision will be included in the centre-based exercise sessions. The intensity of the exercises is based on the LIFE Study design using the Borg Scale[26,27]. The Borg Scale allows a rating of perceived exertion (RPE) and can be used to monitor and control the intensity of exercise interventions. Strength exercises will be conducted at 15-16 RPE and walking will be conducted at 12-14 RPE[27].

8.2.6. Nutrition Intervention

A qualified dietician will provide the nutrition prescription and instruct participants on how to prepare and consume the protein supplements, and how to record them in the provided compliance diaries. All protein supplements will be provided as a powder in individual 26g sachets to provide 20g of protein. The protein powder (i.e. whey or rice protein) will be blended with a powdered flavour (i.e. vanilla) and reconstituted in ~150ml of water by the participants at home. All drinks will be isocaloric (i.e. both supplying ~90 kcal per 26g protein sachet) and isonitrogenous (~3.5 g of nitrogen per 26g protein sachet) and of comparable taste, texture and aroma. The protein powder will be packaged in identical pharmaceutical grade silver foil sachets marked with an A or B to ensure that participants and the study co-ordinator and research staff performing all study assessments are blinded.

The protein load, source and timing of consumption are based on the recommendations by the PROT-AGE group[28] and the aforementioned meta-analyses[17,18,29]. Splitting the total load of protein into two supplements per day is based on evidence that a load of 20g when combined with multicomponent exercise is sufficient to increase muscle protein synthesis in healthy, non-frail older people. During periods of hospitalisation, research staff will interact with the participant and treating health professionals to encourage, where safe to do so, continuation with the supplementation. Also, it is anticipated that participants will take sachets with them on holidays, thus continuing with supplementation.

8.2.7. Screening and Assessments

8.2.7.1. Screening

Participants will be screened for eligibility over the phone using the FRAIL Screen[22] and demographic and health related information will be collected. Medical clearance and serum creatinine investigation will then be obtained from participants' general practitioner before a home visit is scheduled for further screening. The home visit will include the Rapid Cognitive Screen (RCS)[25], the Charlson Co-morbidity Index[30], the Geriatric Depression Screen-5 (GDS-5)[31], Katz Activities of daily living (KATZ ADL)[32], and a safety check to ensure participants exercise in a safe home environment. The screening process over the phone will take approximately five minutes and the home assessments will take approximately 30 minutes for each participant. The Short Form Health Survey-36 (SF-36)[33] and the Lawton Instrumental Activities of Daily Living (Lawton iADL)[34,35] questionnaire will be completed by the participants as self-assessments. At the completion of the screening, inclusion and exclusion criteria will be reviewed by the research team's co-ordinator, and participants who fulfil all eligibility criteria will be enrolled into the six month nutrition and exercise intervention.

8.2.7.2. Completion of Baseline, Three and Six Month Assessments

At baseline, and at three and six months after commencing the nutrition and exercise intervention, assessments will be performed at the participants' closest study centre (currently two locations including the Queen Elizabeth Hospital in the western suburbs and the Centre for Physical Activity in Ageing in the north-east of the city).

Baseline assessments will be conducted approximately one week after participants have completed the screening process and been enrolled into the study. These assessments will take approximately one hour per participant and include the Trail Making Test[36], gait speed, grip strength (using a handgrip dynamometer)[37], Short Physical Performance Battery (SPPB)[38], Timed Up and Go Test (TUG)[39], bioelectrical impedance analyses (BIA)[40], 24 hour dietary recall[41] and an accelerometer attached to the participant's thigh[42]. The accelerometer will be collected one week later. At that time, participants will commence their exercise program (with the first session being a centre-based exercise class), and consuming their allocated twice daily protein supplements.

The Rapid Cognitive Screen (RCS)[25], the Charlson Co-morbidity Index[30] and the Self Mini Nutritional Assessment (MNA-SF)[43,33] will be conducted only at baseline to determine participants' risk of cognitive impairment, five-year mortality and malnutrition.

A timeline of the screening process, interventions and assessments is displayed in Table 8.1. An overview of the assessment tools used to measure the potential primary and secondary outcomes related to the patient-centred objectives for the main trial at baseline, three months and six months is displayed in Table 8.2.

8.2.8. Compliance and Safety

Compliance diaries will be handed out to participants with instructions provided on how to complete them; specifically, they will be asked to record the timing and number of supplements consumed per day. The researchers will check compliance with the supplements and exercise prescription on a weekly basis for the first two weeks and then every two weeks thereafter if no problems are evident. If the study team identify a participant's compliance to the planned number of exercise sessions per fortnight, or the planned number of protein sachets, is less than 70% (i.e. <7 exercise sessions attended, or <20 sachets consumed), the research exercise physiologist and dietician, respectively, will interview the participant to assess any difficulties and identify strategies that could facilitate compliance.

For participants who have glomerular filtration rates (GFR) of >30 but <60 ml/min/1.73m^2, the GFR will be retested at three and six months, and if deterioration is noted (very unlikely), the medical registrar will liaise with the general practitioner and the participant for further assessment and management. Protein supplementation can be safely prescribed up to 1.2g/kg body weight/day where GFR is >60[28].

Adverse events (AEs), that is, any untoward medical occurrences (i.e. pain, discomfort, wind, headaches, noticeable difference in body and memory) will be investigated during all visits, whether or not they are related to the study product or physical regimen. The events will be reviewed by the study's medical registrar and participants will be referred to the research physician as required.

8.2.9. Statistical Analyses

Statistical advice has been provided by a co-investigator (KL) who is a professional biostatistician; she will be responsible for overseeing all statistical analysis for the team. Descriptive analyses will be used to assess the completeness and variability of the outcomes using means, medians, standard deviations and ranges as appropriate. Mean and median outcomes within each group will be presented with 95% confidence intervals to help inform power calculations for a possible definitive trial. A preliminary assessment of the efficacy of the treatment will also be conducted via an intention-to-treat analysis. For each study outcome, the change from baseline after three months and six months will be compared between the two study arms. These analyses will be estimated in an ANCOVA model with the three and six months value as outcome and the baseline value age, gender and frailty status as covariates. The resulting treatment effect will be reported as the least square mean and 95% confidence interval for the primary outcomes of gait speed, grip strength and physical performance. A plot of changes over time for pre-frail and frail participants will be used to observe whether changes in the frailty status can be seen.

If recruitment is going to take substantially longer than twelve months, an interim analysis will be performed on the numbers of participants who have completed the study within that period, and a decision will be made as to whether the study is feasible to complete within a reasonable timeframe of an additional twelve months.

8.3. Discussion

Frailty is a major public health issue. It directly, and also indirectly through increased disability, contributes to increased health and aged-care costs of elderly populations around the world[2]. Frailty is a continuum of accumulated lifetime assaults on the body that compromises physical and/or mental equilibrium, predisposing older adults to increased dependency on health-care resources[4]. Adults who are identified as being pre-frail have an increased risk over the next three to four years of becoming frail, requiring greater support in performing activities of daily living, and maintaining independence[7]. This means the early detection of frailty is pivotal for timely interventions that may assist in managing this geriatric condition and reducing health-care costs, and to date there remains a paucity of information about lifestyle interventions that may be beneficial for this target population. While exercise in combination with protein supplementation has been shown to positively impact a variety of physical and/or psychological health attributes in pre-frail and/or frail older people, several aspects related to the study design of previous research, still limit the interpretation of the collective results. Accordingly, the proposed study protocol hopes to extend the current knowledge in this area by specifically examining the feasibility, tolerability, efficacy and safety of consuming twice daily protein supplements in the context of a multicomponent exercise program.

Recruiting and retaining frail older adults into community-based intervention programs is a major issue that prior research has identified and is generally the reason why many studies report relatively small numbers of participants (and especially small numbers of completers)[45]. Accordingly, this study has been designed to represent and test the efficacy of a pragmatic, community-led, exercise and nutrition program which is based on postulated hypotheses that remain to be debated within the fields of nutrition and gerontology[28]. Addressing many of the methodological limitations noted in the background literature, this study protocol should optimise the ability to recruit pre-frail and frail older participants who want to remain independent and engaged within their communities. For example, participants will be diagnosed as being pre-frail or frail using the FRAIL Screen which can be easily used in all primary care settings because it is simple and quick; as such, a variety of recruitment channels will target to promote the study including general practise clinics, age-care organisations, groups that are dedicated to supporting older adults and also the general public via social media channels. Secondly, on a weekly basis throughout the six month intervention, our multi-disciplinary research team consisting of geriatricians, age-care nurses, exercise physiologists and dieticians/nutritionists will be supporting each participant - albeit in a group setting - to build a study community that should assist with maintaining participant motivation. Thirdly, the personalised tailoring of the exercise program should also maximise the likelihood that each participant will progressively improve their strength, flexibility, balance and endurance, and thereby improve their physical health and overall wellbeing.

Regarding the protein supplementation part of the program, participants will be instructed to consume the daily protein supplements in close proximity (i.e. <1 hr) to the completion of the exercise and in between meals on non-exercise days. The timing of consumption was based on the ongoing theory that resistance training increases amino acid delivery to the muscles, as well as absorption; hence, participants should be consuming an adequate amount of substrate, and in a timeframe, that should maximise stimulation of muscle protein synthesis[46]. Moreover, there is consistent evidence that whey protein rather than casein, milk, soy, or pea is more superior at promoting muscle protein synthesis or building muscle mass due to its higher quality (i.e. higher free amino acid to total amino acid content, and especially its high essential, branched-chain, and leucine content)[47]. However, other plant based proteins such as rice or pea protein are popular with consumers and while they are of lower protein quality, evidence regarding their impact on muscle mass, strength or physical performance/function, particularly when consumed over several months, remains scant. Therefore, this study will directly compare a whey protein supplement (i.e. higher quality protein) to a rice protein supplement (i.e. a lower quality protein) to address this concern. Long-term tolerability and safety to both proteins, as well as to the exercise program, will also be an important issue addressed within this study.

8.4. Conclusion

This study is expected to provide much needed insight into the feasibility of recruiting and retaining frail older adults into community-based intervention programs, while providing knowledge relating to the safety, tolerability and benefits of a combined exercise and protein supplement program designed to halt or reverse the transition of physical frailty in the community. If shown to be effective, this strategy could be used to inform the design of cost-effectiveness trials which will be necessary if public health policy makers and funders are to be strategically influenced. Evaluation of the collective findings from current and future research will be critical to refine and extend current best practice clinical guidelines for community-dwelling older people who are pre-frail or frail.

8.5. References

1. Kinsella K, He W. An Aging World: 2008. In: US Census Bureau (Ed). International Population Reports. Washington, DC: Government Printing Office, 2009;95/09-1.
2. Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27:1-15.
3. Kippen R. The Future Extent of Population Ageing in Australia. J Popul Res 2002(Special ed. 2002):151-9.

4. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381:752-62.
5. Clark BC, Manini TM. Functional consequences of sarcopenia and dynapenia in the elderly. Curr Opin Clin Nutr Metab Care 2010;13:271-6.
6. Weiss CO. Frailty and Chronic Diseases in Older Adults. Clin Geriatr Med 2011;27:39-52.
7. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56:M146-56.
8. Michel JP, Cruz-Jentoft AJ, Cederholm T. Frailty, Exercise and Nutrition. Clin Geriatr Med 2015;31:375-87
9. Cameron ID, Fairhall N, Langron C, Lockwood K, Monaghan N, Aggar C, et al. A multifactorial interdisciplinary intervention reduces frailty in older people: randomized trial. BMC Med 2013;11:65.
10. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 2012;60:1487-92.
11. AIHW. Health expenditure Australia 2008–09. Welfare AIoHa. 2010.
12. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res 2011;2011:569194.
13. Cesari M, Vellas B, Hsu FC, Newman AB, Doss H, King AC, et al. A Physical Activity Intervention to Treat the Frailty Syndrome in Older Persons-Results From the LIFE-P Study. J Gerontol A Biol Sci Med Sci 2015;70:216-22.
14. Bouaziz W, Lang PO, Schmitt E, Kaltenbach G, Geny B, Vogel T. Health benefits of multicomponent training programmes in seniors: a systemtic review. Int J Clin Pract 2016;70:520-36.
15. de Labra CG-P, C.; Maseda, A.; Lorenzo, T.; Millan-Calenti, J. C. Effects of physical exercise interventions in frail older adults: a systematic review of randomized controlled trials. BMC Geriatrics 2015;15:16.
16. Ng TP, Feng L, Zin Nyunt MS, Feng L, Niti M, Tan BY, et al. Nutritional, Physical, Cognitive and Combination Interventions and Frailty Reversal among Older Adults: A Randomized Controlled Trial. Am J Med 2015;128:1225-36.

17. Cermak NM, De Groot LCPGM, Van Loon LJC. Perspective: Protein Supplementation During Prolonged Resistance Type Exercise Training Augments Skeletal Muscle Mass and Strength Gains. J Am Med Dir Assoc 2013;14:71-2.
18. Finger D, Goltz FR, Umpierre D, Meyer E, Rosa LH, Schneider CD. Effects of protein supplementation in older adults undergoing resistance training: a systematic review and meta-analysis. Sports Med 2015;45:245-55.
19. Björkman MP, Finne-Soveri H, Tilvis RS. Whey protein supplementation in nursing home residents. A randomized controlled trial. Eur Geriatr Med 2012;3:161-6.
20. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2012;13:713-9.
21. Rosendahl E, Lindelof N, Littbrand H, Yifter-Lindgren E, Lundin-Olsson L, Haglin L, et al. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: a randomised controlled trial. Aust J Physiother 2006;52:105-13.
22. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. J Am Med Dir Assoc 2013;14:392-7.
23. Woo J, Leung J, Morley JE. Comparison of frailty indicators based on clinical phenotype and the multiple deficit approach in predicting mortality and physical limitation. J Am Geriatr Soc 2012;60:1478-86.
24. Woo J, Yu R, Wong M, Yeung F, Wong M, Lum C. Frailty Screening in the Community Using the FRAIL Scale. J Am Med Dir Assoc 2015;16:412-9.
25. Malmstrom TK, Voss VB, Cruz-Oliver DM, Cummings-Vaughn LA, Tumosa N, Grossberg GT, et al. The Rapid Cognitive Screen (RCS): A Point-of-Care Screening for Dementia and Mild Cognitive Impairment. J Nutr Health Aging 2015;19:741-4.
26. Cesari M, Vellas B, Hsu FC, Newman AB, Doss H, King AC, et al. A physical activity intervention to treat the frailty syndrome in older persons-results from the LIFE-P study. J Gerontol A Biol Sci Med Sci 2015;70:216-22.
27. Pritchett RC, Del Pozzi AT, Katica CP, Pritchett KL. Field Test Validation Of The Borg 15-point Categorical Scale For Rating Of Perceived Exertion. Med Sci Sports Exerc 2011;43:86.
28. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people:

a position paper from the PROT-AGE Study Group. J Am Med Dir Asso. 2013;14:542-59.

29. Cawood AL, Elia M, Stratton RJ. Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. Ageing Res Rev 2012;11:278-96.
30. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373-83.
31. Yesavage JA. Geriatric Depression Scale. Psychopharmacol Bull 1988;24(4):709-11.
32. Shelkey M, Wallace M. Katz Index of Independence in Activities of Daily Living (ADL). Director 2000;8:72-3.
33. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992;30:473-83.
34. Graf C. The Lawton Instrumental Activities of Daily Living (IADL) Scale. Medsurg Nurs 2009;18:315-6.
35. Bourne PA. Activities of daily living, instrumental activities for daily living and predictors of functional capacity of older men in Jamaica. N Am J Med Sci 2009;1:184-92.
36. Salthouse TA. What cognitive abilities are involved in trail-making performance? Intelligence 2011;39:222-32.
37. Visser M, Deeg DJ, Lips P, Harris TB, Bouter LM. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. J Am Geriatr Soc 2000;48:381-6.
38. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol 1994;49:M85-94.
39. Podsiadlo D, Richardson S. The timed 'Up & Go': a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39(2):142-8.
40. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol (1985) 2000;89:465-71.
41. Conway JM, Ingwersen LA, Moshfegh AJ. Accuracy of dietary recall using the USDA five-step multiple-pass method in men: an observational validation study. J Am Diet Assoc 2004;104:595-603.

42. Murphy SL. Review of physical activity measurement using accelerometers in older adults: considerations for research design and conduct. Prev Med 2009;48:108-14.
43. Huhmann MB, Perez V, Alexander DD, Thomas DR. A self-completed nutrition screening tool for community-dwelling older adults with high reliability: a comparison study. J Nutr Health Aging 2013;17:339-44.
44. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging 2009;13:782-8.
45. Harris R, Dyson E. Recruitment frail older people to research: lessons learnt through experience. J Adv Nurs 2001;36:643-51.
46. Phillips SM. The impact of protein quality on the promotion of resistance exercise-induced changes in muscle mass. Nutr Metab 2016;13:64.
47. Devries MC, Phillips SM. Supplemental protein in support of muscle mass and health: advantage whey. J Food Sci 2015;80 Suppl 1:A8-A15.

Table 8.1: Schedule of enrolment, interventions and assessments

TIMEPOINT	Screening -T2	Home Visit -T1	Baseline 0	3 Months T1	6 Months T2
ENROLMENT					
Eligibility	X	X			
Blood Investigation	X				
Medical Clearance	X				
Informed Consent			X		
Randomisation			X		
INTERVENTIONS					
Intervention A			←	—	→
Intervention B			←	—	→
ASSESSMENTS					
Demographic information	X	X			
Charlson Comorbity Index		X			
Rapid Cognitive Screen		X			
MNA - Short Form			X		
FRAIL Screen	X			X	X
Katz ADL		X		X	X
Lawton ADL		X		X	X
SF-36		X		X	X
GDS-5		X		X	X
Trail Making Test			X	X	X
Nutritional Recall			X	X	X
Gait Speed			X	X	X
Grip Strength			X	X	X
SPPB			X	X	X
Timed Up & Go			X	X	X
BIA			X	X	X
Accelerometer			X	X	X

Table 8.2: EXPRESS Study assessments and cut-off criteria

EXPRESS Study Assessments	Cut-Off Criteria		
Demographic information			
Charlson Comorbity Index	≤ 3 low risk	4-5 moderate risk	≥ 6 high risk
Rapid Cognitive Screen	8-10 normal	6-7 mild impaired	5 dementia
MNA-SF	12-14 normal	8-11 at-risk	0-7 malnourished
FRAIL Screen	0 robust	1-2 pre-frail	≥ 3 frail
Katz Activities of Daily Living	6 full function	4 moderate impaired	≤ 2 severe impaired
Lawton iADL	0-3 high dependent	4-6 moderate dependent	7-8 independent
Short Form Health Survey-36	n/a		
Geriatric Depression Scale-5	≥ 2 answers: indicates depression		
Trail Making Test	part A: >78 sec deficient	part B: >273 sec deficient	
Nutritional Recall	n/a		
Gait Speed	♂: 0.65/0.76m/s (≤173/>173cm)	♀: 0.65/0.76m/s (≤159/>159cm)	
Grip Strength	♂: 29-32kg according to BMI	♀:17-21 kg according to BMI	
Short Performance Physical Battery	Limitation: 0-3 severe 4-6 moderate 7-9 mild 10-12 minimal		
Timed Up & Go	<12 sec normal mobility	≥12 sec limited mobility	
Bioelectrical Impedance Analyses	n/a		
Accelerometer	low activity ♂ <383kcal/week	low activity ♀ <270kcal/week	

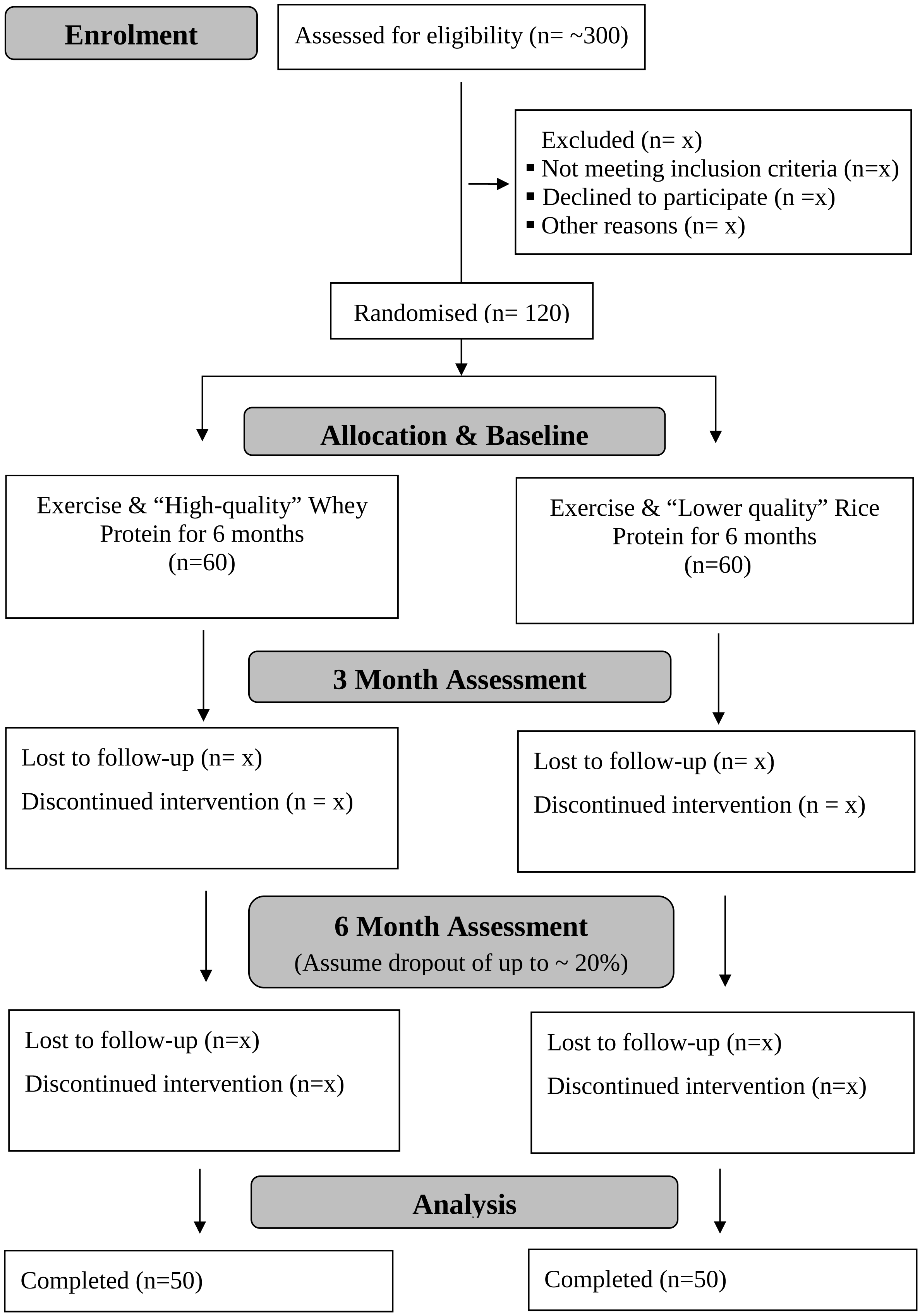


Figure 8.1: EXPRESS Study CONSORT flow diagram

Chapter 9

The Feasibility of a Randomised Controlled Pilot Exercise and Protein Effectiveness Supplementation Study (EXPRESS) Supporting Autonomy in Community-Dwelling Frail Older People

Summary

Research has repeatedly demonstrated that exercise has a positive impact on physical function, and is beneficial in the treatment of frailty. However, an even more effective strategy might be the combination of a multi-component exercise program with the intake of high-quality protein supplements. The efficacy, tolerability, feasibility and safety of such an intervention, however, remains unclear for older adults who are pre-frail and frail.

The primary aim of this study was to examine the feasibility of recruiting community-dwelling pre-frail and frail older adults to a trial designed to determine the potential effects of a six month exercise and nutrition program on physical function. The feasibility objectives included frail older peoples' compliance, safety and tolerability of the two components of the program. Data collection is ongoing.

Despite employing a limited number and types of recruitment strategies, 145 older adults expressed interest in the study. Of those who expressed interest, only 38 participants (26.2%) were enrolled and randomised into the study over a period of twelve months, and 27 participants (18.6%) have completed the study to date.

Our findings indicate that having only two study sites, and two exercise physiologists involved in running the exercise classes, was a major limiting factor in recruitment. In addition, while our advertising budget for recruitment was limited, the preliminary results indicate that television, flyers and public seminars were the most effective sources to recruit community-dwelling pre-frail and frail older adults.

With respect to the feasibility, tolerability and safety of the six month exercise and protein supplementation intervention, our preliminary findings indicate that the multicomponent exercise program, performed five times per week, was feasible, tolerable and safe. However, the data also indicate that pre-frail and frail older adults living in the community preferred to exercise at, or close to home, rather than at the study-specific exercise centres. Several

non-serious side effects (namely, gastrointestinal related symptoms) in regards to the consumption of the commercially available protein supplements were also noted among the participants. This later finding suggests that even when protein supplements which have undergone extensive consumer acceptance testing are used, many individuals still require tailored strategies to help them adjust to what is essentially a new food for them.

This chapter represents unpublished work written in manuscript style which we expect to submit to a peer-reviewed journal once the final cohort of participants have completed the study (Appendix 8 including Statement of Authorship).

9.1. Background

The most effective strategies to treat, delay and prevent frailty in the community are multi-component exercise interventions including resistance, aerobic, balance and flexibility tasks[1]. It is clear that exercise plays an essential role in the treatment of frailty, but exercise combined with additional interventions such as protein supplements might provide additional improvements given that protein provides the substrate whilst exercise the stimulus to initiate and maintain muscle protein synthesis, resulting possibly in improved muscle mass and/or strength[2,3]. Moreover, a higher intake of protein appears to be associated with a lower risk of frailty in older adults[4].

Whilst there is some suggestion that exercise in combination with protein supplementation may positively impact on a variety of physical function parameters in pre-frail and/or frail older people, the results are not conclusive[5-7]. Discrepant findings are, in part, due to limitations of several aspects related to the design of previous research, and these limit or bias the interpretation of the collective results. Several frequently cited limitations include a small sample size, insufficient amounts of protein, single rather than multiple-daily bolus doses, the time of protein consumption in relation to the exercise stimulus, lack of a sufficient dose of resistance training, and not controlling for differences in background diet. Accordingly, more studies are needed to identify feasible protein supplementation regimes in combination with exercise, for community-dwelling pre-frail and frail older adults.

While combining exercise with protein supplementation appears to be a rational strategy for preventing frailty, the compliance to such a program, as well as information on the tolerability and feasibility of both components of the program (i.e. on both the exercise and protein supplements), in pre-frail and frail older adults, together with their associated drop-out rates, have not been well reported across the literature[8-10].

Accordingly, this chapter presents preliminary findings from an ongoing study[11] and addresses only the primary aim which was to report on the recruitment of pre-frail and frail older people from the community using several recruitment channels, how well pre-frail and frail older people comply with the exercise and nutritional components of the study, and the safety and tolerability of the exercise and nutrition intervention.

9.2. Methods

Full details of the design and methodology used in this study were described previously in Chapter 8 and in the published protocol paper[11] (Appendix 7). The design and methods are therefore only described briefly in this chapter.

9.2.1. Participants and Setting

Participants were eligible if they were aged ≥65 years, able to converse in English, lived in the community, and were identified as pre-frail (i.e., scored ≥1 but <3 out of 5) or frail (i.e., scored ≥3 out of 5) using the FRAIL Screen[12]. Participants with dementia (i.e., scored ≤5 out of 10) as per the Rapid Cognitive Screen[13], or severe renal impairment (eGFR ≤30 mmol/L), and those unable to comply with either the exercise or nutrition protocol, were excluded. All participants gave written informed consent and were able to withdraw from the study at any time.

9.2.2. Recruitment

Participants were recruited using social media (e.g., Facebook), public seminars, radio and television advertising, as well as flyers displayed in newsletters and the halls of collaborative aged care services, medical centres, the Queen Elizabeth Hospital in Adelaide, South Australia, Australia, and the Commonwealth Scientific Industrial Research Organisation (CSIRO) Clinical Research Unit.

9.2.3. Study Intervention

The study included two study arms, namely: (i) exercise in combination with a commercially available lower-quality rice protein (RicePro) and (ii) exercise in combination with a commercially available high-quality whey protein supplement (WheyPro).

The exercise intervention was undertaken by all participants and included a supervised centre-based group exercise class, two home-based exercise sessions, and walking twice a week, resulting in five exercise sessions per week. Participants were advised to replace each missed centre-based exercise class (i.e., due to holidays or transportation issues) by one additional home-based exercise session in the associated week and were also allowed, if desired, to perform the home-based exercise sessions and walking more often which could lead to compliance rates of more than 100%. The exercise prescription and intensity was based on the LIFE study and comprised strength, aerobic, balance and flexibility tasks[14]. Two accredited exercise physiologists were responsible for delivering the program which progressively adapted in time, complexity and intensity as participants improved their strength and endurance.

The protein supplements were provided as a powder in individual sachets containing 20g of protein. The commercial protein powder (i.e., whey or rice protein) (Bulk Nutrients, Grove, Tasmania, Australia) was blended with a powdered flavour and participants were advised to reconstitute the entire 20g sachet in 150ml of water twice daily. All drinks were prepared at home by the participant, and were isocaloric (i.e., both supplying ~90 kcal per 20g protein), isonitrogenous (~3.5 g of nitrogen per 20g protein) and of comparable flavour and aroma. If participants experienced issues with the texture or taste of the protein, pre-planned strategies developed by the research team to assist with maintaining high compliance were implemented. These strategies included: washing the taste away with a glass of water after consumption; blending in some of their typically consumed serves of fruit; or adding coffee powder or ice cubes to the protein drinks. However, participants were advised not to change their diet during the study and not to add anything that included additional protein (i.e., no additional dairy or meat-based foods).

9.2.4. Screening and Assessments

The screening for eligibility was performed over the phone and took approximately five minutes for each participant.

Medical clearance and serum creatinine investigation were obtained from participants' general practitioner. If a participant had serum creatinine test done within the last month, a copy of this result from their general practitioner was sufficient, but if this was not available an appropriate form was posted out and the participant was requested to get a blood test done at their closest pathology laboratory. Participants received medical clearance if their eGFR was >30 mmol/L and there were no other physical or mental limitations that would prevent the participant from completing the study assessments or interventions. GFRs were estimated by local pathology laboratories using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) creatinine equation[15].

Assessments were conducted with each participant at the participants' closest study centre and took approximately one hour. The Rapid Cognitive Screen (RCS)[13], the Charlson Co-morbidity Index (CCI)[16] and the Mini Nutritional Assessment (MNA-SF)[17,18] were conducted only at baseline to determine participants' risk of cognitive impairment, five-year mortality and malnutrition. All other assessments were completed at baseline, and at weeks 12 and 24. These assessments included the Short Form Health Survey-36 (SF-36)[19], Katz Activities of daily living (Katz ADL)[20], Lawton Instrumental Activities of Daily Living (Lawton iADL)[21], the Geriatric Depression Screen-5 (GDS-5)[22], the Trail Making Test[23], gait speed, grip strength (using a handgrip dynamometer)[24], the Short Physical Performance Battery (SPPB)[25], Timed Up and Go Test (TUG)[26], bioelectrical impedance analyses (BIA)[27], 24 hour dietary recall[28] and an accelerometer that was attached to the participant's thigh for a period of 7 days[29]. Gait speed was tested as part of the SPPB over a distance of 4 meters[25]. Two markers on the ground marked the beginning and end of the walking distance. Participants were advised to start and finish approximately 1.5 meters before and after the markers to build up their usual pace. For the assessment of grip strength, participants were asked to use their dominant hand and press the dynamometer three times for approximate 3 seconds with a break of 15 seconds between the attempts. All three attempts were recorded and the average grip strength was calculated. All assessments were selected based on methods commonly used in the fields of geriatrics and gerontology, and which have a high level of specificity and sensitivity in measuring changes in outcomes.

9.2.5. Compliance, Tolerability and Safety

Compliance diaries for the exercises and protein supplements were handed out and checked on a weekly basis for the first two weeks, and then every two weeks if no problems were evident. If the study team identified a problem with a participant's compliance to the planned number of exercise sessions per fortnight, or that consumption of the planned number of protein sachets was less than 70% (i.e. <7 exercise sessions attended, or <20 sachets consumed), the research exercise physiologist and dietician, respectively, interviewed the participant to assess any difficulties and identify strategies to facilitate compliance.

Adverse events (AEs) (i.e., pain, discomfort, headaches, noticeable difference in body and memory) were investigated during all visits and reviewed by the research physician when required. Data collected in regard to AEs included the type, time and duration of AE, causality to the trial, severity (mild, moderate, severe), action (unchanged, temporarily or permanent changed/reduced/discontinued), and outcome (resolved or withdrew). The severity of an AE was graded as follow:

- mild if the AE was easily tolerated by the participant causing minimal discomfort and not interfering with everyday activities
- moderate if AE was sufficiently discomforting to interfere with normal everyday activities
- severe if AE was incapacitating and prevented normal everyday activities

A serious AE was defined as any untoward medical occurrence that at any dose resulted in death, was life-threatening, required inpatient hospitalisation or caused prolongation of existing hospitalisation, resulted in persistent or significant disability/incapacity, or required intervention to prevent permanent impairment or damage.

9.2.6. Statistical Analyses

Descriptive analyses including means, medians, standard deviations, and ranges, were used to assess the completeness and variability of the key feasibility outcomes. Percentages were used to describe compliance and recruitment rates. Independent t-test was used to determine differences between the intervention groups.

9.3. Results

The presented results are preliminary and may change once our final sample is collected. Only the feasibility aspects of the study are reported here. Recruitment flow, recruitment sources and retention to the study are illustrated in the CONSORT flow figure (Figure 9.1).

9.3.1. Recruitment

Over a period of twelve months, 145 older adults were contacted and screened for eligibility. Most interest in the study arose as a result of promotion via television news (n=44, 30.3%), public seminars (n=26, 17.9%), referrals from affiliated clinical and/or research staff (n=25, 17.2%), and flyers distributed through newsletters of collaborating aged care organisations (n=17, 11.7%). Subjects were also sourced by approaching former research participants (n=9, 6.2%), through word of mouth (n=7, 4.8%), via social media (n=2, 1.4%) and by advertising on radio (n=1, 0.7%).

One third of subjects (n=50, 34.5%) expressed no interest at the first point of contact. A further third (n=49, 33.8%) were excluded because they did not meet the eligibility criteria.

Eight older adults (5.5%) reported other reasons for not wishing to enrol following initial discussions with the research team (i.e., exercise location/times did not suit, current medical issues). This resulted in the inclusion of 38 eligible participants (recruitment rate of 26.2%) who were mainly recruited through television advertisement (n=15, 39.5%), flyers (n=7, 18.4%) and public seminars (n=7, 18.4%). All recruitment strategies including their success rates are presented in Table 9.1.

9.3.2. Baseline Characteristics

To date, 38 participants have been enrolled in the study and were randomly allocated to either RicePro (exercise + low quality protein; n=19) or WheyPro (exercise + high quality protein; n=19). Twenty-seven participants have so far completed the six months intervention, which represents a 71.1% completion rate (RicePro: n=14; WheyPro: n=13). Mean age was 74.0 ± 6.74 years and 63.2 % of the sample (n=24) was female. The majority of participants (n=33, 86.8%) were pre-frail and only five participants (13.2%) were frail according to the FRAIL Screen. Most of the participants were well nourished (n=36, 94.7%), had a low 5-year mortality risk as per the CCI (n=35, 92.1%), were not cognitively impaired (n=34, 89.5%), were not depressed (n=34, 94.7%) and independent in basic (n=38, 100%) and instrumental (n=36, 94.7%) activities of daily living. Participants' protein intake at baseline was high (mean of 1.10 ± 0.37g/kg) ranging from 0.28g/kg to 1.71g/kg of body weight per day. There were no significant differences between intervention groups in terms of their baseline characteristics (Table 9.2).

9.3.3. Safety

A summary of serious (n=1) and non-serious (moderate n=11; mild n=4) AEs are listed in Table 9.3. The serious AE was a fall in week five, resulting in hospitalisation overnight and required consultation with the research physician and participants' GP. The fall was not related to study treatment and resulted in an intervention break (i.e., suspension of exercise) of 4.5 weeks. The participant continued consuming the protein supplement and was cleared by the GP before re-commencing the exercise.

Five of the fifteen non-serious AEs were not related to the study treatment, and included a wrist surgery due to arthrodesis (week 15), a car accident (week 16), a visit to hospital due to chest pain which did not result in admission (week 19), and two cancer diagnosis (week 5 and 17). The AEs were graded as moderate and intervention was interrupted while participants recovered from either the wrist surgery (exercise and protein break of 4 weeks) or the car accident (exercise break of 5 weeks), respectively. Participants who were diagnosed with cancer withdrew from the study.

The other ten non-serious AEs (n=7 RicePro; n=3 WheyPro) were related to the consumption of the protein supplements and graded as moderate (n=3 RicePro; n=3 WheyPro) and mild (n=4 RicePro); all AEs were upper gastrointestinal symptoms including constipation or runny stool, flatulence, bloating, stomach pains, and/or headaches and nausea. No side effects have been reported in regard to the safety or ability to tolerate the prescribed exercises.

9.3.4. Withdrawals

A total of eleven participants (n=5 RicePro; n=6 WheyPro) dropped out during the six months intervention, resulting in a drop-out rate of 28.5%. Most withdrawals occurred early and within the first two months of intervention (Figure 9.1).

Nine out of the eleven participants withdrew because of complaints related to the protein supplement with six of these complainants meeting the criteria for moderate AEs (n=3 RicePro; n=3 WheyPro). In weeks three and four, two participants withdrew due to stomach pain, indigestion, migraine, and nausea (n=2 RicePro group); in week five, two participants withdrew due to constipation, feeling bloated, headaches and nausea after consuming the protein drink (n=2 WheyPro group); in week seven, one participant withdrew due to ongoing moderate stomach pain (n=1 WheyPro) and another participant withdrew due to stomach pain and constipation (n=1 WheyPro). In addition, three participants withdrew because they wanted to completely stop consuming the protein from week three (n=1 RicePro) and week twelve (n=2 WheyPro) due to perceived weight gain but, objectively, there was no weight gain.

Diagnosis of cancer was another reason for withdrawing from the study, and occurred in week five for one participant (n=1 RicePro) and week seventeen for another participant (n=1 WheyPro).

9.3.5. Compliance

The protein and exercise compliance is displayed in Table 9.4.

9.3.5.1. Protein Compliance

Compliance to the protein was 86.2% (277.6 ± 44.0) for the 27 participants who completed the 24 weeks intervention. Compliance to RicePro (83.3%; 268.1 ± 33.2) was slightly lower than to the WheyPro supplement (89.4%; 287.8±52.8), but there was no statistical difference between groups ($p>0.05$).

9.3.3.2. Exercise Compliance

Overall compliance to the total 114 exercise sessions including centre-based exercise classes, home-based exercises and walking, was 126.4% (144.1 ± 47.5). Although exercise compliance was slightly higher in the RicePro (133.2%; 151.8 ± 54.3) compared to WheyPro (119.2%; 135.9 ± 39.4) group, there was no statistical difference between the groups ($p=0.394$).

With respect to the centre-based exercise classes, compliance was low (66.4%; 14.6 ± 4.8) but there was no statistical difference between the groups ($p=0.362$; RicePro: 70.0% / 15.4 ± 4.5 vs WheyPro: 62.3% / 13.7 ± 5.2).

With respect to the home-based exercise session, compliance was high (129.8%; 59.7 ± 24.0) but there was no statistical difference between the groups ($p=0.129$; RicePro: 144.6% / 66.5 ± 27.0 vs WheyPro: 113.9% /52.4 ± 18.5).

With respect to the walking exercises, compliance was high (151.7%; 69.8 ± 31.8) but there was no statistical difference between the groups ($p=0.994$; RicePro: 152.0% / 69.9 ± 33.6 vs WheyPro: 151.7% / 69.8 ± 1.1).

The compliance percentages of the three exercise components suggest that walking exercise was the most popular exercise component (151.7%), followed by the home-based exercise sessions (129.8%) and least popular were the centre-based exercise sessions with a total compliance of 66.4%.

9.3.6. Strategies to Facilitate Protein and Exercise Compliance

Strategies to overcome issues related to participants disliking the taste of the protein were implemented for four participants (i.e. n=3 RicePro and n=1 WheyPro); two participants added fruit and ice cubes to their protein drinks, one participant added coffee powder, and one participant consumed fruit immediately after the protein drink. Two participants (n=2 RicePro) also experienced issues with the texture of the protein and drank a glass of water immediately after consuming the supplement to counteract this.

For four participants (all RicePro) who reported feeling constipated, bloated or experienced mild stomach pain, the strategies used included to have 1-2 days off the protein, or to have only one protein sachet per day for 2 to 7 days until symptoms ceased and then re-commence the suggested dose. This later strategy was successfully implemented for two participants (n=2 RicePro), whereas for the other two participants, the symptoms ceased naturally without changes required.

Over the course of the study, three participants (n=1 RicePro; n=2 WheyPro) reported difficulties with transport and the distance to the exercise centres. As a strategy to facilitate overall exercise compliance, the participants were allowed to skip the centre-based exercise class and replace it by an additional weekly home-based exercise session.

9.4. Discussion

Three key findings have emerged from preliminary analysis of the data collected to date. Firstly, television, flyers and public seminars appear to be effective sources for recruiting community-dwelling older people at-risk of frailty to a six months intervention study involving exercise and protein supplementation. However, similar to other studies[30], it was difficult to recruit frail subjects. Secondly, drop-out rates were highest in the first two months of intervention and were mostly related to individuals' ability to tolerate the taste and texture of the protein supplementation even though the supplements used were commercially available and a popular brand on the market. And thirdly, participants were more complaint with home based exercises rather than centre based exercises.

Recruiting and retaining frail older adults into community-based intervention programs is a major issue and is generally the reason why many studies have small sample sizes[31]. The preliminary findings of this research indicate that recruitment through media (i.e., television), flyers and public seminars were successful in attracting predominantly pre-frail older people from the community. These findings were complimentary to the results of the research presented in Chapter 4 where older people indicated that they wanted information relating to exercise to be made available to them through brochures and flyers. The recruitment rate of 26.2% was mid-range compared to other studies reporting rates between 16.6%[31] and 42.1%[33] for community-based exercise and nutrition interventions involving pre-frail and frail older adults. The higher rate reported in the literature was achieved through door-to-door open invitation[33], while the lower rate was reported when a direct approach in hospitals and editorial features (i.e. newspaper article) were the key recruitment strategy. Previous research has suggested that multiple recruitment strategies, the simplification of the recruitment process (short and clear information) and early face-to-face contact are likely to help increasing recruitment rates[30], and we used this combination of strategies with moderate success over twelve months.

Participant retention is a key component in ensuring sample size is maintained. The participant drop-out rate in this study was 28.5% which is ~10-20% higher when compared to other studies which included pre-frail and frail older adults of similar or greater age[7,32,33]. Haider et al (2017)[32] utilised a twelve week home-based exercise program combined with nutritional education and reported a drop-out rate of 18% (14 out of 80 participants), while Rosendahl et al (2006)[7] reported having a drop-out of only 7.3% (14 out of 191 participants) comprising a three months centre-based exercise program combined with a protein-enriched energy supplement including older people living in residential care facilities. These dropout rates might be lower compared to our study due to the location of the exercises that were performed either at home or in participants' residential care facilities and more representative sample sizes. Ng et al (2015)[33] reported also low drop-out rates of 8% for a nutritional intervention involving vitamins and minerals, 4% for an exercise intervention including home and centre-based exercises, and 6% for a combined nutrition, exercise and cognitive intervention for 246 community-dwelling pre-frail and frail older adults over period of twelve months.

Most of the participants in our study dropped out during the first one to two months of intervention mainly as a result of adverse effects related to the protein supplements. Participant retention is generally higher when people do not experience any adverse effects from the program they are undertaking. In this current study, consumption of both types of protein supplements did elicit some adverse effects which, however, were not severe. Previous studies that have tested the health effects of protein supplementation have reported similar types of AEs[34]. However, there are some studies that identified no adverse events in response to protein supplements for frail older adults when consuming slightly lower doses of protein (twice daily 250ml drink containing 15g protein) over a period of six months[6]. However, more investigations in this target population are needed to examine the tolerability and the effects of more 'pure' forms of protein supplementation (i.e. those that contain minimal carbohydrates, fats, and total energy), as compared to complex food matrix that has a relatively high protein content. It is hoped that the ongoing data collection in this study will provide more clarity regarding the feasibility and efficacy of the protein supplements that we have utilised. However, despite the reported side effects, the protein compliance of 86.2% reported in this study was high when compared to other studies which included protein supplements for frail older people, with compliance ranging between 72%[35] and 82%[7].

None of the serious or non-serious AEs reported were related to the exercise intervention, confirming that professionally supported, multi-component exercise programs are safe for pre-frail and frail older adults[36]. Pre-frail and frail older adults appeared to be compliant to the six-month multi-component exercise intervention which included at least five exercise sessions per week. However, these preliminary findings suggest that a predominantly home-based exercise program may be more suitable for pre-frail and frail older adults than programs which include a weekly centre-based class which requires transport. This is consistent with the literature which suggests transport is a frequently mentioned barrier to exercise[37]. While the overall compliance to the exercise intervention in this study was high at 126.4%, the compliance to the centre-based exercise sessions was low at 66.4% compared to other studies reporting compliance rates between 70.0%[7] and 85%[33], suggesting that the availability of exercise centres closer to participants' home and community may reduce transport issues and facilitate compliance. Additionally, greater compliance to exercise programs might be achieved in residential aged care homes and retirement villages where programs are offered on-site.

9.5. Strengths and Limitations

A major limitation of the study was the reliance on self-report regarding home-based exercise participation and protein intake using diaries. Also, the fact that participants only recorded the number of performed exercise sessions, but not the amount of exercises or their duration may have contributed to inconsistency in the prescribed exercise program and might limit the interpretation of the results. Also, the already high protein intake at baseline might reduce the anticipated effects of this intervention. Further, participants were asked to initially return empty sachets of protein but early on in the study this was deemed to be too much of a burden for both the older adults and staff.

9.6. Conclusion

The preliminary findings of this study provided much needed insight into the feasibility of recruiting and retaining pre-frail and frail older adults into community-based intervention programs, in addition to information relating to the safety, and tolerability of a combined exercise and protein supplement program designed to halt or reverse the progression of frailty in the community. The results need to be confirmed by a larger sample size, but indicate that a six month intervention including a multicomponent exercise program performed five times per week is feasible, tolerable and safe in pre-frail and frail older adults living in the community. However, participants preferred to exercise at home or closer to home, and even when implementing commercial nutritional supplements, which have undergone extensive consumer acceptance testing, many pre-frail and frail older adults still experienced issues that require tailored strategies to help them to adjust to this new nutritional product. Further, to effectively assess the impact of home-based exercise programs in future research, the amount and duration of performed exercises need to be better monitored and strategies need to be developed to overcome these types of issues.

9.7. References

1. Bray NW, Smart RR, Jakobi JM, Jones GR. Exercise prescription to reverse frailty. Appl Physiol Nutr Metab 2016;41(10):1112-6.
2. Phillips SM. The impact of protein quality on the promotion of resistance exercise-induced changes in muscle mass. Nutr Metab (Lond) 2016;13:64.
3. Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia: Protein, amino acid metabolism and therapy. Curr Opin Clin Nutr Metab Care 2009;12(1):86-90.
4. Beasley JM, LaCroix AZ, Neuhouser ML, Huang Y, Tinker L, Woods N, et al. Protein intake and incident frailty in the Women's Health Initiative observational study. J Am Geriatr Soc 2010;58(6):1063-71.
5. Björkman MP, Finne-Soveri H, Tilvis RS. Whey protein supplementation in nursing home residents. A randomized controlled trial. Eur Geriatr Med 2012;3(3):161-6.
6. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2012;13:713-9.
7. Rosendahl E, Lindelof N, Littbrand H, Yifter-Lindgren E, Lundin-Olsson L, Haglin L, et al. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: a randomised controlled trial. Aust J Physiother 2006;52(2):105-13.
8. Eliot KA, Knehans AW, Bemben DA, Witten MS, Carter J, Bemben MG. The effects of creatine and whey protein supplementation on body composition in men aged 48 to 72 years during resistance training. J Nutr Health Aging 2008;12(3):208-12.
9. Verdijk LB, Jonkers RA, Gleeson BG, Beelen M, Meijer K, Savelberg HH, et al. Protein supplementation before and after exercise does not further augment skeletal

muscle hypertrophy after resistance training in elderly men. Am J Clin Nutr 2009;89(2):608-16.

10. Leenders M, Verdijk LB, Van der Hoeven L, Van Kranenburg J, Nilwik R, Wodzig WK, et al. Protein supplementation during resistance-type exercise training in the elderly. Med Sci Sports Exerc 2013;45(3):542-52.
11. Jadczak AD, Luscombe-Marsh N, Taylor P, Barnard R, Makwana N, Visvanathan R. The EXPRESS Study: Exercise and Protein Effectiveness Supplementation Study supporting autonomy in community dwelling frail older people-study protocol for a randomized controlled pilot and feasibility study. Pilot Feasibility Stud 2017;4(1):8.
12. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. J Am Med Dir Assoc 2013;14(6):392-7.
13. Malmstrom TK, Voss VB, Cruz-Oliver DM, Cummings-Vaughn LA, Tumosa N, Grossberg GT, et al. The Rapid Cognitive Screen (RCS): A Point-of-Care Screening for Dementia and Mild Cognitive Impairment. J Nutr Health Aging 2015;19(7):741-4.
14. Cesari M, Vellas B, Hsu FC, Newman AB, Doss H, King AC. A physical activity intervention to treat the frailty syndrome in older persons-results from the LIFE-P Study. J Gerontol A Biol Sci Med Sci 2015;70(2):216-22.
15. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF, Feldman HI, et al. A new equation to estimate glomerular filtration rate. Ann Intern Med 2009;150(9):604-12.
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40(5):373-83.
17. Huhmann MB, Perez V, Alexander DD, Thomas DR. A self-completed nutrition screening tool for community-dwelling older adults with high reliability: a comparison study. J Nutr Health Aging 2013;17(4):339-44.
18. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging 2009;13(9):782-8.
19. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992;30(6):473-83.
20. Shelkey M, Wallace M. Katz Index of Independence in Activities of Daily Living (ADL). Director 2000;8(2):72-3.

21. Graf C. The Lawton Instrumental Activities of Daily Living (IADL) Scale. Medsurg Nurs 2009;18(5):315-6.
22. Yesavage JA. Geriatric Depression Scale. Psychopharmacol Bull 1988;24(4):709-11.
23. Salthouse TA. What cognitive abilities are involved in trail-making performance? Intelligence 2011;39(4):222-32.
24. Visser M, Deeg DJ, Lips P, Harris TB, Bouter LM. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. J Am Geriatr Soc 2000;48(4):381-6.
25. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol 1994;49:M85-94.
26. Podsiadlo D, Richardson S. The timed 'Up & Go': a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39(2):142-8.
27. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol (1985) 2000;89(2):465-71.
28. Conway JM, Ingwersen LA, Moshfegh AJ. Accuracy of dietary recall using the USDA five-step multiple-pass method in men: an observational validation study. J Am Diet Assoc 2004;104(4):595-603.
29. Murphy SL. Review of physical activity measurement using accelerometers in older adults: considerations for research design and conduct. Prev Med 2009;48(2):108-14.
30. Piantadosi C, Chapman IM, Naganathan V, Hunter P, Cameron ID, Visvanathan R. Recruiting older people at nutritional risk for clinical trials: what have we learned? BMC Res Notes 2015;8:151.
31. Harris R, Dyson E. Recruitment frail older people to research: lessons learnt through experience. J Adv Nurs 2001;36:643-51.
32. Haider S, Dorner TE, Luger E, Kapan A, Titze S, Lackinger C, et al. Impact of a Home-Based Physical and Nutritional Intervention Program Conducted by Lay-Volunteers on Handgrip Strength in Prefrail and Frail Older Adults: A Randomized Control Trial. PLoS ONE 2017;12(1):e0169613.

33. Ng TP, Feng L, Zin Nyunt MS, Feng L, Niti M, Tan BY, et al. Nutritional, Physical, Cognitive and Combination Interventions and Frailty Reversal among Older Adults: A Randomized Controlled Trial. Am J Med 2015;128:1225-36.
34. Chapman IM, Visvanathan R, Hammond AJ, Morley JE, Field JB, Tai K, et al. Effect of testosterone and a nutritional supplement, alone and in combination, on hospital admissions in undernourished older men and women. Am J Clin Nutr 2009;89(3):880-9.
35. Chale A, Cloutier GJ, Hau C, Phillips EM, Dallal GE, Fielding RA. Efficacy of whey protein supplementation on resistance exercise-induced changes in lean mass, muscle strength, and physical function in mobility-limited older adults. J Gerontol A Biol Sci Med Sci 2013;68(6):682-90.
36. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res 2011;2011:569194.
37. Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. Prev Med 2004;39(5):1056-61.

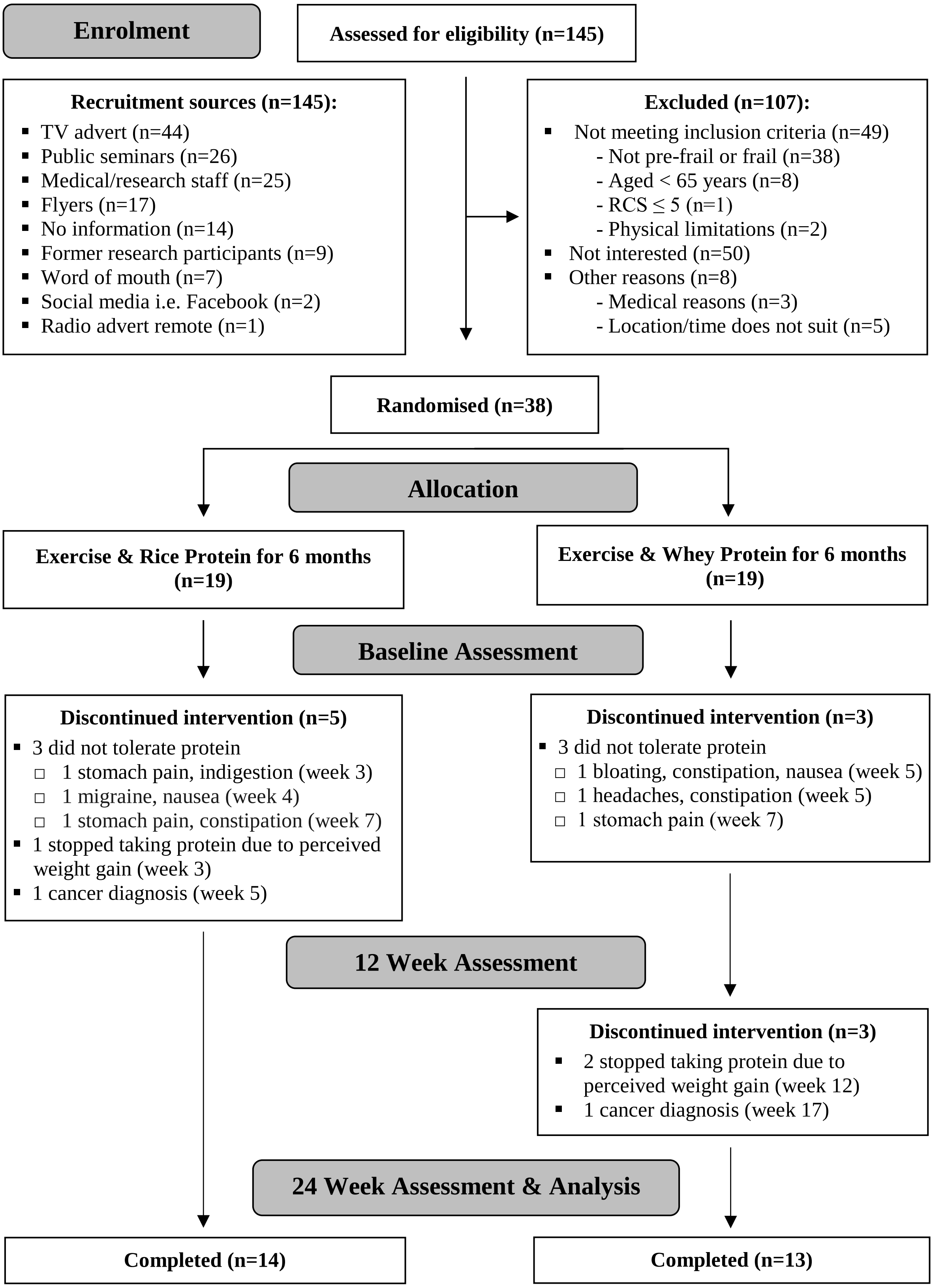


Figure 9.1: EXPRESS Study Feasibility CONSORT flow diagram

Table 9.1: Recruitment strategies and their success rates

	Expression of Interest										
		Recruitment Outcome									
Recruitment Source	Contacted n*	Opted out n	%	Excluded n	%	Other** n	%	Enrolled n	%	Completed n	%
Total	145	58	34.5	49	33.8	8	5.5	38	26.2	27	18.6
TV advert	44	11	25.0	15	34.1	3	6.8	15	34.1	8	18.2
Public seminars	26	5	19.2	13	50.0	1	3.8	7	26.9	6	23.1
Medical/research staff	25	15	60.0	5	20.0	2	8.0	3	12.0	2	8.0
Flyers/brochures	17	4	23.5	5	29.4	1	5.9	7	41.2	5	29.4
No information	14	6	42.9	7	50.0	1	7.1				
Former research participants	9	7	77.8	2	22.2						
Word of mouth	7	1	14.3	2	28.6			4	57.2	4	57.1
Social media i.e. Facebook	2							2	100.0	2	100.0
Radio advert	1	1	100.0								

* equal to 100%
**other reasons for not being able to participate (i.e. medical issues, time/place of exercise do not suit)

Table 9.2: Participants' baseline characteristics

Characteristic	**Total n=38**	**RicePro n=19**	**WheyPro n=19**	**P-Value Rice Vs Whey**
Gender	14 ♂ 36.8% 24 ♀ 63.2%	6 ♂ 31.6% 13 ♀ 68.4%	8 ♂ 42.1% 11 ♀ 57.9%	0.514
Age	74.00 ± 6.74	72.58 ± 5.81	75.26 ± 7.48	0.225
FRAIL Screen	1.42 ± 0.72	1.42 ± 0.77	1.42 ± 0.69	1.000
CCI	1.24 ± 2.02	1.11 ± 1.91	1.37 ± 2.17	0.694
RCS	9.24 ± 1.19	9.26 ± 1.15	9.21 ± 1.23	0.894
MNA-SF	13.45 ± 0.86	13.53 ± 0.70	13.3 ± 1.01	0.579
GDS-5	0.71 ± 0.80	0.58 ± 0.61	0.84 ± 0.96	0.319
Lawton iADL	7.74 ± 0.76	7.68 ± 0.95	7.79 ± 0.54	0.675
Katz ADL	5.97 ± 0.16	6.00 ± 0.00	5.95 ± 0.23	0.324
Trail Making Test A	27.77 ± 8.17	31.05 ± 9.69	37.74 ± 24.82	0.281
Trail Making Test B	65.82 ± 25.56	77.79 ± 37.43	72.53 ± 29.20	0.631
SF-36 physical	35.94 ± 8.28	36.72 ± 9.91	35.14 ± 6.42	0.564
SF-36 mental	37.94 ± 10.63	37.74 ± 11.71	38.15 ± 9.76	0.909
Protein intake (g/kg)	1.10 ± 0.37	1.15 ± 0.44	1.06 ± 0.30	0.485
Grip Strength (kg)	23.63 ± 9.21	24.85 ± 11.18	22.42 ± 6.81	0.423
Gait Speed (m/sec)	1.17 ± 0.21	1.23 ± 0.16	1.11 ± 0.24	0.067
Physical Performance	9.84 ± 1.55	10.16 ± 1.07	9.53 ± 1.90	0.214
Timed Up & Go (sec)	9.36 ± 2.23	8.80 ± 1.51	9.92 ± 2.69	0.122
Activity Status (MET)	220.84 ± 8.75	218.99 ± 8.54	222.58 ± 8.81	0.951
Muscle Mass (kg)	47.78 ± 8.90	46.34 ± 9.43	49.30 ± 8.30	0.317

CCI: Charlson Comorbidity Index RCS: Rapid Cognitive Screen MNA-SF: Mini Nutritional Assessment
GDS: Geriatric Depression Scale ADL: Activities of Daily Living SF-36: Short Form Health Survey

Table 9.3: Serious and non-serious adverse events recorded during the study

No	Type	Week	Causality	Severity	SAE	Action	Duration	Outcome
1	Fall	5	Not related to trial	Severe	Yes	Exercise temporary discontinued	4.5 weeks	Resolved
2	Wrist surgery (arthodesis)	15	Not related to trial	Moderate	No	Trial temporary discontinued	4 weeks	Resolved
3	Car accident	16	Not related to trial	Moderate	No	Exercise temporary discontinued	5 weeks	Resolved
4	Hospital visit due to chest pain	19	Not related to trial	Moderate	No	Trial unchanged	1 day	Resolved
5	Cancer diagnosis	17	Not related to trial	Moderate	No	Trial permanently discontinued	Unknown	Withdrew
6	Cancer diagnosis	5	Not related to trial	Moderate	No	Trial permanently discontinued	Unknown	Withdrew
7	Upper GI symptoms i.e. stomach pain, indigestion	1	Related to rice protein supplement	Moderate	No	Trial permanently discontinued	2 weeks	Withdrew
8	Migraine, nausea	1	Related to rice protein supplement	Moderate	No	Trial permanently discontinued	3 weeks	Withdrew
9	Upper GI symptoms i.e. stomach pain, constipation	5	Related to rice protein supplement	Moderate	No	Trial permanently discontinued	2 weeks	Withdrew
10	Upper GI symptoms i.e. frequent bowel actions, flatulence	4	Related to rice protein supplement	Mild	No	Protein intake temporary reduced	3 weeks	Resolved
11	Bloating	1	Related to rice protein supplement	Mild	No	Trial unchanged	4 weeks	Resolved
12	Upper GI symptoms i.e. stomach pain, bloating	2	Related to rice protein supplement	Mild	No	Trial unchanged	1 day	Resolved
13	Upper GI symptoms i.e. constipation, bloating	2	Related to rice protein supplement	Mild	No	Protein intake temporary reduced	2 weeks	Resolved
14	Upper GI symptoms i.e. stomach pain	5	Related to whey protein supplement	Moderate	No	Trial permanently discontinued	2 weeks	Withdrew
15	Headaches, upper GI symptoms i.e. constipation	4	Related to whey protein supplement	Moderate	No	Trial permanently discontinued	1 week	Withdrew
16	Upper GI symptoms i.e. bloating, constipation, nausea	4	Related to whey protein supplement	Moderate	No	Trial permanently discontinued	1 week	Withdrew

SAE: Serious Event; GI: Gastrointestinal

Table 9.4: Participants' exercise and nutrition compliance

Compliance	**Total (n=27)**		**RicePro (n=14)**		**WheyPro (n=13)**		**P-Value**
	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Rice vs Whey
Protein Total (Sachets)	277.6 ± 44.0	86.2	268.1 ± 33.2	83.3	287.8 ± 52.8	89.4	0.255
Exercise Total (Sessions)	144.1 ± 47.5	126.4	151.8 ± 54.3	133.2	135.9 ± 39.4	119.2	0.394
Centre Exercise Sessions	14.6 ± 4.8	66.4	15.4 ± 4.5	70.0	13.7 ± 5.2	62.3	0.362
Home Exercise Sessions	59.7 ± 24.0	129.8	66.5 ± 27.0	144.6	52.4 ± 18.5	113.9	0.129
Walking Exercise Sessions	69.8 ± 31.8	151.7	69.9 ± 33.6	152.0	69.8 ± 31.1	151.7	0.994

RicePro: Exercise + low quality protein; WheyPro: Exercise + high quality protein
A compliance of <70% is considered as not complaint to study protocol

Chapter 10

Discussion, Future Directions and Conclusion

As the prevalence of frailty increases, there is a need for early identification and intervention to avoid institutionalisation, poor health outcomes and rising health care costs[1]. Intervening in the community is an important strategy in avoiding downstream adverse consequences and costs as well as helping older people maintain their functional capacity to achieve healthy ageing[2]. Over the last two decades, there has been an increase in frailty research due to the increased need for an effective global action capable of dealing with this major public health issue[3]. Despite the increase, there still remains a considerable need for research. This PhD has generated new knowledge and built on current evidence. The research will likely contribute to clinical practice, not only in South Australia but also elsewhere.

10.1. Significance for Clinical Practice and Research

The umbrella review presented in Chapter 3 suggests that multi-component exercise interventions including strength, aerobic, balance, and flexibility tasks can currently be recommended for pre-frail and frail older adults to improve muscular strength, gait speed, balance, and physical performance. The evidence was greatest for progressive resistance training on its own where benefits were seen in relation to improved muscle strength, gait speed, and physical performance. There is a need however for evidence to be better established for other types of exercise. Additionally, further research is necessary to establish the benefits of nutritional interventions in combination with exercise on physical function in pre-frail and frail older adults.

Based on the results of the umbrella review, as well as current exercise recommendations from the World Health Organisation[4], the American College for Sports Medicine[5], and other available literature on exercise for pre-frail and frail older adults[6], a consumer friendly handout and referral form (Figure 10.1) was developed with the intention that it be used by clinicians (e.g., GPs, consultants and junior medical doctors) for education and referral purposes. Further discussions will, however, be required with exercise experts (e.g., physiotherapists and exercise physiologists), and end users, to ensure that it is easily understood, useful and translatable.

Exercise Referral

Patient's Name: ______________________

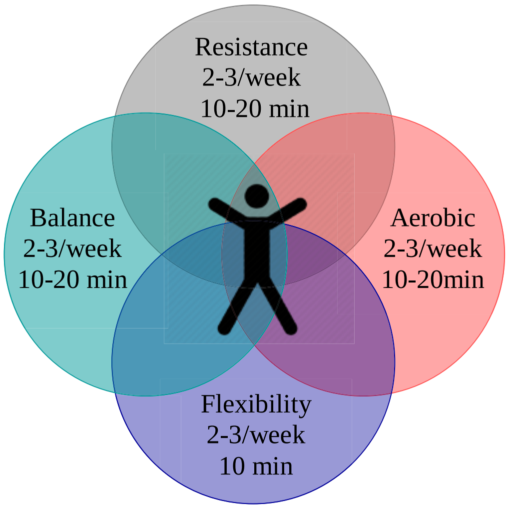
DOB: ___________ Date: ___________

Notes: ____________________________

____

____

____



Recommendations:

Type: □ All □ Resistance □ Aerobic

□ Balance □ Flexibility

Frequency: □ 2 x week □ 3 x week □ __________

Duration: □ 45 min □ 60 min □ __________

Signature ____________

Recommendation for Pre-Frail Patients:

- Multi-component exercise
- Sessions of 60 min
- 2-3 x per week
- Resistance (20 min) Balance (20 min) Aerobic (10min) Flexibility (10min)
- Goal is to reverse frailty

Recommendation for Frail Patients:

- Multi-component exercise
- Sessions of 45 min
- 2-3 x per week
- Aerobic (20 min) Resistance (10 min) Balance (8 min) Flexibility (7 min)
- Goal is to prevent further progression

Types of Exercise:

Resistance:	sit to stand, climbing stairs, sit ups, push-ups in standing position, lunges, weights & elastic bands (including major muscle groups)
Aerobic:	walking, swimming, cycling, dancing
Balance:	one leg stand, tandem stand, knee marching, heel to toe
Flexibility	neck stretch, shoulder rolls, calf stretch, sideways bend, quadriceps stretch, hip stretch, ankle rolls

Intensity of Exercise:

Resistance: 80% of 1 RM (one repetition maximum) Aerobic: "somewhat hard" on Borg Scale

Exercise programs should progress in intensity and difficulty to accommodate individual's fitness gains

Figure 10.1: Front and back of a consumer-friendly exercise handout and referral form for clinicians

Doctors are an integral member of any healthcare team and have a role to play in encouraging older people to exercise[7]. They can do this by increasing awareness of the importance of exercise, dispelling fears, helping to overcome perceived barriers, and by providing direction on where to go and what to do. However, doctors commonly cite the lack of education during medical school training as a reason why they do not prescribe exercise or counsel their patients about exercise[8]. The research work relating to medical students described in Chapters 5 has directly influenced the current 5th year undergraduate geriatric medicine teaching program at the University of Adelaide, especially at the Queen Elizabeth Hospital clinical campus, where this research was undertaken. The research confirms that a 1.5 hour physical activity module added to a geriatric course, can positively impact on student's perceived competency in relation to counselling older people about exercise. It is hoped that the publication of this research may influence undergraduate geriatric medicine curriculum elsewhere, especially given the growing body of evidence about the health and wellbeing benefits of exercise to older people.

The sustained impact of the physical activity module presented in this PhD is currently being evaluated by examining interns' perceived competence over a period of three years. This research will conclude in January 2018 with 2016 being the pre-research year (5th year in 2014), 2017 being the baseline research year (5th year in 2015), and 2018 being the intervention year (5th year in 2016), as an extension of the research described in Chapter 5 and 6. Accordingly, the findings of this research will provide information on whether the teaching of the physical activity module in the 5th year of undergraduate geriatric medicine has a sustainable influence on perceived competency of graduating interns. Continued professional development will likely be a key requirement for ensuring sustainability of confidence of medical practitioners in counselling older people with regards to exercise. Ongoing improvements to the medical teaching programs is a critical strategy in ensuring that our future medical workforce is appropriately skilled to meet the healthcare needs of older people, especially in utilising exercise as a treatment modality.

The uptake of exercise by older people is poor[20]. Locally, there was a need to understand older people's attitudes towards exercise and how they preferred to be advised about exercise. This was the basis for the qualitative research presented in Chapter 4. Encouragingly, we now have evidence to present to general practitioners and other primary care providers that older people at-risk of frailty have a positive attitude towards exercise. General practitioners can be encouraged by the fact that older people value their advice and would like to hear from them about the need to exercise and how to exercise. We also now have evidence that older people value information provided through their local communities and through brochures sent to them. Future research should explore what general practitioners think about prescribing exercise for older adults and where they see opportunities existing for improving or facilitating this process. A better understanding of the perceptions of both, consumers as well as general practitioners, will allow for local models of care to be developed in partnership with primary healthcare networks.

Understanding the health benefits of a pragmatic regimen of nutritional supplementation in combination with exercise for pre-frail and frail community-dwelling older adults, is another important aspect to successfully manage this public health issue. We know that very few studies have been conducted to determine the effects of nutritional interventions such as protein supplements in combination with exercise in a population of pre-frail and frail older adults, and studies to date have yielded conflicting results[9-11]. Chapter 9 focuses on the feasibility aspects of a pragmatic supplement-exercise regimen for pre-frail and frail older adults and we found that spreading the word through media (i.e. television) and flyers appeared to be the most successful strategy to recruit to an intervention study. These findings complement the findings from the qualitative research discussed in Chapter 4 where older people valued information relating to exercise presented through brochures or flyers. Our research confirms that in intervention studies, drop-out is common within the first one to two months. Hence, for individuals commencing any new lifestyle modification program, regardless of whether it is in a research or a real-world-setting, intensive encouragement and supportive strategies are critical in the early phases of adopting changes in eating and exercise habits. Our findings also demonstrated, that even when implementing commercial nutritional supplements that have undergone extensive consumer acceptance testing, many individuals still require tailored strategies to help them adjust to what represents a new nutritional product for them. Completion of this study will provide further insights into the benefits of a protein-supplementation and exercise program on the health and well-being of older people at-risk of frailty. Finally, the safety and tolerability of exercise for this population was supported through our preliminary results but our findings did highlight that the majority of older pre-frail and frail individuals preferred to exercise at home or close to home. This has implications for the urban planning of future cities.

As a result of the research presented in Chapter 7, we also now have a greater understanding of the utility of various geriatric assessment tools in studies involving frail older people such as those commonly seen in geriatric wards.

10.2. Conclusion

The research presented in this PhD has contributed to the knowledge base in relation to addressing the public health issue of frailty. Older adults at-risk of frailty have a positive attitude toward exercise and value advice from their doctors. There is a greater need for research involving older adults at-risk of frailty and media strategies can aid recruitment. Supporting research participants early in the study period will aid retention. Achieving sample sizes coupled with the use of feasible assessments will provide us with relevant evidence. Finally, medical school programs must be relevant to the needs of older people and minor modifications to the medical curriculum can result in improved perceived competencies among future doctors. However, increasing awareness in work units and policies in regards to exercise provision is also required so that what the medical students learn will not be discarded.

11. References

1. Kinsella K, He W. An Aging World: 2008. In: US Census Bureau (Ed). International Population Reports. Washington, DC: Government Printing Office, 2009;95/09-1.
2. Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27(1):1-15.
3. Kippen R. The Future Extent of Population Ageing in Australia. J Popul Res 2002(Special ed. 2002):151-9.
4. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56.
5. Kojima G. Prevalence of Frailty in Nursing Homes: A Systematic Review and Meta-Analysis. J Am Med Dir Assoc 2015;16(11):940-5.
6. Rockwood K, Abeysundera MJ, Mitnitski A. How should we grade frailty in nursing home patients? J Am Med Dir Assoc 2007;8(9):595-603.
7. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 2012;60(8):1487-92.
8. Cesari M, Landi F, Vellas B, Bernabei R, Marzetti E. Sarcopenia and physical frailty: two sides of the same coin. Front Aging Neurosci 2014;6:192.
9. Clark BC, Manini TM. Functional consequences of sarcopenia and dynapenia in the elderly. Curr Opin Clin Nutr Metab Care 2010;13(3):271-6.
10. Weiss CO. Frailty and Chronic Diseases in Older Adults. Clin Geriatr Med 2011;27(1):39-52.
11. Australian Institute of Health and Welfare. Health expenditure Australia 2008–09. Canberra: AIHW; 2010.
12. Cesari M, Vellas B, Hsu FC, Newman AB, Doss H, King AC, et al. A Physical Activity Intervention to Treat the Frailty Syndrome in Older Persons-Results From the LIFE-P Study. J Gerontol A Biol Sci Med Sci 2015;70:216-22.
13. Liu CK, Fielding RA. Exercise as an intervention for frailty. Clin Geriatr Med 2011;27(1):101-10.
14. Taylor D. Physical activity is medicine for older adults. Postgrad Med J 2014;90(1059):26-32.

15. Cermak NM, De Groot LCPGM, Van Loon LJC. Perspective: Protein Supplementation During Prolonged Resistance Type Exercise Training Augments Skeletal Muscle Mass and Strength Gains. J Am Med Dir Assoc 2013;14:71-2.
16. Finger D, Goltz FR, Umpierre D, Meyer E, Rosa LH, Schneider CD. Effects of protein supplementation in older adults undergoing resistance training: a systematic review and meta-analysis. Sports Med 2015;45(2):245-55.
17. Björkman MP, Finne-Soveri H, Tilvis RS. Whey protein supplementation in nursing home residents. A randomized controlled trial. Eur Geriatr Med 2012;3:161-6.
18. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2012;13(8):713-9.
19. Rosendahl E, Lindelof N, Littbrand H, Yifter-Lindgren E, Lundin-Olsson L, Haglin L, et al. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: a randomised controlled trial. Aust J Physiother 2006;52(2):105-13.
20. Franco MR, Tong A, Howard K, Sherrington C, Ferreira PH, Pinto RZ, et al.. Older people's perspectives on participation in physical activity: a systematic review and thematic synthesis of qualitative literature. Br J Sports Med 2015;49(19):1268-76.
21. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 2012;380(9838):247-57.
22. Lawton BA, Rose SB, Elley CR, Dowell AC, Fenton A, Moyes SA. Exercise on prescription for women aged 40-74 recruited through primary care: two year randomised controlled trial. BMJ 2008;337:a2509.
23. Andersen RE, Blair SN, Cheskin LJ, Bartlett SJ. Encouraging patients to become more physically active: the physician's role. Ann Intern Med 1997;127(5):395-400.
24. Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. Prev Med 2004;39(5):1056-61.
25. Forman-Hoffman V, Little A, Wahls T. Barriers to obesity management: a pilot study of primary care clinicians. BMC Fam Pract 2006;7:35.
26. Weiler R, Chew S, Coombs N, Hamer M, Stamatakis E. Physical activity education in the undergraduate curricula of all UK medical schools: are tomorrow's doctors equipped to follow clinical guidelines? Br J Sports Med 2012;46(14):1024-6.

27. Cardinal BJ, Park EA, Kim M, Cardinal MK. If Exercise is Medicine, Where is Exercise in Medicine? Review of U.S. Medical Education Curricula for Physical Activity-Related Content. J Phys Act Health 2015;12(9):1336-43.
28. Strong A, Stoutenberg M, Hobson-Powell A, Hargreaves M, Beeler H, Stamatakis E. An evaluation of physical activity training in Australian medical school curricula. J Sci Med Sport 2017;20(6):534-8.
29. Dacey ML, Kennedy MA, Polak R, Phillips EM. Physical activity counseling in medical school education: a systematic review. Med Educ Online 2014;19:.24325.
30. Rockwood K, Mitnitski A. Frailty in relation to the accumulation of deficits. J Gerontol A Biol Sci Med Sci 2007;62(7):722-7.
31. Michel JP, Cruz-Jentoft AJ, Cederholm T. Frailty, Exercise and Nutrition. Clin Geriatr Med 2015;31(3):375-87.
32. Cameron ID, Fairhall N, Langron C, Lockwood K, Monaghan N, Aggar C, et al. A multifactorial interdisciplinary intervention reduces frailty in older people: randomized trial. BMC Med 2013;11:65.
33. Thompson MQ, Theou, O., Yu, S., Adams, R. J., Tucker, G. R., & Visvanathan, R. Frailty prevalence and factors associated with the frailty phenotype and frailty index. Findings from the North West Adelaide Health Study. Australas J Ageing 2017; In press.
34. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-23.
35. Semba RD, Blaum CS, Bartali B, Xue QL, Ricks MO, Guralnik JM, et al. Denture use, malnutrition, frailty, and mortality among older women living in the community. J Nutr Health Aging 2006;10(2):161-7.
36. Xue QL, Bandeen-Roche K, Varadhan R, Zhou J, Fried LP. Initial manifestations of frailty criteria and the development of frailty phenotype in the Women's Health and Aging Study II. J Gerontol A Biol Sci Med Sci 2008;63(9):984-90.
37. Bandeen-Roche K, Xue QL, Ferrucci L, Walston J, Guralnik JM, Chaves P, et al. Phenotype of frailty: characterization in the women's health and aging studies. J Gerontol A Biol Sci Med Sci 2006;61(3):262-6.
38. Ekerstad N, Swahn E, Janzon M, Alfredsson J, Lofmark R, Lindenberger M, et al. Frailty is independently associated with short-term outcomes for elderly patients with non-ST-segment elevation myocardial infarction. Circulation 2011;124(22):2397-404.

39. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381(9868):752-62.
40. Robertson DA, Savva GM, Kenny RA. Frailty and cognitive impairment-A review of the evidence and causal mechanisms. Ageing Res Rev 2013;12(4):840-51.
41. Mezuk B, Edwards L, Lohman M, Choi M, Lapane K. Depression and frailty in later life: a synthetic review. Int J Geriatr Psychiatry 2012;27(9):879-92.
42. Ferrucci L, Penninx BW, Volpato S, Harris TB, Bandeen-Roche K, Balfour J, et al. Change in muscle strength explains accelerated decline of physical function in older women with high interleukin-6 serum levels. J Am Geriatr Soc 2002;50(12):1947-54.
43. Leng SX, Xue QL, Tian J, Walston JD, Fried LP. Inflammation and frailty in older women. J Am Geriatr Soc 2007;55(6):864-71.
44. Schmaltz HN, Fried LP, Xue QL, Walston J, Leng SX, Semba RD. Chronic cytomegalovirus infection and inflammation are associated with prevalent frailty in community-dwelling older women. J Am Geriatr Soc 2005;53(5):747-54.
45. De Fanis U, Wang GC, Fedarko NS, Walston JD, Casolaro V, Leng SX. T-lymphocytes expressing CC chemokine receptor-5 are increased in frail older adults. J Am Geriatr Soc 2008;56(5):904-8.
46. Chen X, Mao G, Leng SX. Frailty syndrome: an overview. Clin Interv Aging 2014;9:433-41.
47. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39(4):412-23.
48. Sternberg SA, Levin R, Dkaidek S, Edelman S, Resnick T, Menczel J. Frailty and osteoporosis in older women--a prospective study. Osteoporos Int 2014;25(2):763-8.
49. Puts MT, Visser M, Twisk JW, Deeg DJ, Lips P. Endocrine and inflammatory markers as predictors of frailty. Clin Endocrinol (Oxf) 2005;63(4):403-11.
50. Shardell M, Hicks GE, Miller RR, Kritchevsky S, Andersen D, Bandinelli S, et al. Association of low vitamin D levels with the frailty syndrome in men and women. J Gerontol A Biol Sci Med Sci 2009;64(1):69-75.
51. Afilalo J. Frailty in Patients with Cardiovascular Disease: Why, When, and How to Measure. Curr Cardiovasc Risk Rep 2011;5(5):467-72.

52. World Health Organization. Global Recommendations on Physical Activity for Health Geneva: World Health Organization; 2010. Available from: http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/.

53. Virtuoso Júnior JS, Roza LB, Tribess S, Meneguci J, Mendes EL, Pegorari MS, et al. Time Spent Sitting Is Associated with Changes in Biomarkers of Frailty in Hospitalized Older Adults: A Cross Sectional Study. Front Physiol 2017;8(505).

54. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. J Am Med Dir Assoc 2013;14(8):542-59.

55. Visvanathan R, Chapman I. Preventing sarcopaenia in older people. Maturitas 2010;66(4):383-8.

56. Breen L, Phillips SM. Skeletal muscle protein metabolism in the elderly: Interventions to counteract the 'anabolic resistance' of ageing. Nutr Metab (Lond) 2011;8:68.

57. Weinert DJ. Nutrition and muscle protein synthesis: a descriptive review. J Can Chiropr Assoc 2009;53(3):186-93.

58. Beasley JM, LaCroix AZ, Neuhouser ML, Huang Y, Tinker L, Woods N, et al. Protein intake and incident frailty in the Women's Health Initiative observational study. J Am Geriatr Soc 2010;58(6):1063-71.

59. Shah K, Villareal DT. PREVENTING FRAILTY IN OBESE OLDER ADULTS. J Frailty Aging 2012;1(2):47-9.

60. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. J Am Med Dir Assoc 2013;14(6):392-7.

61. Rolland Y, Morley JE. Frailty and polypharmacy. J Nutri Health Aging 2016;20(6):645-6.

62. Rockwood K, Hogan DB, MacKnight C. Conceptualisation and measurement of frailty in elderly people. Drugs Aging 2000;17(4):295-302.

63. Szanton SL, Seplaki CL, Thorpe RJ, Allen JK, Fried LP. “Socioeconomic Status is associated with Frailty: the Women’s Health and Aging Studies”. J Epidemiol Community Health 2010;64(1):63-7.

64. Duppen D, Elst MCJVd, Dury S, Lambotte D, Donder LD. The Social Environment’s Relationship With Frailty. J Appl Gerontol 2017;1:0733464816688310.

65. Lee L, Patel T, Costa A, Bryce E, Hillier LM, Slonim K, et al. Screening for frailty in primary care: Accuracy of gait speed and hand-grip strength. Can Fam Physician 2017;63(1):e51-e57.
66. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992;30(6):473-83.
67. Radloff LS. The CES-D Scale. Appl Psychol Meas 1977;1(3):385-401.
68. Murphy SL. Review of physical activity measurement using accelerometers in older adults: considerations for research design and conduct. Prev Med 2009;48(2):108-14.
69. Abellan van Kan G, Rolland Y, Andrieu S, Bauer J, Beauchet O, Bonnefoy M, et al. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. J Nutr Health Aging 2009;13(10):881-9.
70. Visser M, Deeg DJ, Lips P, Harris TB, Bouter LM. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. J Am Geriatr Soc 2000;48(4):381-6.
71. Speechley M, Tinetti M. Falls and injuries in frail and vigorous community elderly persons. J Am Geriatr Soc 1991;39(1):46-52.
72. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. Cmaj 2005;173(5):489-95.
73. Song X, Mitnitski A, Rockwood K. Prevalence and 10-year outcomes of frailty in older adults in relation to deficit accumulation. J Am Geriatr Soc. 2010;58(4):681-7.
74. Rockwood K, Mogilner A, Mitnitski A. Changes with age in the distribution of a frailty index. Mech Ageing Dev 2004;125(7):517-9.
75. Wieland D, Hirth V. Comprehensive geriatric assessment. Cancer Control 2003;10(6):454-62.
76. Cesari M, Gambassi G, Abellan van Kan G, Vellas B. The frailty phenotype and the frailty index: different instruments for different purposes. Age Ageing 2014;43(1):10-2.
77. Xue QL, Varadhan R. What is missing in the validation of frailty instruments? J Am Med Dir Assoc 2014;15(2):141-2.
78. Turner G, Clegg A, British Geriatrics S, Age UK, Royal College of General P. Best practice guidelines for the management of frailty: a British Geriatrics Society, Age

UK and Royal College of General Practitioners report. Age Ageing 2014;43(6):744-7.

79. Woo J, Yu R, Wong M, Yeung F, Wong M, Lum C. Frailty Screening in the Community Using the FRAIL Scale. J Am Med Dir Assoc 2015;16(5):412-9.

80. Woo J, Leung J, Morley JE. Comparison of frailty indicators based on clinical phenotype and the multiple deficit approach in predicting mortality and physical limitation. J Am Geriatr Soc 2012;60(8):1478-86.

81. Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. Age Ageing 2006;35(5):526-9.

82. Bielderman A, van der Schans CP, van Lieshout M-RJ, de Greef MH, Boersma F, Krijnen WP, et al. Multidimensional structure of the Groningen Frailty Indicator in community-dwelling older people. BMC Geriatrics 2013;13(1):86.

83. Theou O, Brothers TD, Mitnitski A, Rockwood K. Operationalization of frailty using eight commonly used scales and comparison of their ability to predict all-cause mortality. J Am Geriatr Soc 2013;61(9):1537-51.

84. Clegg A, Rogers L, Young J. Diagnostic test accuracy of simple instruments for identifying frailty in community-dwelling older people: a systematic review. Age Ageing 2015;44(1):148-52.

85. Raiche M, Hebert R, Dubois MF. PRISMA-7: a case-finding tool to identify older adults with moderate to severe disabilities. Arch Gerontol Geriatr 2008;47(1):9-18.

86. Castell MV, Sanchez M, Julian R, Queipo R, Martin S, Otero A. Frailty prevalence and slow walking speed in persons age 65 and older: implications for primary care. BMC Fam Pract 2013;14:86.

87. Martone AM, Lattanzio F, Abbatecola AM, La Carpia D, Tosato M, Marzetti E, et al. Treating Sarcopenia In Older And Oldest Old. Curr Pharm Des 2015;21:1715-22.

88. Deutz NE, Bauer JM, Barazzoni R, Biolo G, Boirie Y, Bosy-Westphal A, et al. Protein intake and exercise for optimal muscle function with aging: recommendations from the ESPEN Expert Group. Clin Nutr 2014;33(6):929-36.

89. Australian Institute of Health and Welfare 2014. Australia’s health 2014.

90. Aguirre LE, Villareal DT. Physical Exercise as Therapy for Frailty. Nestle Nutr Inst Workshop Ser 2015;83:83-92.

91. Broderick L, McCullagh R, White EB, Savage E, Timmons S. Perceptions, Expectations, and Informal Supports Influence Exercise Activity in Frail Older Adults. SAGE Open. 2015;5(2):1-10.

92. Phillips EM, Kennedy MA. The exercise prescription: a tool to improve physical activity. PM R 2012;4(11):818-25.

93. Glasgow RE, Eakin EG, Fisher EB, Bacak SJ, Brownson RC. Physician advice and support for physical activity: results from a national survey. Am J Prev Med 2001;21(3):189-96.

94. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res 2011;2011:569194.

95. Villareal DT, Chode S, Parimi N, Sinacore DR, Hilton T, Armamento-Villareal R, et al. Weight loss, exercise, or both and physical function in obese older adults. N Engl J Med 2011;364(13):1218-29.

96. Cruz-Jentoft AJ, Landi F, Schneider SM, Zuniga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing 2014;43(6):748-59.

97. Rennie MJ, Wackerhage H, Spangenburg EE, Booth FW. Control of the size of the human muscle mass. Annu Rev Physiol 2004;66:799-828.

98. Iolascon G, Di Pietro G, Gimigliano F, Mauro GL, Moretti A, Giamattei MT, et al. Physical exercise and sarcopenia in older people: position paper of the Italian Society of Orthopaedics and Medicine (OrtoMed). Clin Cases Miner Bone Metab 2014;11(3):215-21.

99. Konopka AR, Harber MP. Skeletal muscle hypertrophy after aerobic exercise training. Exerc Sport Sci Rev 2014;42(2):53-61.

100. Mohler MJ, Wendel CS, Taylor-Piliae RE, Toosizadeh N, Najafi B. Motor Performance and Physical Activity as Predictors of Prospective Falls in Community-Dwelling Older Adults by Frailty Level: Application of Wearable Technology. Gerontology 2016;62(6):654-64.

101. Watt JR, Jackson K, Franz JR, Dicharry J, Evans J, Kerrigan DC. Effect of a supervised hip flexor stretching program on gait in frail elderly patients. PM R 2011;3(4):330-5.

102. Geda YE, Roberts RO, Knopman DS, Christianson TJH, Pankratz VS, Ivnik RJ, et al. Physical Exercise and Mild Cognitive Impairment: A Population-Based Study. Arch Neurol 2010;67(1):80-6.

103. American College of Sports Medicine C-ZW, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, Skinner JS. American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 2009;41(7):1510-30.

104. Bray NW, Smart RR, Jakobi JM, Jones GR. Exercise prescription to reverse frailty. Appl Physiol Nutri Metab 2016;41(10):1112-6.

105. Scott D, Blizzard L, Fell J, Giles G, Jones G. Associations between dietary nutrient intake and muscle mass and strength in community-dwelling older adults: the Tasmanian Older Adult Cohort Study. J Am Geriatr Soc 2010;58(11):2129-34.

106. Pennings B, Boirie Y, Senden JM, Gijsen AP, Kuipers H, van Loon LJ. Whey protein stimulates postprandial muscle protein accretion more effectively than do casein and casein hydrolysate in older men. Am J Clin Nutr 2011;93(5):997-1005.

107. Deutz NE, Wolfe RR. Is there a maximal anabolic response to protein intake with a meal? Clin Nutr 2013;32(2):309-13.

108. Bouillanne O, Curis E, Hamon-Vilcot B, Nicolis I, Chretien P, Schauer N, et al. Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: a randomized controlled trial. Clin Nutr 2013;32(2):186-92.

109. Cermak NM, Res PT, de Groot LC, Saris WH, van Loon LJ. Protein supplementation augments the adaptive response of skeletal muscle to resistance-type exercise training: a meta-analysis. Am J Clin Nutr 2012;96(6):1454-64.

110. Deutz NE, Pereira SL, Hays NP, Oliver JS, Edens NK, Evans CM, et al. Effect of beta-hydroxy-beta-methylbutyrate (HMB) on lean body mass during 10 days of bed rest in older adults. Clin Nutr 2013;32(5):704-12.

111. Brose A, Parise G, Tarnopolsky MA. Creatine supplementation enhances isometric strength and body composition improvements following strength exercise training in older adults. J Gerontol A Biol Sci Med Sci 2003;58(1):11-9.

112. Candow DG, Chilibeck PD. Effect of creatine supplementation during resistance training on muscle accretion in the elderly. J Nutr Health Aging 2007;11(2):185-8.

113. Eijnde BO, Van Leemputte M, Goris M, Labarque V, Taes Y, Verbessem P, et al. Effects of creatine supplementation and exercise training on fitness in men 55-75 yr old. J Appl Physiol (1985) 2003;95(2):818-28.

114. Chrusch MJ, Chilibeck PD, Chad KE, Davison KS, Burke DG. Creatine supplementation combined with resistance training in older men. Med Sci Sports Exerc 2001;33(12):2111-7.

115. Beaudart C, Buckinx F, Rabenda V, Gillain S, Cavalier E, Slomian J, et al. The effects of vitamin D on skeletal muscle strength, muscle mass, and muscle power: a systematic review and meta-analysis of randomized controlled trials. J Clin Endocrinol Metab 2014;99(11):4336-45.

116. Bischoff-Ferrari HA, Dawson-Hughes B, Staehelin HB, Orav JE, Stuck AE, Theiler R, et al. Fall prevention with supplemental and active forms of vitamin D: a meta-analysis of randomised controlled trials. BMJ 2009;339:b3692.

117. Morley JE, Argiles JM, Evans WJ, Bhasin S, Cella D, Deutz NE, et al. Nutritional recommendations for the management of sarcopenia. J Am Med Dir Assoc 2010;11(6):391-6.

118. Becker C, Lord SR, Studenski SA, Warden SJ, Fielding RA, Recknor CP, et al. Myostatin antibody (LY2495655) in older weak fallers: a proof-of-concept, randomised, phase 2 trial. Lancet Diabetes Endocrinol 2015;3(12):948-57.

119. Sakuma K, Yamaguchi A. Novel intriguing strategies attenuating to sarcopenia. J Aging Res 2012;2012:251217.

120. Drubbel I, Numans ME, Kranenburg G, Bleijenberg N, de Wit NJ, Schuurmans MJ. Screening for frailty in primary care: a systematic review of the psychometric properties of the frailty index in community-dwelling older people. BMC Geriatrics 2014;14(1):27.

121. Beard JR, Officer A, de Carvalho IA, Sadana R, Pot AM, Michel JP, et al. The World report on ageing and health: a policy framework for healthy ageing. Lancet 2016;387(10033):2145-54.

122. Bendayan M, Bibas L, Levi M, Mullie L, Forman DE, Afilalo J. Therapeutic interventions for frail elderly patients: part II. Ongoing and unpublished randomized trials. Prog Cardiovasc Dis 2014;57(2):144-51.

12. Appendices

Appendix 1: Statement of Authorship and published protocol (Chapter 3)
Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol

Appendix 2: Statement of Authorship and accepted manuscript (Chapter 3)
Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review of systematic reviews

Appendix 3: Statement of Authorship and published manuscript (Chapter 4)
The perspectives of pre-frail and frail older people on being advised about exercise: a qualitative study

Appendix 4: Statement of Authorship and published manuscript (Chapter 5)
Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people

Appendix 5: Statement of Authorship and accepted manuscript (Chapter 6)
Educating medical students in counselling older adults about exercise: the impact of a physical activity module

Appendix 6: Statement of Authorship and published manuscript (Chapter 7)
The feasibility of standardised geriatric assessment tools and physical exercises in frail older adults

Appendix 7: Statement of Authorship and published protocol (Chapter 8)
The EXPRESS Study: Exercise and Protein Effectiveness Supplementation Study supporting autonomy in community dwelling frail older people - study protocol for a randomised controlled pilot and feasibility study

Appendix 8: Statement of Authorship (Chapter 9)
The feasibility of a randomised controlled pilot Exercise and Protein Effectiveness Supplementation Study (EXPRESS) supporting autonomy in community-dwelling frail older people

Appendix 9: Published Abstracts

Appendix 10: Poster Presentations

Appendix 11: Media Articles

Appendix 1

Statement of Authorship and published protocol (Chapter 3)

Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol

Statement of Authorship

Title of Paper	Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	Jadczak AD, Makwana N, Luscombe-Marsh ND, Visvanathan R, Schultz TJ. Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol. JBI Database of Systematic Reviews and Implementation Reports. 2016;14(9):93-102.

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak		
Contribution to the Paper	Developed search terms, selected data bases, prepared methods and data analyses, wrote the protocol, and acted as corresponding author.		
Overall percentage (%)	75%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	09/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Naresh Makwana		
Contribution to the Paper	Helped in selecting data bases and developing search terms.		
Signature		Date	09/10/2017

Name of Co-Author	Natalie Luscombe-Marsh		
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to methods and data analyses.		
Signature		Date	09/10/17

Name of Co-Author	Renuka Visvanathan		
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to methods and data analyses.		
Signature		Date	27/9/17

Name of Co-Author	Timothy Schultz		
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to search strategies, selecting databases, methods and data analyses.		
Signature		Date	9/10/17

Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol

Agathe D. Jadczak[1,2,3] • Naresh Makwana[1,2] • Natalie D. Luscombe-Marsh[4] • Renuka Visvanathan[1,2,3] • Timothy J. Schultz[5,6]

[1]National Health and Medical Research Council Centre of Research Excellence: Trans-disciplinary Frailty Research to Achieve Healthy Ageing, University of Adelaide, Adelaide, Australia, [2]Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, School of Medicine, University of Adelaide, Adelaide, Australia, [3]Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide, Australia, [4]Food and Nutrition, Commonwealth Scientific Industrial Research Organisation (CSIRO), Adelaide, Australia, [5]School of Nursing, University of Adelaide, Adelaide, Australia, and [6]Centre for Evidence-based Practice South Australia (CEPSA): a Joanna Briggs Institute Centre of Excellence

Review question/objective: The objectives of this umbrella review are to determine the effectiveness of exercise interventions, alone or in combination with other interventions, for improving physical function in community-dwelling older people who are identified as frail or at risk of frailty, and to identify if any particular intervention type or characteristic is the most effective.
Specifically, the review question is: What is the effectiveness of exercise interventions, alone or in combination with other interventions, for improving physical function in community-dwelling older people identified as frail or at risk of frailty?

Keywords Umbrella review; exercise; frailty; physical function; older people

Background

The World Health Organization expects the number of people aged 65 years and older to triple in the next 30 years.[1,2] By 2050, in Australia alone, nearly one quarter of the population will be aged over 65 years.[3] Aging is associated with an increased risk of illness and disability, pressure on healthcare services and a decreased quality of life. Maintaining good physical function would help to counter the aforementioned poor outcomes.[4]

One major health condition that has an insidious impact on health and physical function is the frailty syndrome,[5] a prevalent geriatric condition observed in clinical practice and associated with aging.[6] It is defined as a "clinically recognizable state of increased vulnerability resulting from age-associated decline in reserve and function".[2(p.1)] Clinical indicators for frailty include deficit accumulation, fatigue, sedentary behavior, weight loss, cognitive impairment, social isolation, sarcopenia and the impairment of physical function.[5]

A recent systematic review of 21 community-based cohorts reported that prevalence of frailty in the community increases steadily with age.[7] Based on these international figures, it can be extrapolated that by 2050, four million Australians aged 70 years and older will either be frail or at risk of frailty.[7] Of note, two studies within this review indicated that the prevalence of frailty and pre-frailty in older Australians was between 10%-15% and 40%-46%, respectively.[8,9] Data from another longitudinal cohort of Australian women indicate similar prevalence of frailty and pre-frailty.[10]

The impairment of physical function interferes with a person's ability to perform the activities of daily living (ADL).[5] Strength, mobility, balance and physical performance are all impaired, resulting in disability, loss of independence, a reduced quality of life and premature mortality.[11-14] However, frailty is

Correspondence: Agathe D. Jadczak, agathedaria.jadczak@adelaide.edu.au

If a systematic review includes a study that was conducted by one of the authors, another author(s) or an editor(s) will extract these data, and check the interpretation against the study report and any available study registration details or protocol. There are no further conflicts identified.

DOI: 10.11124/JBISRIR-2016-003081

a dynamic syndrome that is both treatable and reversible,[15,16] and studies have shown that physical, nutritional, cognitive and combined interventions are effective in reversing frailty and improving physical function in community-dwelling frail older people.[6,17-19] Exercise interventions, in particular, have the potential to prevent, delay and reverse frailty.[20] They can be used to maintain or restore muscle strength, balance, physical performance and prevent the loss of independence.[6,15]

Several systematic reviews, including meta-analyses, discuss the effects of exercise interventions on important physical parameters, such as mobility, gait speed, balance and strength.[21-23] The investigations described in the reviews indicate that multi-component exercise, including strength, endurance and balance training, appears to be the best way to improve physical function in frail older people.[22] However, there is still uncertainty as to which exercise characteristics (type, frequency, intensity, duration, setting and combinations) are most effective.

In addition, further evidence suggests that multi-component exercise interventions that are combined with protein supplementation may be more effective than exercise alone for improving physical function in older people.[24-26] However, a systematic review including older adults found that protein supplements in combination with resistance training were associated with gains in fat-free mass, which decreases as we age, contributing to the development of frailty, disability and functional impairment in vulnerable individuals.[27]

The frailty syndrome already affects or is likely to affect a significant portion of aging individuals, who will consequently lose much of their quality of life because of impaired physical function. Current research suggests that this is preventable through utilizing effective interventions and management of the at-risk population.

The number of identified systematic reviews on this topic[19,21-23,28-31] indicates the need for an umbrella review to identify important repeated or interrelated findings that could inform future research and clinical trial development.

Inclusion criteria

Types of participants

The current umbrella review will examine systematic reviews involving sample populations of individuals:

- Aged 60 years and above (at least 50% of the people included in the review should be 60 years or older, OR the mean age of the people in the study should be at least 60 years).
- Living in the community (at least 50% of people included in the review should be living in the community in their own homes).
- Identified as frail or at risk of frailty using an operationalized definition of frailty or standardized criteria to measure frailty (at least 50% of the people included in the review should be identified as frail or at risk of frailty).

The following definitions of frailty identified by Bouillon *et al.*[32] will be accepted in this umbrella review: Groningen Frailty Indicator,[33] frailty index,[34] Canadian Study of Health and Aging Clinical Frailty Scale,[35] Vulnerable Elder Survey-13,[36] Tilburg Frailty Indicator,[37] Physical Frailty Score,[38] Phenotype of Frailty,[16] Edmonton Frail Scale[39] and the Study of Osteoporotic Fractures Index.[40]

Reviews that do not provide sufficient detail about the sample populations of included studies will be excluded. Reviews that do not use an operationalized definition of frailty or standardized criteria to measure frailty according to Bouillon *et al.*[32] will be excluded. Reviews that focus on healthy older people or older people who are in hospital, subacute settings or nursing homes will be excluded. Nursing homes are defined as "a facility with a domestic-styled environment that provides 24-hour functional support and care for persons who require assistance with ADL and who often have complex health needs and increased vulnerability".[41(p.183)]

Types of intervention(s)/phenomena of interest

This umbrella review will include systematic reviews that evaluate exercise interventions of any form, duration, frequency and intensity, alone or in combination with other interventions designed to alter physical function of frail older people. The types of exercise interventions will include, but are not limited to:

- Resistance and strength training
- Aerobic and endurance training
- Balance training

- Flexibility and stretching training
- Multicomponent training.

If other exercise interventions are identified during the review, they will be assessed for inclusion. Systematic reviews that involve interventions that are not combined with exercise will be excluded. To determine the effectiveness of exercise interventions, they will be compared to either a control group (i.e. no intervention, placebo intervention and usual care) or a comparator group (i.e. another type of exercise and exercise in combination with other interventions).

Outcomes

The current umbrella review will include systematic reviews of quantitative measures of physical function in frail older people. The types of outcomes will include, but are not limited to:

- Muscular strength measured by, for example, grip strength or lower limb strength
- Gait ability and performance measured by, for example, gait speed
- Balance measured by, for example, berg balance scale or tandem stand
- Mobility measured by, for example, timed up and go test.

This umbrella review will exclude systematic reviews of physical function parameters that are not measured quantitatively by standard or appropriate measurements.

Types of studies

The current umbrella review will include any quantitative systematic reviews with or without meta-analysis that examine the effectiveness of exercise interventions, alone or in combination with other interventions, in relation to improving physical function in frail older people.

Systematic reviews that meet the following criteria will be considered for inclusion:

- Clearly articulated and comprehensive search strategy including multiple bibliographic databases (of no less than three bibliometric databases)
- Evidence of critical appraisal/assessment of risk of bias.

If it is not clear whether the inclusion criteria are met, authors will be contacted for confirmation before excluding the review. Furthermore, literature reviews, withdrawn or retracted publications and systematic reviews not published in English will be also excluded.

Search strategy

A three-step search strategy will be utilized in this review with the aim of locating published systematic reviews with or without meta-analyses. An initial limited search of PubMed and EMBASE will be undertaken followed by an analysis of the text of the title and abstract, and of the index terms used to describe the article. A second search using all identified keywords and index terms will then be undertaken across all included databases. Third, the reference list of all identified reports and articles will be searched for additional studies. Studies written in English and published from 1990 until the present date will be considered for inclusion in this umbrella review. The selection of 1990 was a conservative estimate of the earliest likely publication of a systematic review on this topic as this pre-dates some of the earliest operationalized definitions of frailty and standardized criteria to measure frailty according to Bouillon *et al.*[32] In addition, extending the search as far back as 1990 will help to allow us to identify whether a review is an update of a previous review.

The sources to be searched include:

- PubMed
- EMBASE
- CINAHL
- Scopus
- The Cochrane Database of Systematic Reviews
- Database of Abstracts of Reviews of Effects
- *Joanna Briggs Institute (JBI) Database of Systematic Reviews and Implementation Reports*
- Web of Sciences
- The Campbell Collaboration Library of Systematic Reviews
- Google Scholar.

Gray literature will be searched using Google, the Gray Literature Report (http://www.greylit.org/) and ProQuest Dissertations and Theses that will also include a search for unpublished studies.

The initial search terms/keywords in PubMed will be:

- exercise or "physical activity" or intervention or therapy or training AND
- frailty or frail or pre-frail or prefrail or "at-risk of frailty" AND

- elderly or "older person" or "older adult" [filter: Aged: 60+ years] AND
- [filter: "systematic review"].

The keywords, index terms, titles and abstracts of retrieved studies relevant to the topic will then be carefully assessed to identify all of the search terms for a comprehensive secondary search of the literature. This second phase will incorporate all of the identified search terms. This search will be followed by the third phase of searching the reference lists of all included studies.

Papers will be assessed for relevance utilizing the title, abstract and index terms, including papers found from searching a reference list of relevant papers. Screening will be conducted independently by two reviewers.

Assessment of methodological quality

Papers selected for retrieval will be appraised using eligibility criteria listed in Appendix I. Studies that meet all the eligibility criteria will be appraised using standardized critical appraisal instruments from the JBI System for the Unified Management, Assessment and Review Instrument and The JBI Reviewers' Manual 2014 (Appendix II).[42] Any disagreements that arise between the reviewers will be resolved through discussion or with a third reviewer. We will not exclude studies on the basis of critical appraisal score, and all studies that are appraised and meet the eligibility criteria will be included in data extraction. We will use sensitivity analysis based on study quality to determine whether study quality impacts on the findings of the umbrella review. We will rank the quality of each study based on the critical appraisal results using the following scale: 0-33% of criteria met (low quality), 34-66% of criteria met (medium quality) and 67% or more of criteria met (high quality). Any "not applicable" criteria will be excluded from these estimates of study quality. Reasons why any criteria were not applicable will be provided.

Data extraction

The data of interest will be extracted using a standardized JBI instrument designed for umbrella reviews (Appendix III). The following information will be extracted:

- Type of review
- Countries where the studies were conducted
- Number of studies in the review
- Participants (number, age group and comorbidities)
- Type(s) of intervention(s) including duration, intensity and frequency
- Outcomes identified (type/characteristics)
- Length and completeness of follow-up
- Primary outcome measures
- Method of analyses
- Heterogeneity
- Effect size
- Confidence intervals.

Data synthesis

The data extracted from selected reviews related to interventions will be tabulated and accompanied by narrative synthesis to address the review question. Tables of quantitative results recording the overall size of the effects of intervention and a clear description of the intervention will be presented with supporting interpretation. Tables will include extensive records of the outcomes for each systematic review, including the number of studies, total number of participants, heterogeneity of results, setting, age, comorbidity and information about the intervention. Where possible, the sensitivity of the study findings will be considered based on the determinants of study quality, as assessed by critical appraisal.

The results of the umbrella review will be provided in tabular form in a "Summary of Evidence" table that includes the intervention name, the included systematic review(s) and a simple visual indicator of the effectiveness of the intervention using the three colors of the traffic light: a beneficial or effective intervention (green), no effect or difference compared to a control treatment (amber) and a detrimental intervention or one that is less effective than a control treatment (red).[42] The quality of the evidence will be determined using Grading of Recommendations Assessment, Development and Evaluation criteria, where possible. A four-point rating scale will be used to rate the quality of the evidence: high, moderate, low and very low.[43] The quality of evidence will be classified by evaluating it using the following criteria: methodological limitations, consistency, risk of bias and relevance to the study population. In the event that there are missing data, the authors of this umbrella review will endeavor to contact the author(s) of the paper in question to seek clarification.

References

1. Kinsella K, He W. An aging world: 2008. In: US Census Bureau, editor. International population reports. Washington, DC: Government Printing Office, 2009. 95/09-1.
2. Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27(1):1–15.
3. Kippen R. The future extent of population ageing in Australia. J Popul Res (Special ed. 2002):2002:151–9.
4. Taylor D. Physical activity is medicine for older adults. Postgrad Med J 2014;90(1059):26–32.
5. Cesari M, Landi F, Vellas B, Bernabei R, Marzetti E. Sarcopenia and physical frailty: two sides of the same coin. Front Aging Neurosci (6):2014:192.
6. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381(9868):752–62.
7. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 2012;60(8):1487–92.
8. Blyth FM, Rochat S, Cumming RG, Creasey H, Handelsman DJ, Le Couteur DG, *et al*. Pain, frailty and comorbidity on older men: the CHAMP study. Pain 2008;140(1):224–30.
9. Hyde Z, Flicker L, Almeida OP, Hankey GJ, McCaul KA, Chubb SA, *et al*. Low free testosterone predicts frailty in older men: the health in men study. J Clin Endocrinol Metab 2010;95(7):3165–72.
10. Cameron ID, Fairhall N, Langron C, Lockwood K, Monaghan N, Aggar C, *et al*. A multifactorial interdisciplinary intervention reduces frailty in older people: randomized trial. BMC Med 2013;11(1):65.
11. Painter P, Marcus RL. Assessing physical function and physical activity in patients with CKD. Clin J Am Soc Nephrol 2013;8(5):861–72.
12. Clark BC, Manini TM. Functional consequences of sarcopenia and dynapenia in the elderly. Curr Opin Clin Nutr Metab Care 2010;13(3):271–6.
13. Weiss CO. Frailty and chronic diseases in older adults. Clin Geriatr Med 2011;27(1):39–52.
14. Reiman MP, Manske RC. Functional testing in human performance. Champaign, IL: Human Kinetics; 2009.
15 Gill T M, Gahbauer E A, Allore H G, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418–23.
16. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, *et al*. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146–56.
17. Ng TP, Feng L, Zin Nyunt MS, Feng L, Niti M, Tan BY, *et al*. Nutritional, physical, cognitive and combination interventions and frailty reversal among older adults: a randomized controlled trial. Am J Med 2015;128(11):1225–1236.e1.
18. Pahor M, Blair SN, Espeland M, Fielding R, Gill TM, Guralnik JM, *et al*. Effects of a physical activity intervention on measures of physical performance: results of the lifestyle interventions and independence for Elders Pilot (LIFE-P) study. J Gerontol A Biol Sci Med Sci 2006;61(11):1157–65.
19. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, *et al*. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res 2011;2011:569194.
20. Paterson DH, Jones GR, Rice CL. Aging and physical activity data on which to base recommendations for exercise in older adults. Appl Physiol Nutr Metab 2007(32)(Suppl 2F):S75-S171.
21. Gine-Garriga M, Roque-Figuls M, Coll-Planas L, Sitja-Rabert M, Salva A. Physical exercise interventions for improving performance-based measures of physical function in community-dwelling, frail older adults: a systematic review and meta-analysis. Arch Phys Med Rehabil 2014;95(4):753–769.e3.
22. Cadore EL, Rodriguez-Manas L, Sinclair A, Izquierdo M. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. Rejuvenation Res 2013;16(2):105–14.
23. de Vries NM, van Ravensberg CD, Hobbelen JSM, Olde Rikkert MGM, Staal JB, Nijhuis-van der Sanden MWG. Effects of physical exercise therapy on mobility, physical functioning, physical activity and quality of life in community-dwelling older adults with impaired mobility, physical disability and/or multi-morbidity: a meta-analysis. Ageing Res Rev 2012;11(1):136–49.
24. Deutz NE, Bauer JM, Barazzoni R, Biolo G, Boirie Y, Bosy-Westphal A, *et al*. Protein intake and exercise for optimal muscle function with aging: recommendations from the ESPEN Expert Group. Clin Nutr 2014;33(6):929–36.
25. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, *et al*. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. J Am Med Dir Assoc 2013;14(8):542–59.
26. Cesari M, Vellas B, Hsu FC, Newman AB, Doss H, King AC, *et al*. A physical activity intervention to treat the frailty syndrome in older persons-results from the LIFE-P study. J Gerontol A Biol Sci Med Sci 2015;70(2):216–22.
27. Finger D, Goltz FR, Umpierre D, Meyer E, Rosa LH, Schneider CD. Effects of protein supplementation in older adults undergoing resistance training: a systematic review and meta-analysis. Sports Med 2015;45(2):245–55.
28. Clegg AP, Barber SE, Young JB, Forster A, Iliffe SJ. Do home-based exercise interventions improve outcomes for frail older people? Findings from a systematic review. Rev Clin Gerontol 2012;22(1):68–78.
29. Chin A, Paw MJM, Van Uffelen JGZ, Riphagen I, Van Mechelen W. The functional effects of physical exercise training in frail older people: a systematic review. Sports Med 2008;38(9):781–93.

30. Anthony K, Robinson K, Logan P, Gordon AL, Harwood RH, Masud T. Chair-based exercises for frail older people: a systematic review. Biomed Res Int 2013; 2013:309506.
31. Lee PH, Lee YS, Chan DC. Interventions targeting geriatric frailty: a systemic review. J Clin Geront Geriat 2012;3(2):47–52.
32. Bouillon K, Kivimaki M, Hamer M, Sabia S, Fransson EI, Singh-Manoux A, *et al*. Measures of frailty in population-based studies: an overview. BMC Geriatr 2013;13:64.
33. Steverink N, Slaets J, Schuurmans H, MVL. Measuring frailty: developing and testing of the Groningen Frailty Indicator (GFI). Gerontologist 2001;41(1):236–7.
34. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficits as a proxy measure of aging. Scientific World Journal (1):2001:323–36.
35. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, *et al*. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173(5):489–95.
36. Kanauchi M, Kubo A, Kanauchi K, Saito Y. Frailty, health-related quality of life and mental well-being in older adults with cardiometabolic risk factors. Int J Clin Pract 2008;62(9):1447–51.
37. Gobbens RJ, van Assen MA, Luijkx KG, Wijnen-Sponselee MT, Schols JM. The Tilburg Frailty Indicator: psychometric properties. J Am Med Dir Assoc 2010;11(5):344–55.
38. Gill TM, Baker DI, Gottschalk M, Peduzzi PN, Allore H, Byers A. A program to prevent functional decline in physically frail, elderly persons who live at home. N Engl J Med 2002;347(14):1068–74.
39. Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. Age Ageing 2006;35(5):526–9.
40. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Cawthon PM, Stone KL, *et al*. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Arch Intern Med 2008;168(4):382–9.
41. Sanford AM, Orrell M, Tolson D, Abbatecola AM, Arai H, Bauer JM, *et al*. An international definition for “nursing home”. J Am Med Dir Assoc 2015;16(3):181–4.
42. Institute TJB. The Joanna Briggs Institute Reviewers’ manual: methodology for JBI Umbrella Reviews. In: Institute TJB, editor. Adelaide 2014.
43. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, *et al*. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336(7650):924–6.

Appendix I: Verification of review eligibility

Verification of review eligibility: inclusion criteria

Author and year
Journal
Title
Name/code of reviewer
Design: The article is/contains a systematic review with or without meta-analysis Yes
Review type: For effectiveness reviews, a comparator group is utilized Yes
Participants: Participants of interested are older people aged 60 years and over, Yes Identified as pre-frail, frail or at-risk of frailty in title, abstract or text Yes And living in the community Yes
Interventions: Interventions of interest are exercise interventions, alone or combined with other interventions Yes
Outcomes: Outcomes of interest are: muscular strength, gait ability including gait speed and gait performance, balance and mobility Yes
If you have not answered "yes" to all of the above questions, you should exclude the study. If you answered yes to all, please continue.

Appendix II: JBI critical appraisal checklist for systematic reviews and research syntheses

Reviewer ______________________________Date _____________________

Author ______________________________Year _____________ Record Number _________

	Yes	No	Unclear	Not applicable
1. Is the review question clearly and explicitly stated?	☐	☐	☐	☐
2. Were the inclusion criteria appropriate for the review question?	☐	☐	☐	☐
3. Was the search strategy appropriate?	☐	☐	☐	☐
4. Were the sources and recourses used to search for studies adequate?	☐	☐	☐	☐
5. Were the criteria for appraising studies appropriate?	☐	☐	☐	☐
6. Was critical appraisal conducted by two or more reviewers independently?	☐	☐	☐	☐
7. Were there methods to minimize errors in data extraction?	☐	☐	☐	☐
8. Were the methods used to combine studies appropriate?	☐	☐	☐	☐
9. Was the likelihood of publication bias assessed?	☐	☐	☐	☐
10. Were recommendations for policy and/or practice supported by the reported data?	☐	☐	☐	☐
11. Were the specific directives for new research appropriate?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

____

____

____

Appendix III: JBI data extraction form for review for systematic reviews and research syntheses

<table>
<tr><td colspan="4">Study Details</td></tr>
<tr><td>Author/Year</td><td colspan="3"></td></tr>
<tr><td>Objectives</td><td colspan="3"></td></tr>
<tr><td>Participants (characteristics/ total number or %)</td><td colspan="3">Male: ____ (n or %) Female: ____ (n or %) Total: ____ (n or %)
Identified as frail: _____________ (n or %)
Standardised method/definition to assess frailty: □ yes □ no
Method/definition used: _________________________________
Ethnicity of participants:</td></tr>
<tr><td>Setting/Context</td><td colspan="3"></td></tr>
<tr><td rowspan="3">Description of Interventions/ Phenomena of Interest</td><td>Exercise:</td><td>Resistance/strength training:
____
Aerobic/endurance training
____
Balance training
____
Flexibility/stretching training
____
Multi-component training</td><td>□
□
□
□
□
□</td></tr>
<tr><td>Other:</td><td colspan="2"></td></tr>
<tr><td>Combinations:</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Characteristics of Intervention</td><td>Duration</td><td colspan="2"></td></tr>
<tr><td>Frequency</td><td colspan="2"></td></tr>
<tr><td>Intensity</td><td colspan="2"></td></tr>
<tr><td colspan="4">Search Details</td></tr>
<tr><td>Sources searched</td><td colspan="3"></td></tr>
<tr><td>Range (years) of included studies</td><td colspan="3"></td></tr>
<tr><td>Number of studies included</td><td colspan="3"></td></tr>
</table>

Types of studies included	
Country of origin on included studies	
Appraisal	
Appraisal instruments used	
Appraisal rating	
Analysis	
Method of Analysis	
Outcome assessed	☐ Strength:
	☐ Gait ability/performance:
	☐ Balance:
	☐ Mobility:
	☐ Other:
Results/Findings	
Limitations	
Significance/direction	
Heterogeneity	
Comments	

Appendix 2

Statement of Authorship and accepted manuscript (Chapter 3)

Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review of systematic reviews

Statement of Authorship

Title of Paper	Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review
Publication Status	☐ Published ☑ Accepted for Publication on 23 November 2017 ☒ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Jadczak AD, Makwana N, Luscombe-Marsh ND, Visvanathan R, Schultz TJ. Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review. JBI Database of Systematic Reviews and Implementation Reports.

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak		
Contribution to the Paper	First reviewer, conducted search, analyzed and interpreted data, constructed summary tables, wrote the manuscript and acted as corresponding author.		
Overall percentage (%)	70%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	09/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Naresh Makwana		
Contribution to the Paper	Acted as second reviewer, helped in analyzing and interpretation of the data and writing the manuscript.		
Signature		Date	09/10/2017

Name of Co-Author	Natalie Luscombe-Marsh		
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to data interpretation and manuscript evaluation.		
Signature		Date	09/10/17.

Name of Co-Author	Renuka Visvanathan
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to data interpretation and manuscript evaluation.
Signature	Date 27/9/17

Name of Co-Author	Timothy Schultz
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to data analyses, interpretation and manuscript evaluation.
Signature	Date 9/10/17

Review title

The effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review of systematic reviews

Agathe D Jadczak[1,2,3]

Naresh Makwana[1,2]

Natalie Luscombe-Marsh[4]

Renuka Visvanathan[1,2,3]

Timothy J Schultz[1,5,6]

1. National Health and Medical Research Council Centre of Research Excellence: Trans-disciplinary Frailty Research to Achieve Healthy Ageing, University of Adelaide, South Australia, Australia
2. Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Adelaide Medical School, University of Adelaide, South Australia, Australia
3. Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide, South Australia, Australia
4. Health & Biosecurity, Commonwealth Scientific Industrial Research Organisation (CSIRO), Adelaide, Australia
5. Adelaide Nursing School, University of Adelaide, South Australia, Australia
6. Centre for Evidence-based Practice South Australia (CEPSA): An affiliate centre of the Joanna Briggs Institute

Corresponding author:

Agathe Daria Jadczak

agathedaria.jadczak@adelaide.edu.au

Executive Summary

Background

Exercise is said to have a positive impact on muscle mass and strength, which improves physical function, and hence, is beneficial for the treatment of frailty. Several systematic reviews discuss the effects of exercise interventions on physical function parameters, such as strength, mobility, gait, balance, and physical performance and indicate that multi-component exercise, including resistance, aerobic, balance and flexibility training, appears to be the best way in which to improve physical function parameters in frail older people. However, there is still uncertainty as to which exercise characteristics (type, frequency, intensity, duration, and combinations) are most effective and sustainable over the long-term.

Objectives

This umbrella review aimed to determine the effectiveness of exercise interventions, alone or in combination with other interventions, in improving physical function in community-dwelling older people identified as pre-frail or frail.

Inclusion criteria

Types of participants: Participants were adults, 60 years or older, living in the community and identified as pre-frail or frail.

Types of interventions: Exercise interventions of any form, duration, frequency and intensity, alone or in combination with other interventions designed to alter physical function parameters in frail older people.

Types of studies: Quantitative systematic reviews, with or without meta-analysis that examined the effectiveness of exercise interventions.

Types of outcomes: The quantitative outcome measures of physical function, including muscular strength, gait, balance, mobility and physical performance.

Search strategy

An iterative search strategy for ten bibliometric databases and grey literature was developed.

Methodological quality

Critical appraisal of the included systematic reviews was conducted independently by two reviewers using a standard Joanna Briggs Institute tool.

Data extraction

Data was extracted independently by two reviewers using a standard Joanna Briggs Institute data extraction tool.

Data summary

Data were summarized in a narrative synthesis approach.

Results

Seven systematic reviews were included in this umbrella review with a total of 58 relevant randomized controlled trials and 6,927 participants. Five systematic reviews examined the effects of exercise only, while two systematic reviews reported on exercise in combination with a nutritional approach, including protein supplementations, as well as fruit and dairy products. The average exercise frequency was 2-3 times per week (mean 3.0±1.5 times per week; range 1-7weekly) for 10-90 minutes per session (mean of 52.0±16.5 mins) and a total duration of 5-72 weeks with the majority lasting a minimum of 2.5 months (mean 22.7±17.7 weeks). Multi-component exercise interventions can currently be recommended for pre-frail and frail older adults to improve muscular strength, gait speed, balance and physical performance, including resistance, aerobic, balance, and flexibility tasks. Resistance training alone also appeared to be beneficial, in particular for improving muscular strength, gait speed and physical performance. Other types of exercise were not sufficiently studied and their effectiveness is yet to be established.

Conclusions

Interventions for pre-frail and frail older adults should include multi-component exercises, including in particular resistance training, as well as aerobic, balance and flexibility tasks. Future research should adopt a consistent definition of frailty and investigate the effects of other types of exercise alone or in combination with nutritional interventions so that more specific recommendations can be made.

Keywords

umbrella review; exercise interventions; frailty; older people; community-dwelling

BACKGROUND

The world's population is aging. The proportion of Australians aged 65 years and older, for example, increased from 11.8% to 14.7% between 1994 and 2014.[1] Maintaining health and independence, avoiding functional decline and improving health-related quality of life are significant challenges for older adults.[2]

Because aging is accompanied by physiological changes, such as reduced hormone production, oxidative stress, poor cellular oxygenation and reduced mobility,[3] the proportion of older people in danger of becoming frail will increase as the population ages.[4] While many people can experience the natural physiological alteration of aging cells with no uncommon issues, for large numbers of the elderly, growing older means growing frailer. Many researchers and geriatricians now consider frailty to be a clinical syndrome, defined by the presence of specified symptoms and signs. The World Health Organization has noted that frailty has become an indicator of unsuccessful aging.[5]

The most commonly used frailty phenotype criteria by Fried et al.[6] categorizes people into robust, pre-frail and frail by using a physiological approach to frailty. Fried et al. propose that the following five indicators are related to each other within a framework of frailty: unintentional weight loss, exhaustion, slow walking speed, low grip strength and low physical activity. A person with three or more of these criteria is categorized as frail; a person with one or two criteria is considered to be pre-frail; and those with none of the indicators are considered to be robust.

In the last two decades there has been a sharp rise in frailty research due to the increasing need for effective interventions to manage the condition.[7] Evidence suggests that exercise interventions can be used to restore or maintain functional independence in older adults[8] and subsequently help to prevent institutionalization and increasing health care costs. Exercise interventions may also potentially prevent, delay or reverse frailty.[9,10]

A preliminary search revealed that several systematic reviews have been conducted to examine the effects of exercise interventions both alone,[10-14] and in combination with nutritional supplements,[15,16] on important functional parameters in frail older people, such as strength, mobility, gait speed, balance and physical performance. Low muscular strength and slow gait speed, for example, are strong indicators for frailty.[17] Mobility includes a person's ability to physically move and is usually measured by tests including muscular strength and gait, while physical performance is based on the combination of mobility, gait speed and balance tasks representing a person's ability to physically function as a multidimensional concept.[18]

The exercise interventions described in the various reviews indicate that multi-component exercise, including resistance, aerobic, and balance training, can alleviate functional decline and improve strength in frail older people.[11,12] Contradictory, the randomized controlled trials included in two of the systematic reviews demonstrated both positive and negative outcomes of the exercise interventions.[13,14] Interventions including both exercise and nutrition supplements also showed contentious results. Lee et al.[19] showed that exercise combined with diet improves strength and gait speed more significantly than exercise alone, whereas Cruz-Jentoft et al.[15] demonstrated that resistance exercise in combination with protein supplementation did not improve muscle strength and physical performance. Uncertainty exists for which exercise characteristics (type, frequency, duration, and intensity) are most effective, either alone or in combination with other interventions. Nevertheless, the American College of Sports Medicine's (ACSM)[20] has published updated guidelines for physical activity in older adults that recommend the prioritization of resistance exercises over aerobic training for this population. The conflicting results of some of the systematic reviews indicating the need for an umbrella review to better understand and evaluate the effectiveness of exercise interventions and their characteristics.

Therefore, an umbrella review was conducted to examine the effectiveness of exercise intervention, alone or in combination with other interventions, for improving physical function in community-dwelling older people identified as frail or at-risk of frailty. This review was conducted according to an *a priori* published protocol.[21]

OBJECTIVES

The objectives of this umbrella review were to: (i) determine the effectiveness of exercise interventions, alone or in combination with other interventions, for improving physical function in community-dwelling older people who are identified as frail or at-risk of frailty and (ii) examine if any particular intervention type or characteristic is more effective than others.

REVIEW QUESTION

What is the effectiveness of exercise interventions, alone or in combination with other interventions, for improving physical function in community-dwelling older people who are identified as frail or at-risk of frailty?

INCLUSION CRITERIA

Types of participants

This umbrella review included systematic reviews involving individuals:

- aged 60 years and above. More specifically, it was proposed that at least 50% of the people included in the review were 60 years or older, OR that the mean age of the people in the study was at least 60 years. If one of these criteria was fulfilled but the other is not, the review was included.
- living in the community. More specifically, it was proposed that at least 50% of people included in the review were living in the community in their own homes.
- identified as frail or at-risk of frailty using an operationalized definition of frailty or standardized criteria to measure frailty. More specifically, it was proposed that at least 50% of the people included in the review were identified as frail or at-risk of frailty.

The following indices for measuring frailty identified by Bouillon et al.[22] were accepted in this umbrella review: Gronigen Frailty Indicator (GFI),[23] Frailty Index (FI),[24] Canadian study of health and aging (CSHA) Clinical Frailty Scale,[25] Vulnerable Elder Survey-13 (VES-13),[26] Tilburg Frailty Indicator (TFI),[27] Physical Frailty Score,[28] Phenotype of Frailty,[17] Edmonton Frail Scale (EFS)[29] and the Study of Osteoporotic Fractures Index (SOF Index).[30]
Any other frailty indicators used by author/s of systematic reviews which were based on the indices above were also considered for inclusion.

Reviews that did not provide sufficient detail about the sample populations of included studies were excluded. Reviews that did not use an operationalized definition of frailty or standardized criteria to measure frailty according to Bouillon et al. were excluded.[22] Reviews that focused on healthy older people or older people in hospital, sub-acute settings or nursing homes were excluded. Nursing homes were defined as "a facility with a domestic-styled environment that provides 24-hour functional support and care for persons who require assistance with activities of daily living (ADL) and who often have complex health needs and increased vulnerability".[31(p183)]

Types of interventions

Systematic reviews that evaluated exercise interventions of any form, duration, frequency and intensity, alone or in combination with other interventions designed to alter physical function in frail older people, were included in this umbrella review. The types of exercise interventions included, but not limited to, were:

1. resistance or strength training
2. aerobic or endurance training
3. balance training
4. flexibility or stretching training
5. multi-component training

Systematic reviews that included interventions that were not combined with exercise were excluded. To determine the effectiveness of exercise interventions, included reviews had to use either a control group (i.e. no intervention, placebo intervention, usual care) or a comparator group (i.e. another type of exercise, exercise in combination with other interventions).

Types of outcomes

The primary outcomes were quantitative measures of physical function in frail older people including:

1. muscular strength defined as the maximal amount of force a muscle can produce measured by, for example, grip strength or lower limb strength
2. gait speed defined as the time it takes to walk a specific distance measured by, for example, 6 Minute Walking Test (6MWT)
3. balance defined as the ability to maintain a controlled body position during task performance measured by, for example, Berg Balance Scale or tandem stand
4. mobility defined as the person's ability to move physically measured by, for example, Timed Up & Go or chair rise & stand
5. physical performance defined as a multidimensional concept based on the combination of mobility, gait speed and balance skills measured by, for example, Physical Performance Test

The umbrella review excluded systematic reviews of physical function outcomes that were measured using non-standard or invalidated measures.

Types of studies

This umbrella review considered any quantitative systematic reviews with or without meta-analysis that examined the effectiveness of exercise interventions, alone or in combination with other interventions, in relation to improving physical function in frail older people. Included systematic reviews provided:

- a clearly articulated and comprehensive search strategy including at least two or more bibliographic databases
- evidence of critical appraisal/assessment of risk of bias

If it was not clear whether the inclusion criteria were met, authors were contacted for confirmation before including or excluding the review. Furthermore, literature reviews, withdrawn or retracted publications, systematic reviews not published in English, and earlier versions of updated systematic reviews were also excluded.

METHODS

Search strategy

The search strategy aimed to find both published and unpublished reviews. The following electronic databases were broadly searched for published systematic reviews and meta-analyses: PubMed, EMBASE, CINAHL, Scopus, The Cochrane Database of Systematic Reviews, The JBI Database of Systematic Reviews and Implementation Reports, Web of Science, The Campbell Collaboration Library of Systematic Reviews, Google Scholar. Grey literature was searched using Google and ProQuest Dissertations and Theses. Only reviews published in the English language were considered for inclusion in this umbrella review. Reviews published from 1990 (as this pre-dates some of the earliest work in this field) until September 2016 were considered for inclusion.

The final search strategies, which were developed using an iterative process to minimize false positives and optimize results, are included in Appendix I.

Methodological quality

Reviews selected for retrieval were assessed using the eligibility criteria listed in Appendix II. Reviews that met all the eligibility criteria were appraised by two independent reviewers for methodological validity using a standardized critical appraisal instrument from the JBI System for the Unified Management, Assessment and Review Instrument and the JBI *Reviewers' Manual 2014*.[32] The following eleven criteria were assessed:

1. Is the review question clearly and explicitly stated?
2. Were the inclusion criteria appropriate for the review question?
3. Was the search strategy appropriate?
4. Were the sources and resources used to search for studies adequate?
5. Were the criteria for appraising studies appropriate?
6. Was critical appraisal conducted by two or more reviewers independently?
7. Were there methods to minimize errors in data extraction?
8. Were the methods used to combine studies appropriate?
9. Was the likelihood of publication bias assessed?
10. Were recommendations for policy/practice supported by the reported data?
11. Were the specific directives for new research appropriate?

The quality of each review was ranked based on the following criteria: 0-33% of criteria met (low quality), 34-66% of criteria met (medium quality) and 67% or more of criteria met (high quality)[32]. No review was excluded on the basis of a critical appraisal score, and all reviews that were appraised and met the eligibility criteria were included in data extraction.

To assist in the sensitivity analysis, the reviews were categorized according to how well they met the eligibility criteria: low quality (0-33% of the criteria met); medium quality (34-66% of the criteria met); and high quality (67% or more of the criteria met). Any differences of opinion between the reviewers were resolved through discussion, or by consulting a third reviewer (TS).

Data collection and synthesis

The data were extracted using a standardized JBI instrument designed for umbrella reviews.[32] The following information was extracted from each review included in the umbrella review: 1) type of study design; 2) country where the review was conducted; 3) number of studies in the review; 4) sample size; 5) type of exercise intervention and its characteristics, and its combination with other intervention; 6) effect on physical function parameters; and 7) main results.
Data related to interventions were extracted from selected systematic reviews and tabulated, accompanied by a narrative synthesis to address the review question. All possible statistical measures were retrieved, such as effect size, 95% confidence intervals and heterogeneity.

Interventions were judged on the strength of the evidence for their effectiveness. Beneficial and effective interventions were given a tick (✓). Interventions that did not show any benefit were marked with a cross (X). An earlier protocol[21] suggesting the use of traffic light colours was not used because it was not possible to differentiate between a lack of effect (orange) and a detrimental effect (red) for any intervention compared to a control. The effectiveness of the intervention was based on the total number of participants affected positively across the relevant trials (i.e., 7 trials [n=391] showed an increase [↑]; 4 trials [n=602] showed no effects [-]; overall decision X).

An overall assessment of the quality of the evidence for each comparison using GRADE (Grading of Recommendations, Assessment, Development and Evaluation)[32] was not possible. The original GRADE scores derived for the included systematic reviews were rendered inaccurate because the umbrella review extracted a subset of relevant RCTs from the included systematic reviews for all interventions.

RESULTS

Review inclusion/exclusion

The literature search identified 1437 titles, of which 1390 records were from bibliometric databases (Figure 1). The search in grey literature identified 47 records. After removing duplicates (n=263), the titles and abstracts of 1174 records were screened independently by two reviewers and 1016 records were excluded as irrelevant to the umbrella review. Full text reviews assessing the eligibility of the remaining 158 records were conducted by two reviewers independently and 151 records failed to meet at least one of the five eligibility criteria (type of study, participants, interventions, outcomes and language). The remaining seven records were advanced to the critical appraisal stage using the checklist for the verification of review eligibility (Appendix II). All seven systematic reviews had been identified from the original search of bibliometric databases. The last search was conducted in September 2016.

Review characteristics

The seven systematic reviews included a total of 157 randomized controlled trials (RCTs), but only 59 (37.6%) RCTs were considered to be relevant for this review based on the inclusion criteria (Appendix II). The relevant RCTs included one duplicate[11,13] which was considered only once throughout this umbrella review, resulting in 58 relevant RCTs. Information from this subset of RCTs relevant to the umbrella review question was extracted from the selected reviews (Appendix III). The number of participants involved in the relevant trials (n=58) was 6,927 (from a total sample size of 14,642). The grand mean of the mean ages from selected reviews was 80.9 years.

Five systematic reviews reported on the gender of participants from included RCTs[10,12-15] and the majority of the participants were female (68.5%). In regards to the classification of pre-frail and frail participants, five systematic reviews[11-13,15,16] included RCTs only if they followed an operationalized definition of frailty or used standardized criteria to measure frailty. Two systematic reviews,[10,14] including 21 relevant RCTs, however, did not include RCTs based on operationalized definitions or standardized criteria. Instead, participants were simply identified as frail in either text, title or abstract. The 21 RCTs were therefore checked individually to ensure they met the inclusion criteria of this umbrella review.

Of the seven eligible systematic reviews, three were from the Netherlands, two from Spain and one each from the UK and Canada. The reviews were conducted or published between 2008 and 2015. In regards to the individual RCTs (n=58), it was observed that most RCTs (n=52; 89.7%) were conducted in or after 2000 and only six RCTs (10.3%) dated back to 1998.

Heterogeneity was calculated in only one systematic review, which included a meta-analysis in addition to a narrative synthesis.[11] The other six systematic reviews conducted a narrative synthesis only.[10,12-16]

Methodological quality

The critical appraisal results for each of the seven systematic reviews are summarized in Table 1. Six out of seven systematic reviews were of high quality and only one was of medium quality as per the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses.[32] The minimum number of criteria met was six and the maximum was nine, out of 11. Criteria 2-5, relating to inclusion criteria, search strategy, and study appraisal, were met by all included systematic reviews. Only one systematic review, however, stated that the likelihood of publication bias had been assessed (criteria 9). No reviews were excluded on the basis of methodological quality criteria.

Intervention characteristics

Type

Five systematic reviews examined the effects of exercise intervention only,[10-14] while two systematic reviews included trials examining exercise in combination with nutritional intervention.[15,16]

In regards to the exercise interventions, 33 trials included multi-component exercises involving resistance, balance, flexibility and aerobic exercises. Fifteen trials examined the effects of resistance exercise only.[10-14] One trial examined resistance exercise with an additional component of motion exercise[13] and one trial assessed balance only.[11] Another trial examined the effect of a horse riding simulator,[10] while another used sit-to-stand exercises with the help of an electronic device called GrandStand™. [11,13] Three trials performed personalized exercise without providing further information on the type of exercise.[11]

Three trials in two systematic reviews[15,16] evaluated the effects of exercise in combination with a nutritional approach. One trial examined the effects of resistance exercise combined with protein supplementation of 30g per day.[15] Another trial examined multi-component exercise, including resistance, aerobic, and balance exercises combined with nutrition (without details of the nutritional supplement),[15] and another trial looked at exercise combined with fruit and dairy products.[16]

Frequency

Six systematic reviews reported on the frequency of exercise interventions with a range of 1-7 exercise sessions per week.[10-14,16] The majority of the systematic reviews (n=3) reported a frequency of 2-3 times per week.[10,13,14] Other systematic reviews reported frequencies of 2-5 sessions per week,[16] 3-7 sessions per week,[12] and 1-7 sessions per week. One systematic review did not provide any information on frequency.[15] The mean exercise frequency was 3.0 ± 1.5 times per week.

The length of the exercise sessions was stated in five systematic reviews, and ranged between 10 to 90 minutes each session, with a mean of 52.0 ± 16.5 mins.[10-12,14,16] Two systematic reviews did not provide any information on the length of the exercise sessions.[13,15]

Duration

All seven systematic reviews reported on the duration of the exercise interventions. The total duration of the interventions ranged from 5 to 72 weeks with a mean of 22.7 ± 17.7 weeks. The majority of systematic reviews (n=4) reported a minimum duration of 2.5 months.[10,12,14,16] One systematic review reported a minimum duration of 12 weeks,[15] while two other systematic reviews reported shorter durations of 5 to 6 weeks.[11,13] The maximum duration of exercise interventions ranged between 9, 12 and 18 months.

Intensity

The intensity of the exercise interventions was reported in two systematic reviews[12,14] and ranged from 2-3 times of 8-12 repetitions at 85-100% 1RM (repetition maximum), as well as 30-80% 1RM and 60-80% 1RM for resistance exercises. The intensity of aerobic exercises ranged from 15 minutes at 65–70% of VO2max (equivalent to 80% of maximum heart rate in older adults of 65 years) and 3-5 minutes at 85–90% VO2max (equivalent to 90-95% maximum heart rate in older adults of 65 years) to 6-8 points on a 10-point perceived exertion scale. Personalized intensity, and low, medium and high intensity were discussed without further definition. Three systematic reviews did not include any information on intensity[13,15,16] and two systematic reviews stated either low to high intensity or low versus high intensity without any further information.[11,14]

Effects on physical function

Muscle strength

Muscular strength was measured using knee extension and flexion for lower limb strength, and grip strength and shoulder strength for upper limb strength. Strength exercises included progressive resistance training alone or with Thera bands, as well as a variation of concentric, isometric and eccentric knee-extension exercises.

Four systematic reviews[12,13,15,16] involving 15 relevant trials and 1395 participants evaluated the impact of exercise interventions on muscular strength. Eleven trials (75.6%; n=1055 participants) showed a positive impact on muscular strength using multi-component exercises (n=5 trials),[12,16] resistance exercises (n=5 trials)[12,13,15,16] and multi-component exercises in combination with nutrition (no details stated) (n=1 trial).[15] Four trials (24.4%; n=340 participants) failed to show improvements in muscular strength using multi-component exercises (n=2 trials),[12,13] strength and motion exercises (n=1 trial),[13] as well as resistance exercises in combination with protein supplementation of 30g per day (n=1 trial).[15]

With regards to the overall effect, multi-component exercises, including resistance training, as well as resistance exercises on their own, seemed to be most effective in improving muscular strength (Table 2). The exercises were performed 2-5 times per week for 20-90 minutes each session for a duration of 2.5-9 months. The intensity of the resistance training ranged from 40-70% 1RM using 6-12 repetitions and 1-3 sets.[12] Trials that did not show any improvements of muscular strength did not provide any information on intensity. An overview of the extracted data is presented in Table 3.

Gait speed

Gait speed was measured using 2.4, 3, 4, 5, 6, 10 and 400 meter tests; normal, rapid and maximal gait speed; as well as the 6MWT.

Five systematic reviews[10-12,14,16] involving 34 trials (n=4017 participants) included gait speed as an outcome measure. However, only 13 trials (40.5%; n=1626) out of three systematic reviews reported on the effects on gait speed as an individual outcome. The remaining two systematic reviews included gait speed as part of their mobility and physical performance assessments and did not report on gait speed specifically.

Ten trials (31.1%; n=1250 participants) showed a positive impact on gait speed using multi-component exercises (n=7 trials)[12,14,16] and resistance exercises (n=3 trials);[12,14] while three trials (9.4%; n=376 participants) failed to show improvements in gait speed using multi-component exercises (n=3 trials).[11,12,14]

With regards to the overall effect, multi-component and resistance exercises on their own seemed to be most effective in improving gait speed. The exercises were performed 2-5 times per week for 20-90 minutes per session over 2.5-18 months. The intensity for the resistance exercises ranged from 1-3 sets of 6-8 repetitions at 70% 1RM[12] to less specific information stating low, moderate and high intensity without further details.[14]

Mobility

Mobility was measured by chair rise & stand, as well as the Timed Up & Go Test (TUG) alone or in combination with gait speed. Six systematic reviews[10-14,16] including 36 trials (n=4791 participants) reported on mobility as an outcome.

Nineteen trials (52.8%; n=2545 participants) showed a positive effect on mobility using multi-component exercises (n=9 trials),[10-13,16] resistance exercises (n=6 trials),[10-12] personalized training (n=3 trials)[11] and resistance exercises combined with range of motion exercises (n=1 trial).[13] However, 17 trials (47.2%; n=2246 participants) failed to show any improvement using multi-component exercises (n=10 trials),[11,13,14] resistance exercises (n=4 trials),[11,14,16] GrandStand™ based exercises (n=1 trial),[11,13] the horse riding simulator (n=1 trial)[10] or balance exercises (n=1 trial).[11]

With regards to the overall effect, the results were inconclusive and suggested that only personalized exercises seemed to consistently be effective in improving mobility. However, a sufficient number of trials showed positive effects on mobility using multi-component exercises (n=9 trials; 1205 participants) and resistance exercises (n=6 trials; 391 participants) to suggest that these interventions might also be of benefit. The exercises were performed 1-7 times per week for 26-90 minutes per session and over a period of 5 weeks to 18 months. The intensity for resistance exercises was 60-80% 1RM using 6-10 repetitions and 1-3 sets,[10,12] as well as personalized intensity without further details.[11]

Balance

Five systematic reviews[10,12-14,16] including 24 trials (n=2552 participants) reported on balance as an outcome. However, only 13 trials (54.2%, n=1630 participants) reported on the effects of exercise on balance as an individual outcome measure. How balance was assessed was not stated.

Nine trials (46.0%; n=1174 participants) showed a positive effect on balance using multi-component exercises (n=8)[10,12,13,16] and resistance exercise (n=1).[16] Four trials (17.9%; n=456 participants) failed to show improvements in balance using multi-component (n=1 trial),[13] resistance (n=1 trial),[14] resistance combined with a range of motion (n=1 trial)[13] or GrandStand™ based exercise (n=1 trial). [11,13]

With regards to the overall effect, multi-component exercises seemed to be most effective in improving balance. The exercises were performed from 3 times per day to 3 times per week for 20-75 minutes each session for a duration of 2.5 weeks to 18 months. The intensity ranged from 3 times of 8-12 repetitions at 85-100% 1RM for resistance exercise, and 15 mins at 65-70% VO2max and 3-5 mins at 85–90% VO2max for aerobic exercise.[10]

Physical performance

Physical performance was measured using the Physical Performance Test (PPT), the Tinetti Performance-Oriented Mobility Assessment (POMA) and the MacArthur Battery.

All seven included systematic reviews including 27 trials (n=3765 participants) reported on physical performance as an outcome measure.

Twenty-two trials (81.5%, n=3067 participants) showed positive effects on physical performance using multi-component (n=16 trials),[10-12,14,16] resistance (n=4 trials),[10,11,16] personalized (n=1 trial)[11] and balance exercises (n=1 trial).[11] Five trials (18.3%; n=698 participants) reported in three systematic reviews[11,13,15] failed to show improvements in physical performance following multi-component (n=1 trial),[13] resistance (n=1 trial),[11] GrandStand™ based (n=1 trial) [11,13] and personalized exercises (n=1 trial),[11] as well as exercise combined with protein supplementation (n=1 trial).[15]

With regards to the overall effect, multi-component exercises, resistance exercises on their own, as well as balance exercises, appeared to be the most effective in improving physical performance. The exercises were performed between 1 and 5 times per week for 20-90 minutes each session and over a period of 2.5-18 months. The intensity ranged from 2-3 times of 8-12 repetitions at 85-100% 1RM for resistance exercise; 15 minutes at 65-70% VO2max and 3-5 minutes 85-90% VO2max, as well as 6-8 points on a 10-point perceived exertion scale for aerobic exercise. Exercises conducted at a personalized intensity, as well as low, medium and high intensity did not provide any further details.[10,11]

Compliance, dropout rates and safety

Five[10-12,14,16] of the seven systematic reviews reported on compliance and dropout rates. Dropouts were defined as the number of randomized participants having no post intervention measurements. One systematic review, including eight relevant trials, reported dropout rates from 4% to 32%.[14] Two other systematic reviews, including 23 relevant trials, only assessed whether the dropout rate was below or above 15%. Seventeen trials had less than a 15% dropout rate, while six had higher dropout rates without providing further information.[11,12] As part of their methodological quality assessment, Daniels et al.[16] determined whether the compliance in the trials was acceptable. Out of seven relevant trials, four demonstrated meaningful compliance. Two trials did not provide any data about compliance and another was not compliant. In the systematic review of Theou et al.,[10] eight out of 13 relevant trials included information regarding exercise compliance; however, specific information was not available. Additionally, five of these trials reported on adverse events, stating that no adverse events had occurred in the intervention group, or, if they had, they were similar to the control group, demonstrating that exercise is a safe intervention for frail older people.[10]

DISCUSSION

Key findings suggest that studies should follow a consistent definition of frailty to clearly identify the target population group and investigate the effects of different exercise types, alone or in combination with nutritional interventions on physical function parameters in frail older adults. Studies should also provide sufficient information and report on frequency, intensity, and duration of exercise so that more specific recommendations for frail older people can be made.

This umbrella review summarized the evidence from seven systematic reviews including 58 relevant trials and involving 6,927 participants. The majority of the included trials examined mobility (n=36 trials), followed by physical performance (n=27 trials), gait speed (n=13 trials), muscle strength (n=15 trials) and balance (n=12 trials).

Multi-component exercise interventions can currently be recommended for pre-frail and frail older adults to improve muscular strength, gait speed, balance and physical performance, including resistance, aerobic, balance, and flexibility tasks. Resistance training was also suggested to be beneficial in particular for improving muscular strength, gait speed and physical performance and should be considered as part of a multi-component exercise intervention. Other types of exercise were not sufficiently studied and their effectiveness is yet to be established.Exercise combined with nutritional interventions was also comparatively little studied and results were mixed.

Most of the systematic reviews stated an average frequency of 2-3 times per week for 10-90 minutes per exercise session. The total duration of the interventions ranged from 5 to 72 weeks, with the majority of the reviews reporting a minimum duration of 2.5 months (mean 22.7 ± 17.7 weeks). The intensity of the exercise interventions ranged from 30-80% 1RM to 2-3 times of 8-12 repetitions at 85-100% 1RM for resistance exercise; 15 minutes at 65-70% VO2max and 3-5 minutes at 85-90% VO2max, as well as 6-8 points on a 10-point perceived exertion scale for aerobic exercise.

Type and effects of exercise interventions

The current exercise recommendations for healthy older adults aged 65 years and older include a combination of aerobic (150 minutes of moderate intensity or 75 minutes of vigorous intensity per week) and resistance training (at least twice per week).[34] The results of this umbrella review extend these recommendations and suggest that multi-component exercises, including a combination of resistance, aerobic, flexibility, and balance exercises, are effective in improving physical function parameters, such as strength, gait speed, balance and physical performance, in older adults who are frail or at-risk of frailty. The extended recommendations agree with recent published literature that suggests that pre-frail and frail older adults should aim to meet the current recommendations for healthy older adults but should participate in a multi-component exercise program that includes resistance, aerobic, balance and flexibility exercises.[35]

Bray et al.[35] also suggest a focus on resistance exercises, including lower extremity muscle groups for pre-frail older adults and longer aerobic exercise sessions for frail older adults. The results of this umbrella review support the observation that an important element of multi-component exercise interventions is resistance training. For three out of four physical function parameters (strength, gait speed, physical performance), resistance training made a positive difference. This concurs with Cadore et al.[36] who conducted a systematic review on the effects of exercise interventions in frail older adults and reported that resistance training (either alone or as part of a multi-component exercise program) revealed greater strength gains in physical frail older adults than multi-component exercise interventions without resistance training. However, the participants' setting was not stated, and therefore no definite comparisons to the results of this umbrella review can be made.

The effects of exercise interventions on mobility were inconclusive as both multi-component and resistance exercises resulted in mixed results. Other types of exercise were not sufficiently studied and their effectiveness is yet to be established.Only personalized exercises tailored for the individual frail older adult seemed to increase mobility consistently A possible reason for the inconclusive results across the trials included in this umbrella review could also be variations in the use of the TUG which is an assessment tool for mobility. It has been reported that TUG scores can be affected by several circumstances, like the use of an assistive device or the height of the chair.[37] Another reason why the TUG could have been a major reason for the inconclusive results is that mobility was also assessed by gait speed which increased in the majority of the trials using multi-component interventions and resistance training. It is suggested that future trials should use an additional test to the TUG and examine the effectiveness of other potential exercise types further.

Numerous studies have demonstrated substantial benefits of protein supplementation in combination with resistance exercise in healthy older adults.[38] However, few studies have been conducted in frail older adults and those that have been undertaken have yielded conflicting results on the benefits of protein in combination with exercise on physical function parameters.[39-41] This umbrella review also found mixed results in studies that combined exercise with nutritional interventions. Inconclusive findings might be due to a low number of studies and heterogeneous study designs, with some study samples being too small or others providing insufficient doses of nutrition or administering the nutritional supplements on different timings. One systematic review confirmed that the timing of nutritional intervention before or after exercise should be explored in further clinical trials, as basic studies suggest there may be time-sensitive factors that influence the outcome of nutrition intervention in association with exercise.[15] More studies are needed before recommendations for frail older adults can be made related to nutrition and exercise in combination.

Frequency

This umbrella review supports current literature that suggests an optimal frequency of 2-3 times per week (mean 3.0 ± 1.5 times per week; range 1-7 weekly) for multi-component exercise interventions involving pre-frail and frail older adults.[35,36] Bray et al.[35] suggest that less than two times per week would likely not improve physical function parameters and more than three exercise sessions per week could cause some pre-frail and frail older adults to become over trained and lose interest. Nevertheless, whenever possible, pre-frail and frail older adults should be encouraged to increase their exercise frequency to at least three exercise sessions per week.[42]

Duration

The duration of the exercise sessions noted in this umbrella review ranged from 10-90 minutes (mean of 52.0 ± 16.5 mins). One of the systematic reviews suggested that the optimal duration for exercise sessions was 45-60 minutes for pre-frail older adults and 30-45 minutes for frail older adults.[10] This observation agrees with recently published literature that suggests a total duration of multi-component exercise sessions of up to 60 minutes for pre-frail older adults (20 mins resistance, 10 mins aerobic, 20 mins balance, 10 mins flexibility) and up to 45 minutes for frail older adults (10 mins resistance, 20 mins aerobic, 8 mins balance, 7 mins flexibility).[35] The appropriate duration depends on frailty status, age and consistency of exercise participation.[35] Exercise sessions may start at lower durations but should progress to the recommended levels.[36]

Intensity

The intensity of exercise was reported in only two systematic reviews and was of higher intensity than the recommendations in the literature. When using heart rate as an indicator for intensity, according to current guidelines, aerobic exercises should be performed at 70-75% of older people's maximal heart rate.[43] The intensity in this umbrella review was reported to be between 80-95% of the maximum heart rate.

Another quantifiable measure of intensity is the Borg scale, a scale that allows a rating of perceived exertion (RPE). A RPE between 12 and 14 (somewhat hard) is reported to be the optimal intensity range for frail and pre-frail adults[36] which is equivalent to 3-4 on the 10-point Borg scale.[35] Recent literature does recommend that pre-frail and frail older adults should eventually progress to a reasonably moderate-vigorous intensity,[8] working toward the upper end of the RPE scale.[35] The intensity found in this umbrella review was reported to be higher, 6-8 points on a 10-point perceived exertion scale. It should be noted that many older adults are using medications that might influence their heart rates. When using heart rate as a measurement for exercise intensity, therefore, measurements should be adjusted.

Resistance exercises should be performed using an estimated percentage of the 1RM starting with three sets of 8-12 repetitions at an intensity of 20-30% 1RM and progressing to 80% of 1RM[36] or beyond (if appropriate)[35] as high-intensity resistance training appears to be more effective than low-intensity training.[44] Another progression strategy could be higher repetitions (12-15) at a lower intensity (55% of 1RM) to build up muscular endurance, and progress to fewer repetitions (4-6) at a greater intensity (>80% of 1RM) to maximize muscular strength.[35] The recommended level of exercise is in agreement with the results of this umbrella review, which states an intensity of 8-12 repetitions at 85-100% 1RM, as well as resistance exercises performed at 30-80% and 60-80% 1RM.

STRENGTHS AND LIMITATIONS

The strengths of this umbrella review include the comprehensiveness of the search strategy, the currency of the studies and the large number of RCTs and participants representing the effects of exercise interventions on physical function parameters in community-dwelling frail older adults.

A limitation of this umbrella review was the heterogeneity of RCTs in the included systematic reviews due to different types of exercise interventions and outcome parameters. However, predefined inclusion and exclusion criteria aimed to minimize this heterogeneity. Further, there was not enough evidence to draw any conclusions about the effectiveness of other types of exercise resulting in only limited recommendations focusing on multi-component and resistance interventions only.

Another limitation was the lack of consensus in the definition of frailty and the use of various criteria to define frailty. A consistent definition of frailty would help to ensure a more uniform target population, allowing for a more rational examination of the effects of exercise interventions on the status of an individual's frailty.

The intensity of exercise interventions was reported in only two systematic reviews, which makes conclusions in regards to this exercise characteristic difficult. Systematic reviews should provide sufficient information and report on frequency, intensity, duration and type of exercise so that more specific recommendations for frail older people can be made.

CONCLUSION

To the best of our knowledge, this is the first umbrella review examining the effects of exercise interventions on physical function parameters in community-dwelling frail older adults. The review sought to determine the most effective exercise interventions for improving physical well-being in this group. The results compiled from the systematic reviews indicated that pre-frail and frail older adults should participate in a multi-component exercise program, including in particular resistance training, as well as aerobic, balance and flexibility exercises. However, other types of exercise interventions have not been sufficiently studied and their effectiveness is yet to be established. Nevertheless, to optimize the exercise interventions and improve physical function, an optimal combination of intensity, duration and frequency is crucial, as well as gradual increases in these characteristics. Multi-component interventions should be performed up to three times per week for 45-60 minutes per exercise session at a moderate to high intensity aiming to progress to “somewhat hard” on the Borg scale for aerobic exercises and ≥80% of 1RM for resistance exercises for a duration of at least 2.5 months.

Implications for practice

Evidence suggests that multi-component exercise interventions, including in particular, resistance training, as well as aerobic, balance and flexibility exercises, are an effective strategy to improve physical function (i.e., strength, gait speed, balance, physical performance) in pre-frail and frail older adults. However, other types of exercise interventions might also be effective but have not been sufficiently studied yet to draw any conclusions. Nevertheless, an optimal combination of frequency, duration and intensity is crucial to ensuring a positive response in physical function. Frail older people should not only gradually increase the frequency of their exercise from once or twice per week up to at least three times per week, but also increase the intensity and duration of their exercise. Multi-component intervention programs should be promoted more actively amongst older adults to increase their participation in exercise and to tackle frailty in the community.

Implications for research

Future research should adopt a consistent definition of frailty to clearly identify the target population and investigate the effects of other exercise types, alone or in combination with nutritional interventions on physical function in frail older adults. Also, systematic reviews should provide sufficient information and report on frequency, intensity, duration and type of exercise so that more specific recommendations for frail older people can be made. Furthermore, compliance and dropout rates need to be reported consistently across studies so that exercise interventions for frail older people can be optimized.

Investigations into the management of the proposed increase in intensity, frequency and duration over time are required, as is research into how to monitor the quality of exercise interventions. Results of these investigations would assist in the optimization of exercise interventions for frail older adults.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

REFERENCES

1. Australian Bureau of Statistics, Australian Demographic Statistics 2014 [updated June 2014]. Available from: http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/126E319BBCA7E237CA257DB1001620B4/$File/31010_jun%202014.pdf.
2. Bierman AS. Functional Status: The Sixth vital sign. J Gen Intern Med 2001;16:785-86.
3. Australian Institute for Health and Welfare, Australia's Health 2016. Available from: http://aihw.gov.au/WorkArea/DownloadAsset.aspx?id=60129555788, p. 226.
4. Nash KCM. The effects of exercise on strength and physical performance in frail older people: A systematic review. Rev Clin Gerontol 2012;22(4):274-85.
5. Chang SF, Lin PL. Frail phenotype and mortality prediction: a systematic review and meta-analysis of prospective cohort studies. Int J Nurs Stud 2015;52(8):1362-74.
6. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56.
7. Bendayan M, Bibas L, Levi M, Mullie L, Forman DE, Afilalo J. Therapeutic interventions for frail elderly patients: part II. Ongoing and unpublished randomized trials. Prog Cardiovasc Dis 2014;57(2):144-51.
8. Paterson DHJ, Gareth R.; Rice, Charles L. Ageing and physical activity: evidence to develop exercise recommendations for older adults. Can J Public Health 2007; 98 Suppl 2:S69-S108.
9. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-23.
10. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res 2011;2011:569194.
11. de Vries NM, van Ravensberg CD, Hobbelen JSM, Olde Rikkert MGM, Staal JB, Nijhuis-van der Sanden MWG. Effects of physical exercise therapy on mobility, physical functioning, physical activity and quality of life in community-dwelling older adults with impaired mobility, physical disability and/or multi-morbidity: A meta-analysis. Ageing Res Rev 2012;11(1):136-49.
12. de Labra C, Guimaraes-Pinheiro C, Maseda A, Lorenzo T, Millan-Calenti JC. Effects of physical exercise interventions in frail older adults: a systematic review of randomized controlled trials. BMC Geriatr 2015;15:154.
13. Clegg AP, Barber SE, Young JB, Forster A, Iliffe SJ. Do home-based exercise interventions improve outcomes for frail older people? Findings from a systematic review. Rev Clin Gerontol 2012;22(1):68-78.
14. Chin A Paw MJM, Van Uffelen JGZ, Riphagen I, Van Mechelen W. The functional effects of physical exercise training in frail older people: A systematic review. Sports Med 2008;38(9):781-93.
15. Cruz-Jentoft AJ, Landi F, Schneider SM, Zúñiga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: A systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing 2014;43(6):48-759.
16. Daniels R, van Rossum E, de Witte L, Kempen GI, van den Heuvel W. Interventions to prevent disability in frail community-dwelling elderly: a systematic review. BMC Health Serv Res 2008;8:278.
17. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56.
18. van Lummel RC, Walgaard S, Pijnappels M, Elders PJ, Garcia-Aymerich J, van Dieen JH, et al. Physical Performance and Physical Activity in Older Adults: Associated but Separate Domains of Physical Function in Old Age. PLoS One 2015;10(12):e0144048.
19. Lee PH, Lee YS, Chan DC. Interventions targeting geriatric frailty: A systemic review. J Clin Gerontol Geriatr 2012;3(2):47-52.
20. American College of Sports Medicine, Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, Skinner JS. American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 2009;41(7):1510-30.

21. Jadczak AD, Makwana N, Luscombe-Marsh ND, Visvanathan R, Schultz TJ. Effectiveness of exercise interventions on physical function in community-dwelling frail older people: an umbrella review protocol. JBI Database System Rev Implement Rep 2016;14(9):93-102.
22. Bouillon K, Kivimaki M, Hamer M, Sabia S, Fransson EI, Singh-Manoux A, et al. Measures of frailty in population-based studies: an overview. BMC Geriatr 2013;13:64.
23. Steverink N, Slaets J, Schuurmans H, M VL. Measuring frailty: developing and testing of the Groningen Frailty Indicator (GFI). Gerontologist 2001;41(1):236-7.
24. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficits as a proxy measure of aging. ScientificWorldJournal 2001;1:323-36.
25. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173(5):489-95.
26. Kanauchi M, Kubo A, Kanauchi K, Saito Y. Frailty, health-related quality of life and mental well-being in older adults with cardiometabolic risk factors. Int J Clin Pract 2008;62(9):1447-51.
27. Gobbens RJ, van Assen MA, Luijkx KG, Wijnen-Sponselee MT, Schols JM. The Tilburg Frailty Indicator: psychometric properties. J Am Med Dir Assoc. 2010;11(5):344-55.
28. Gill TM, Baker DI, Gottschalk M, Peduzzi PN, Allore H, Byers A. A program to prevent functional decline in physically frail, elderly persons who live at home. N Engl J Med 2002;347(14):1068-74.
29. Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. Age Ageing 2006;35(5):526-9.
30. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Cawthon PM, Stone KL, et al. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Arch Intern Med 2008;168(4):382-9.
31. Sanford AM, Orrell M, Tolson D, Abbatecola AM, Arai H, Bauer JM, et al. An international definition for "nursing home". J Am Med Dir Assoc 2015;16(3):181-4.
32. The Joanna Briggs Institute, Joanna Briggs Reviewers' Manual 2014: Methodology for JBI Umbrella Reviews. In: The Joanna Briggs Institute. Adelaide 2014.
33. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. Int J Surg 2010;8(5):336-41.
34. Taylor D. Physical activity is medicine for older adults. Postgrad Med J. 2014;90(1059):26-32.
35. Bray NW, Smart RR, Jakobi JM, Jones GR. Exercise prescription to reverse frailty. Appl Physiol Nutr Metab 2016;41(10):1112-6.
36. Cadore EL, Rodriguez-Manas L, Sinclair A, Izquierdo M. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. Rejuvenation Res 2013;16(2):105-14.
37. Schoene D, Wu SM, Mikolaizak AS, Menant JC, Smith ST, Delbaere K, et al. Discriminative ability and predictive validity of the timed up and go test in identifying older people who fall: systematic review and meta-analysis. J Am Geriatr Soc 2013;61(2):202-8.
38. Finger D, Goltz FR, Umpierre D, Meyer E, Rosa LH, Schneider CD. Effects of protein supplementation in older adults undergoing resistance training: a systematic review and meta-analysis. Sports Med 2015;45(2):245-55.
39. Björkman MP, Finne-Soveri H, Tilvis RS. Whey protein supplementation in nursing home residents. A randomized controlled trial. Eur Geriatr Med 2012;3(3):161-6.
40. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2012;13(8):713-9.
41. Rosendahl E, Lindelof N, Littbrand H, Yifter-Lindgren E, Lundin-Olsson L, Haglin L, et al. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: a randomised controlled trial. Aust J Physiother 2006;52(2):105-13.
42. Liu CK, Fielding RA. Exercise as an intervention for frailty. Clin Geriatr Med 2011;27(1):101-10.
43. Ehsani AA, Spina RJ, Peterson LR, Rinder MR, Glover KL, Villareal DT, et al. Attenuation of cardiovascular adaptations to exercise in frail octogenarians. J Appl Physiol (1985) 2003;95(5):1781-8.

44. Seynnes O, Fiatarone Singh MA, Hue O, Pras P, Legros P, Bernard PL. Physiological and functional responses to low-moderate versus high-intensity progressive resistance training in frail elders. J Gerontol A Biol Sci Med Sci 2004;59(5):503-9.

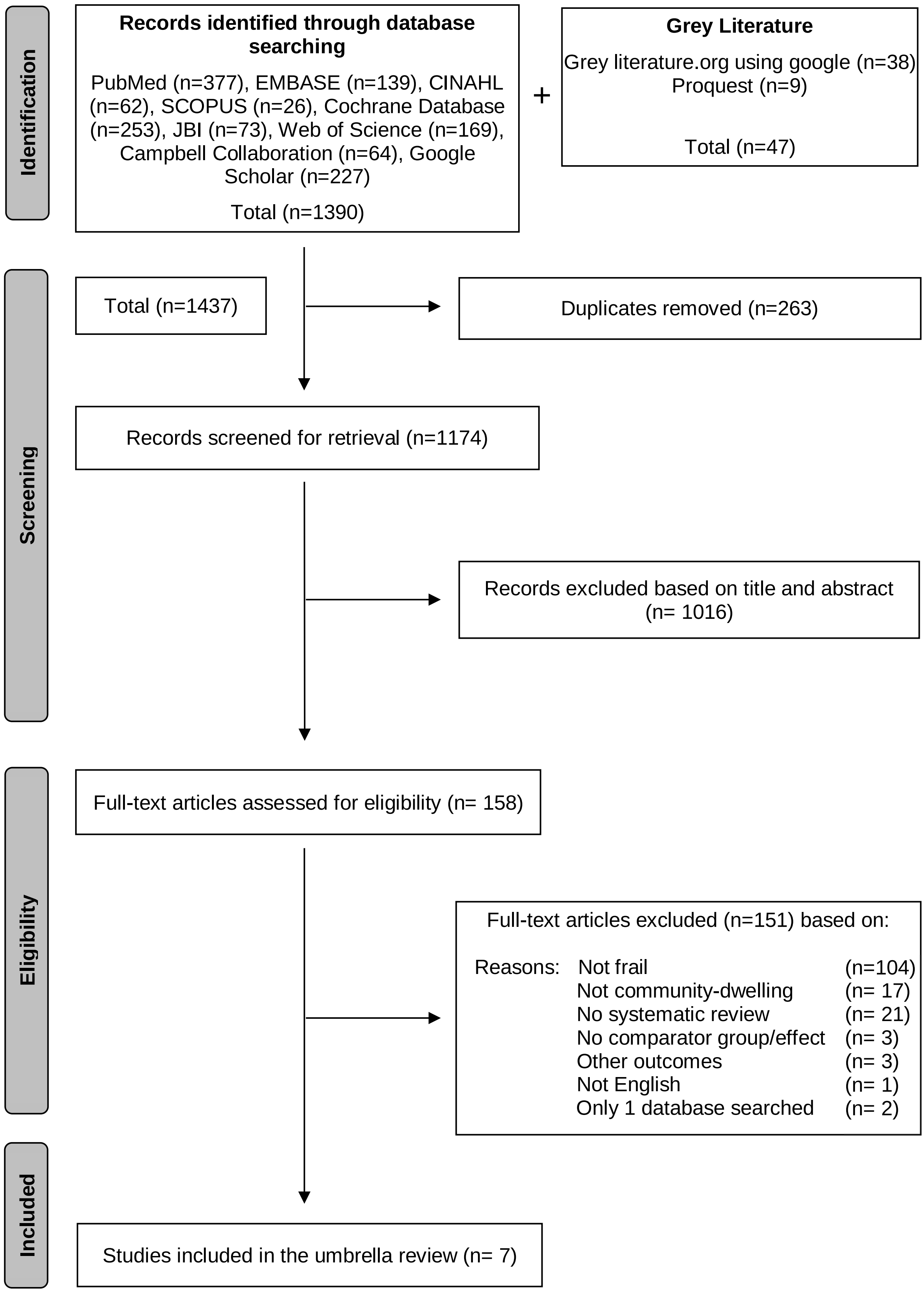


Figure 1: PRISMA Flow Chart[33]

Table 1: Assessment of methodological quality

Systematic Review	1	2	3	4	5	6	7	8	9	10	11	N	%	Quality
Chin et al.[14]	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	8/11	72.7	High
Clegg et al.[13]	Y	Y	Y	Y	Y	N	Y	Y	U	Y	Y	9/11	81.8	High
Cruz-Jentoft et al.[15]	N	Y	Y	Y	Y	U	U	N	N	Y	Y	6/11	54.5	Medium
Daniels et al.[16]	Y	Y	Y	Y	Y	Y	Y	Y	U	U	Y	9/11	81.8	High
De Labra et al.[12]	Y	Y	Y	Y	Y	Y	U	Y	N	U	Y	8/11	72.7	High
De Vries et al.[11]	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	9/11	81.8	High
Theou et al.[10]	N	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	9/11	81.8	High

Y – criteria met **N – criteria not met** **U- unclear**
0-33% low quality **34-66% medium quality** **≥67% high quality**

Table 2: Effects on physical function parameters

Outcome / Intervention	Muscle Strength	Gait Speed	Mobility	Balance	Physical Performance
MCT*	5 trials (n=548) ↑ 2 trials (n=192) - ✓	7 trials (n=887) ↑ 3 trials (n=376) - ✓	9 trials (n=1205) ↑ 10 trials (n=1482) – X	8 trials (n=1102) ↑ 1 trial (n=61) – ✓	16 trials (n=2370) ↑ 1 trial (n=61) - ✓
Resistance Training	5 trials (n=311) ↑ 1 trial (n=86) - ✓	3 trials (n=363) ↑ ✓	7 trials (n=391) ↑ 4 trials (n=602) – X	1 trial (n=72) ↑ 2 trials (n=329) - X	4 trials (n=436) ↑ 1 trial (n=21) - ✓
Balance Training			1 trial (n=73) - X		1 trial (n=73) ↑ ✓
Grand Stand™			1 trial (n=68) - X		1 trial (n=68) – X
Personalized Training			3 trials (n=847) ↑ ✓		1 trial (n=188) ↑ 1 trial (n=486) - X
Horse Riding Simulator			1 trial (n=21) – X		
RT + Protein	1 trial n=62 – X				1 trial (n=62) – X
MCT + Nutr	1 trial n=96↑ ✓				

*MCT: Multi-component training including resistance, aerobic, balance and flexibility exercises
RT: Resistance training Nutr: Nutrition ✓ : Overall increase X : Overall no effect ↑: Effect -: No effect
The overall decision whether an intervention is effective or not was based on the total number of participants across the trials.

Table 3: Data extraction of included systematic reviews using Appendix IV

Systematic Review	Studies	Participants	Intervention	Characteristics	Outcomes	Findings/Effects
Chin 2008[14]	8 out of 20 trials	956 out of 2515 Mean age 80.5 Community & Frail	6 x MCT 2 x RT	2.5-9 months 2-3 x weekly 45-90mins per session Intensity low-high	Gait Mobility Balance PP	MCT: ↑ gait, PP, 1x NE RT: ↑ gait
Clegg 2012[13]	5 out of 6 trials	799 out of 987 Mean Age 82.8 Community & Frail	2 x MCT 1 x RT 1 x RT & Motion 1 x GrandStand™	1.5–18 months 3-7 x weekly Intensity not stated	Strength Gait Mobility Balance	MCT: ↑ balance, mobility, 1x NE RT: ↑ strength RT & Motion: ↑ mobility GrandStand™: NE
Cruz-Jentoft 2014[15]	3 out of 19 trials	249 out of 1453 Mean Age 81.0 Community & Frail	1 x RT 1 x RT & Protein 1 x MCT & NUTR	3–9 months Frequency not stated Intensity not stated	Strength PP	RT: ↑ strength RT & Protein: NE MCT & NUTR: ↑ strength
Daniels 2008[16]	7 out of 10 trials	837 out of 1191 Mean Age 80.0 Community & Frail	4 x MCT 2 x RT 1 x EX & NUTR	2.5–18 months 2-3 x weekly 45-75mins per session Intensity not stated	Strength Gait Mobility Balance PP & FC	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, balance, PP EX & NUTR: ↑ FC
De Labra 2015[12]	5 out of 9 trials	562 out of 1067 Mean Age 80.6 Community & Frail	4 x MCT 1 x RT	2.5–12 months 2–5 x weekly 20–90mins per session 30–80% 1RM	Strength Mobility Balance	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, gait, mobility
De Vries 2012[11]	18 out of 18 trials	2580 out of 2580 Age range 60-85 Community & Frail	9 x MCT 4 x RT 1 x Balance 1 x GrandStand™ 3 x Personalized	1.25–18 months 1-7 x weekly 10-90mins per session Intensity low vs high	Gait Mobility PP	MCT: ↑ gait, mobility, PP RT: ↑ mobility, PP Balance: ↑ PP GrandStand™: NE Personalized: ↑ mobility, PP
Theou 2011[10]	13 out of 75 trials	1010 out of 4915 Mean Age 80.3 Community & Frail	8 x MCT 4 x RT 1 x Horse Simulator	2.5–18 months 2-3 x weekly 10-60mins per session 6-8 on 10-point scale 60–80% & 85-100% 1RM	Gait Mobility Balance PP	MCT: ↑ gait, balance, mobility, PP RT: ↑ mobility, PP Horse Simulator: NE

MCT: Multi-component training; RT: Resistance training; EX: Exercise; NUTR: Nutrition; PP: Physical performance; FC: Functional capacity; NE: No effects; ↑: Increase

Appendix I: Search strategies

PubMed (pubmed.gov)

Search on 02/09/2016

Search	Query
#1	Aged [MH] OR Elder* [all] OR Older [all]
#2	Frail* [all] OR Functionally Impair* [all]
#3	systematic[sb] OR review[pt]
#4	Exercise [MH] OR Exercis* [all] OR Physical Activity
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

EMBASE

Search	Query
#1	Aged/syn OR Elder* OR Older
#2	Frail* OR 'Functionally impaired' OR 'functional impairment' OR 'functional impairments'
#3	'systematic review'/SYN OR 'meta analysis'/SYN
#4	Exercise/SYN OR 'Physical Activity'
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

CINAHL

Search	Query
#1	(MH "Frail Elderly") OR (MH "Aged") OR TI Aged OR AB Aged OR TI Elder* OR AB Elder*OR TI Older OR AB Older
#2	TI Frail* OR AB Frail* OR TI Functional* OR AB Functional*
#3	(MH "Systematic Review") OR (MH "Meta Analysis") ORTI "systematic review*" OR TI "meta analysis" OR TI metaanalysis OR AB "systematic review*" OR AB "meta analysis" OR AB metaanalysis
#4	TI Exercis* OR TI "Physical Activity" OR AB "Physical Activity"
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Scopus

Search	Query
#1	Aged OR Elder* OR Older
#2	Frail* OR Functionally Impair*
#3	“systematic review*” OR “meta analysis” OR metaanalysis
#4	Exercis* OR “Physical activity”
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Cochrane Database of Systematic Reviews, JBI Database of Systematic Reviews and Implementation Reports, Web of Sciences, Campbell Collaboration Library of Systematic Reviews

Search	Query
#1	Aged OR Elder* OR Older
#2	Frail* OR Functionally Impair*
#3	systematic review OR meta analysis OR metaanalysis
#4	Exercis* OR Physical activity
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Google Scholar and Grey Literature

Search	Query
#1	Older Exercise Physical Activity Review (with all of the words)
#2	aged OR elder OR frail OR functional impairment OR systematic review OR meta analysis OR metanalysis OR Exercise Physical Activity (with at least one of these words)
#3	#1 AND #2
Limited to 1990 and English language	

ProQuest Dissertations and Theses

Search	Query
#1	Aged OR Elder OR Older
#2	Frail OR Functionally Impair*
#3	systematic review OR meta analysis
#4	Exercise OR Physical activity
#5	#1 AND #2 AND #3 AND #4
Limited to 1990 and English language	

Appendix II: Verification of Review Eligibility

AUTHOR AND YEAR	
JOURNAL	
TITLE	
NAME/CODE OF REVIEWER	
Design: The article is/contains a systematic review with or without meta-analysis	Yes
Review Type: **For effectiveness reviews, a comparator group is utilized**	Yes
Participants:	
Participants of interested are older people aged 60 years and over,	Yes
identified as pre-frail, frail or at-risk of frailty in title, abstract or text	Yes
and living in the community	Yes
Interventions: **Interventions of interest are exercise interventions, alone or combined with other interventions**	Yes
Outcomes: **Outcomes of interest are: muscular strength, gait ability including gait speed and gait performance, balance and mobility**	Yes
IF YOU HAVE NOT ANSWERED YES TO ALL OF THE ABOVE QUESTIONS, YOU SHOULD EXCLUDE THE STUDY. IF YOU ANSWERED YES TO ALL, PLEASE CONTINUE.	

Appendix III: Details of included reviews

	1. Chin et al.[14]	2. Clegg et al.[13]
Databases searched	PubMed, EMBASE, CENTRAL	Medline, AMED, CINAHL, The Cochrane Library, EMBASE, PSYCHINFO, PEDro
Range of included studies	2000-2005	1995-2007
Total number of studies/total relevant	20 trials / 8 trials	6 trials / 5 trials
Total number of participants/total relevant	2515 / 956 Female 62.2%	987 / 799 Female 75.5%
Heterogeneity[$]	Not calculated	Not calculated
Setting	Community-dwelling	Community-dwelling
Age	Mean age 80.5 years	Mean age 82.8 years
Intervention	6 x Multi-component (MCT) 2 x Resistance (RT)	2 x Multi-component (MCT) 1 x Resistance (RT) 1 x Strength & motion 1 x GrandStand™
Characteristics	Frequency 2-3 x weekly of 45-90 mins Duration 2.5–9 months Intensity 1x low intensity 2x moderate intensity 1x high intensity 4x Intensity not stated	Frequency 3-7 x weekly Duration 6 weeks–18 months Intensity not stated
Intervention setting	2 x Home-based 3 x Centre-based 1 x Centre & home-based 2 x Not stated	Home-based
Control	3 x Home-based exercise 4 x Exercise - no setting stated 1 x Usual care	Not stated
Outcomes	Gait Mobility (TUG & Chair rise/stand) Balance (BBS & other tests) Physical Performance (PP)	Strength Gait Mobility Balance
Effect size	MCT: ↑ gait, PP, 1x no effect RT: ↑ gait	MCT: ↑ balance, mobility, 1x NE RT: ↑ strength RT & Motion: ↑ mobility GrandStand™: no effect
Type of studies	RCTs	RCTs
Analyses	Narrative synthesis	Narrative synthesis
Confidence intervals	Not calculated	Not calculated
P value	Not calculated	Not calculated
Follow-up	10 weeks–9 months	Not stated

	3. Cruz-Jentoft et al.[15]	4. Daniels et al.[16]
Databases searched	PubMed, Dialogue	PubMed, CENTRAL, CINAHL
Range of included studies	2005 – 2012	1998 – 2005
Total number of studies/total relevant	19 trials / 3 trials	10 trials / 7 trials
Total number of participants/total relevant	1453 / 249 Female 62.7%	1191 / 837 Female: No information provided
Heterogeneity$	Not calculated	Not calculated
Setting	Community-dwelling	Community-dwelling
Age	Mean age 81 years 1 trial > 75 years	Mean age 80.0 years
Intervention	1 x Resistance (RT) 1 x Resistance + protein 1 x Multi-component + nutrition	4 x Multi-component (MCT) 2 x Resistance (RT) 1 x Exercise + nutrition (fruit + diary product)
Characteristics	Frequency not stated Duration 3–9 months Intensity 3 x not stated	Frequency 2-3 x weekly of 45-75 mins Duration 2.5–18 months Intensity not stated
Intervention setting	Not stated	1 x Home-based 4 x Home & centre-based supervised 2 x Centre-based
Control	1 x Home based low intensity 1 x No intervention 1 x Not stated	4 x No intervention 3 x Usual care
Outcomes	Strength Physical Performance (PP)	Strength Gait Mobility Balance Physical Performance (PP) Functional/aerobic capacity (FC)
Effect size	RT: ↑ strength RT & Protein: no effect MCT & NUTR: ↑ strength	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, balance, PP EX & NUTR: ↑ FC
Type of studies	RCTs	RCTs
Analyses	Narrative synthesis	Narrative synthesis
Confidence intervals	Not calculated	Not calculated
P value	> 0.05 in 2 trials	Not calculated
Follow-up	Not stated	2.5 -18 months

	5. De Labra et al.[12]	6. De Vries et al.[11]
Databases searched	PubMed, Web of Science, The Cochrane Library	PubMed, CINAHL, EMBASE, PEDro, The Cochrane Library
Range of included studies	2005 – 2015	1998 – 2010
Total number of studies/total relevant	9 trials / 5 trials	18 trials / 18 trials
Total number of participants/total relevant	1067 / 562 Female 75.3%	2580 / 2580 Female: No information provided
Heterogeneity[$]	Not calculated	Mobility exercise vs non I^2 9% Mobility intensity/duration I^2 0% PP exercise vs non I^2 27% PP intensity: I^2 67% dura: I^2 83%
Setting	Community-dwelling	Community-dwelling
Age	Mean age 80.6 years	Age range: 60-85 years
Intervention	4 x Multi-component (MCT) 1 x Resistance (RT)	9 x Multi-component (MCT) 4 x Resistance (RT) 1 x Balance 3 x Personalized/not stated 1 x GrandStand™
Characteristics	Frequency 2-5 x weekly of 20-90mins Duration 2.5-12 months Intensity 30-80% 1RM	Frequency 1-7x weekly of 10--90mins Duration 5 weeks–18 months Intensity: low vs high without definition
Intervention setting	1 x Home-based 4 x Not stated	2 x Centre-based 5 x Home-based 2 x Home & centre-based supervised 4 x Centre vs home 5 x Not stated
Control	Not stated	10 x No intervention 4 x Home-based; 4 x Not stated
Outcomes	Strength Mobility Balance & Physical Performance (PP)	Gait Mobility Physical Performance (PP)
Effect size	MCT: ↑ strength, balance, gait, mobility, PP RT: ↑ strength, gait, mobility Small to very small effect size	Mobility EX vs no EX: SMD: 0.18 Intensity SMD: -0.05 Duration SMD -0.09 short duration SMD 0.00 long duration PP EX vs no EX: SMD: 2.93 Intensity SMD: 0.22 Duration SMD 0.13/0.38 short SMD 0.26 long
Type of studies	RCTs	RCTs
Analyses	Narrative Synthesis	Meta-analysis + Narrative synthesis
Confidence intervals	Not calculated	Mobility EX vs no EX: CI: 0.05-0.30 Intensity CI: -0.25 – 0.15 Duration: CI:-0.35 – 0.18 short CI: -0.32 – 0.32 long PP EX vs no EX: CI:2.50 – 3.36 Intensity: CI:-0.17 – 0.62 Duration: CI:-0.34 – 0.61 short CI: -0.48 – 1.25 short CI: -0.35-0.87 long
P value	Not calculated	Not calculated
Follow-up	2.5 - 12 months	5 weeks -18 months

	7. Theou et al.[10]
Databases searched	Medline, EMBASE, PSYCHINFO, CINAHL, Scopus, AgeLine, ERIC, SPORTDiscus
Range of included studies	1998 – 2008
Total number of studies/total relevant	75 trials / 13 trials
Total number of participants/total relevant	4915 / 1010 Female 70.0%
Heterogeneity$	Not calculated
Setting	Community-dwelling
Age	Mean age 80.3 years
Intervention	8 x Multi-component (MCT) 4 x Resistance (RT) 1 x Horse riding simulator
Characteristics	Frequency 2-3 x weekly 10-60mins Duration 10 weeks – 36 weeks Intensity 1 trail: 6-8 on 10-point scale 2 trials: 3 x 8-12 repetitions at 85-100% 1RM 1 trial: 60 – 80% 1RM
Intervention setting	2 x Home-based 3 x Centre-based supervised 8 x Not stated
Control	Not stated
Outcomes	Gait Mobility Balance Physical Performance (PP)
Effect size	Not stated for community-dwelling separately MCT: ↑ gait, balance, mobility, PP RT: ↑ mobility, PP Horse Simulator: no effect
Type of studies	RCTs
Analyses	Narrative synthesis
Confidence intervals	Not calculated
P value	Not calculated
Follow-up	Not stated

Appendix 3

Statement of Authorship and published manuscript (Chapter 4)

The perspectives of pre-frail and frail older people on being advised about exercise: a qualitative study

Statement of Authorship

Title of Paper	The perspectives of pre-frail and frail older people on being advised about exercise: a qualitative study
Publication Status	☐ Published ☑ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	Jadczak AD, Dollard J, Mahajan N, Visvanathan R. The perspectives of pre-frail and frail older people on being advised about exercise: a qualitative study. Family Practice. Accepted for publication on 26 September 2017.

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak		
Contribution to the Paper	Designed interviews, recruited participants, collected all data, performed data analyses, wrote manuscript, and acted as corresponding author.		
Overall percentage (%)	75%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	09/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Joanne Dollard		
Contribution to the Paper	Helped with developing interview questions, edited the manuscript and provided input in regards to data analyses, interpretation, and manuscript evaluation.		
Signature		Date	10/10/17

Name of Co-Author	Neha Mahajan		
Contribution to the Paper	Helped in developing interview questions and provided input in regards to data interpretation and manuscript evaluation.		
Signature		Date	6th Oct '17

Name of Co-Author	Renuka Visvanathan		
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to data interpretation and manuscript evaluation.		
Signature		Date	27/9/17

Family Practice, 2017, 1–6
doi:10.1093/fampra/cmx108

OXFORD

Qualitative Research

The perspectives of pre-frail and frail older people on being advised about exercise: a qualitative study

Agathe Daria Jadczak[a,b*], Joanne Dollard[a], Neha Mahajan[a] and Renuka Visvanathan[a,b,c]

[a]Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Adelaide Medical School, Faculty of Health and Medical Sciences, University of Adelaide, Adelaide, SA 5075, Australia, [b]National Health and Medical Research Council Centre of Research Excellence: Frailty Trans-Disciplinary Research to Achieve Healthy Ageing, University of Adelaide, Adelaide, SA 5005, Australia and [c]Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide, SA 5011, Australia.

*Correspondence to Agathe Daria Jadczak, Aged & Extended Care Services, The Queen Elizabeth Hospital, 28 Woodville Road, Woodville South 5011, Australia; E-mail: agathedaria.jadczak@adelaide.edu.au

Abstract

Background. Exercise is considered to be the most effective strategy to treat, prevent and delay frailty, a prevalent geriatric syndrome observed in clinical practice. Encouraging frail older people to take up exercise is crucial in the management of this condition. The study aimed to explore pre-frail and frail older peoples' perspectives in relation to being advised about exercise and their perceptions of the general practitioners' (GPs) role in promoting exercise for older people.

Methods. Semi-structured interviews were conducted with 12 community-dwelling older (median age 83 years) participants screened pre-frail or frail using the FRAIL Screen. Their attitudes towards exercise, the advice received, their access to relevant information and their perceptions of the GP's role in promoting exercise were explored. Thematic analysis was conducted to analyse data.

Results. The majority of participants had a positive attitude towards exercise, and many participants indicated a preference for being advised firstly by their GPs and then other healthcare professionals. Participants living in the community reported difficulties in accessing information on exercise and indicated that local governments and GP practices should promote exercise for older people more actively. Participants living in retirement villages, however, reported having access to relevant information and being encouraged to participate in exercise.

Conclusion. This research identified a gap in current practice, demonstrating that GPs, healthcare providers and local governments should promote exercise for older people more actively. Convincing health professionals to encourage regular exercise among their older patients would provide an opportunity to avoid and manage frailty in this population.

Key words: Exercise, frail elderly, general practitioners, health promotion, perceptions, qualitative research.

Introduction

Exercise is considered to be the most effective strategy for the prevention, treatment and postponement of frailty, a prevalent geriatric syndrome observed in clinical practice (1). Frailty is defined as a 'clinically recognisable state of increased vulnerability resulting from age-associated decline in reserve and function' (2). It includes clinical indicators, such as deficit accumulation, fatigue, sedentary behaviour, weight loss and physical function impairment (2,3), and is associated with increased hospitalization, disability, loss of independence and reduced quality of life (4,5).

One of the most commonly used frameworks of frailty is the frailty phenotype by Fried *et al.* (6), *which uses a physiological approach to categorize adults into robust (0 indicators), pre-frail (1–2 indicators) and frail (≥3 indicators) based on the accumulation of the following five physical conditions: unintentional weight loss, exhaustion, slow walking speed, weakness and low physical activity. The prevalence of frailty is reported to be 10.7% in community-dwelling older people, and it is estimated that by 2050,* 4 million Australians will be either pre-frail or frail (7).

Frailty is a dynamic syndrome that is treatable and reversible (8), and a critical component in its treatment is exercise (1). Exercise helps to increase and restore muscle strength and improve the overall physical function. Greater strength and mobility allow for greater independence and an enhanced quality of life (1,8,9). Promoting physical activity programmes for community-dwelling pre-frail and frail older adults and generally encouraging older people to take up exercise are critical in managing frailty (10,11).

Although the benefits of exercise are well known, the uptake of exercise in older people is poor (12,13). Barriers to exercise among older people include health issues (e.g. pain), environmental factors (e.g. lack of transportation), lack of knowledge and the lack of physician advice (14).

Costello *et al.* (15) conducted focus groups with 31 independent living, non-frail older adults and confirmed that general practitioners (GPs) play an important role in promoting exercise for older people. However, older adults perceived their exercise conversations with their GPs as inadequate, and it was suggested that healthcare providers, including GPs, should take collective responsibility for encouraging older people to take up exercise.

With regard to the frail population, Broderick *et al.* (2015) investigated the perceptions of 29 frail older adults in order to determine their exercise motivation and behaviour. The study results indicate that family members and social support networks involving friends and peers are critical motivators of exercise activity among frail older people. However, social support networks decline as frailty increases, and family members may not only motivate but also limit frail older people in their physical activities in an effort to protect them (16).

Research specifically investigating frail older people's experiences of being advised about exercise and their opinions regarding who should advise them, and where, is sparse. By better understanding frail older people's preferred source of exercise advice, researchers can ensure that community-based education and awareness programmes are not only appropriately composed but also that the information is made available through the most appropriate sources.

The aims of this study were to (i) understand the perspectives of community-dwelling older people who are pre-frail or frail in relation to being advised about exercise and to (ii) explore their experiences with regard to any advice provided by their GPs.

Methods

Participants and procedures

Participants were recruited from The Queen Elizabeth Hospital (TQEH), the Queen Elizabeth Specialist Centre (QE Specialist Centre) and the Geriatrics Training and Research with Aged Care Centre (G-TRAC Centre) in Adelaide, South Australia, Australia. Potential participants were asked by their TQEH geriatricians (affiliated with the researchers' department) during a scheduled consult whether they were interested in participating in this study. Interested individuals were then referred to a researcher (ADJ) who provided more information about the study, confirmed interest and performed initial eligibility screening on-site following the consult or over the phone before enrolling them into the study and scheduling an interview.

Participants aged 75 years and older, living in the community and screened pre-frail or frail using the FRAIL screen (17), were included in this study. The FRAIL screen represents the Fried frailty phenotype (6) and includes five questions about fatigue, resistance, ambulation, illness and weight loss. It categorizes individuals into pre-frail (1–2 deficits), frail (≥3 deficits) or robust (0 deficit). Participants with a medical history of dementia or who were unable to communicate in English were excluded from the study.

Interviews and study questionnaires

Semi-structured interviews were held at the Basil Hetzel Institute, an adjacent research centre of TQEH, at the G-TRAC Centre or at the participant's home, depending on the participant's preference. ADJ conducted face-to-face interviews with all participants, each lasting approximately 1 h. The interviews included 16 semi-structured questions asking about participants' previous exercise experiences, their perspectives on receiving advice on exercise, their access to relevant information and their experiences with their GPs. The interviews were audio recorded and transcribed. The transcript of the first interview was reviewed by a member of the research team (JD) to assess ADJ's interview technique for gathering quality data. Participants' 5-year mortality risk was determined using the Charlson Comorbidity Index (18), and current physical activity levels were assessed using the Physical Activity Scale for the Elderly (PASE) questionnaire (19). Demographic information, recorded in a separate questionnaire, included age, gender, nationality, education, income level and participation in regular exercise.

Data analysis

Participants' characteristics and demographic information were analysed using descriptive statistical methods. The interviews were analysed using thematic analysis (20). ADJ transcribed the audio-recorded interviews, reread the transcripts to ensure familiarity and coded the transcripts line by line using an inductive approach (21). Codes were then collated and categorized into potential themes, gathering all data relevant to each theme before refining the themes and generating clear definitions for each specific theme. The coding framework, the codes and the themes were then discussed with a member of the research team (JD), and a scholarly report of the analysis was prepared (20). *NVivo* version 10 software was used to manage data analysis. Quotations are provided in this article to support the themes. Data saturation was reached when there was enough information to replicate the study, and new information was not obtained by interviewing additional participants (22).

Results

Participants' characteristics

Seventeen potential participants were referred to ADJ and screened for eligibility. Three decided not to participate, another felt too unwell and another was neither pre-frail nor frail according to the FRAIL Screen (17). The selected participants provided written informed consent and were advised that participation was voluntary.

Twelve participants (eight females and four males) were interviewed. By the ninth interview, data saturation was reached as it was noted that participants' responses to the interview questions were repetitive. Recruitment was, therefore, ceased after the 12th interview. The median age of the participants was 83 years with a range of 76 to 91 years. Ten participants were pre-frail and two participants were frail. The most common deficits on the FRAIL screen included feeling fatigued ($n = 6$) and currently having more than five illnesses simultaneously ($n = 5$). Eleven participants had a low 5-year mortality risk according to the Charlson Comorbidity Index. Six participants reached the current physical activity recommendations for older people according to the PASE questionnaire, considering their age and gender. Demographic data revealed a lower income and a prevalence of men in the non-active group. However, there were no differences in age, education, frailty status and 5-year mortality risk between active and non-active participants (Table 1).

Themes

Four themes emerged from the data (Fig. 1): older peoples' attitudes towards exercise; their difficulties in accessing information on exercise; the crucial role of GPs and healthcare professionals in promoting exercise; and the missing or limited advice on exercise provided by GPs.

Attitudes, barriers and enablers of exercise

The majority of participants (10 of 12) reported a positive attitude towards exercise and physical activity programmes, commenting on the importance of exercise and its benefits in older age, irrespective of their physical activity status (PASE). Being physically active in the past did not correlate with participants' attitudes towards exercise reported during the interviews.

Participants perceived multiple barriers to participation in exercise. These included family commitments (especially for women whose role as carer may override self-care, hobbies or other activities), physical limitations (pain and illness), transportation and seasonal climate (cold weather and darkness common during winter months in South Australia).

> We just couldn't cope with the cold and both of us stopped exercising and got stuck inside. (#10)

Enablers for exercise included exercising with their partner, social aspects and rehabilitation or healthcare services, such as physiotherapy after hip replacement, where participants recognized the benefits of exercise in the form of improvements in physical function and mobility.

> I was in hospital (hip operation) and then I went to rehabilitation. I had physiotherapy there every day. I really should have started those exercises straight away. (#4)

With regard to enjoyable and preferred aspects of physical activity programmes, participants reported a preference for smaller classes with a variety of gentle, but challenging and beneficial, exercises tailored for their individual health, including strength and balance tasks. Half of the participants (6 out of 12) were engaged in regular exercise, participating in a structured exercise programme.

Access to information on exercise and physical activity programmes

Both active and non-active participants living in the community felt that information relating to opportunities for exercise in the community was insufficient. They suggested that the local government should be more engaged in promoting physical activity programmes for older people.

> The government should send out brochures to older people. They should get something in every suburb, like through the council. (#8)
> I don't see any advertisement (for exercise or physical activity programs) […] and I have been to the local library and places like that […], but I've never seen something […]. I just don't know where to get information. (#6)

All participants living in retirement villages (3 out of 12) revealed that they had greater access to exercise information and physical activity programmes due to the services provided in their villages.

> Before I came here (retirement village) I had no idea where to go, I had no idea that people even went to exercise classes; you've never heard of it. (#12)

The majority of participants (9 out of 12) preferred brochures with information, including the health benefits of exercise in older age and available physical activity programmes in the community. They also commented on their preference for personal advice from someone with a positive attitude.

Role of GPs and healthcare professionals in promoting exercise

Healthcare professionals appear to play a key role in the promotion of exercise for older people, especially when patients receive healthcare services like physiotherapy or rehabilitation. Five participants reported that they received information on exercise opportunities

Table 1. Participants' health and demographic characteristics collected during the interviews

Characteristic	Total participants ($n = 12$)	Active participants; PASE ($n = 6$)	Non-active participants; PASE ($n = 6$)
Age (median)	83 (range 76–91 years)	83 (range 76–91 years)	83 (range 76–90 years)
Gender	8 females; 4 males	5 females; 1 male	3 females; 3 males
FRAIL Screen	10 pre-frail; 2 frail	5 pre-frail; 1 frail	5 pre-frail; 1 frail
Charlson Comorbidity Index	11 low 5-year mortality risk; 1 high 5-year mortality risk	6 low 5-year mortality risk; 0 high 5-year mortality risk	5 low 5-year mortality risk; 1 high 5-year mortality risk
Income	8 low; 3 average; 1 high	3 low; 2 average; 1 high	5 low; 1 average; 0 high
Highest education	2 primary school; 5 secondary school; 4 technical college; 1 university	0 primary school; 4 secondary school; 2 technical college; 0 university	2 primary school; 1 secondary school; 2 technical college; 1 university
Nationality	8 Australian; 3 European; 1 Asian	5 Australian; 1 European; 0 Asian	3 Australian; 2 European; 1 Asian
Participation in exercise programme	6 yes; 6 no	5 yes; 1 no	1 yes; 5 no

PASE, Physical Activity Scale for the Elderly. Income per year: low (< $25 000), average ($25 000–$45 000) and high (> $45 000).

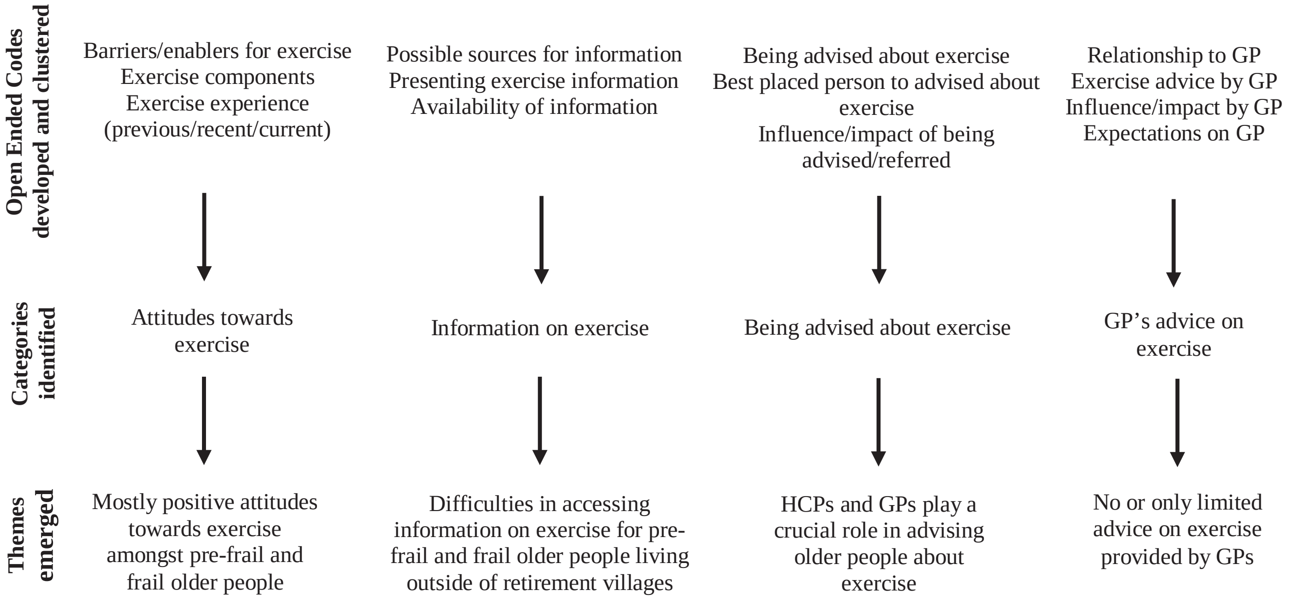


Figure 1. Data analysis and development of themes.

during these services, and four of these participants continued with exercise after completing their treatment.

> I had physiotherapy [. . .] and he gave me some exercises [. . .] which I still do. And they (rehabilitation centre) said there are also other exercise classes you can get involved if you like. (#8)

However, half of the participants (6 out of 12) indicated a preference for being advised on exercise initially by their GPs as they see them regularly, and the GP is aware of their medical conditions and is the primary referrer to healthcare services.

> Initially the doctor as he knows in what condition you are and what you are able to do. (#5)
> At first point I would have thought [. . .], it is our GP. Older people go to see their physicians naturally. So it is first the GP. (#10)

Family members were also reported to have significant influence.

> My daughter, she was the one that encouraged me to go to Pilates. (#4)

Three participants did not nominate a particular individual as the most important adviser, instead, stating that 'someone who knows about it' should advise them about exercise, two participants stated that healthcare professionals should advise initially and one participant did not answer the question. Active participants did not differ from non-active participants in their opinions as to who should advise them on exercise.

Advice on exercise provided by GPs

Even though participants perceived that GPs play a key role in promoting exercise for older people, the majority of participants (11 out of 12; both active and non-active) reported no (n = 6) or only limited (n = 5) recollection of exercise advice being provided during consults. Advice was defined as limited if the GP suggested walking without giving detailed information on the frequency, duration or intensity, or did not refer the individual to healthcare professionals or available physical activity programmes.

However, participants consistently expressed faith in their GPs and said that they would appreciate and follow their advice on exercise.

> I would do it (exercise) if my GP would say it. (#1)
> When the GP would say do this or this (exercises), yes, I would dare it. (#5)

Participants also suggested that GPs should promote exercise and physical activity programmes more actively.

> If the doctor would have something to hand to you. A notice of who to see and what you could do (#5).

One participant received information from his/her GP after taking the initiative and asking about available physical activity programmes.

> I want to go to an exercise class, do you know any where? And he said, yes I do, you are going to need my referral [...]. They are very good, they have classes for falls and balance and all that kind of stuff, and strength. So I went down there for quite a few years. (#12)

Discussion

Three key findings emerged from this study. Firstly, data analysis indicated that pre-frail and frail older people had mostly positive attitudes towards exercise, irrespective of their current physical activity status. Secondly, half of the participants indicated a preference for being advised on exercise initially by their GPs, but only one participant could recollect getting advice. Thirdly, participants received information on exercise and available physical activity programmes mainly through allied healthcare services (i.e. physiotherapy and rehabilitation) and their retirement villages, while participants living outside of retirement villages or those not receiving any allied health services reported a lack of exposure to exercise and available physical activity programmes. The important role of retirement villages in successfully encouraging physical activity among older adults emerged as an unexpected finding.

The mostly positive attitudes towards exercise among the pre-frail and frail older adults reported in this study are consistent with findings in other studies showing that older adults hold positive attitudes towards exercise (23–25). However, findings that report negative attitudes towards exercise among inactive older adults were not supported by this study as most of the inactive participants also reported positive attitudes (24–26). These findings might be due to participants who have a more positive attitude being more likely to consent to an interview about exercise. This bias has been reported previously, for example by Rich and Rogers (25), who used a survey to examine older adults' attitudes towards exercise and mainly received responses from adults who were likely to exercise. However, the positive attitudes of non-exercisers provide an opportunity to coax more pre-frail and frail older people into physical activity.

Attitudes towards GPs confirmed the results of other studies that have noted that older adults are more likely to accept health advice from GPs compared with any other age group (27). Older adults tend to be in regular contact with their GPs, who are not only aware of their medical conditions and limitations but also the primary referrers to healthcare services (13–15). The fact that half of the participants indicated a preference for being advised about exercise firstly by their GPs underlines the important role that GPs play. GPs should capitalize on older people's positive attitudes towards exercise and their readiness to follow their advice by promoting exercise and available physical activity programmes more actively, especially among those who do not receive any therapy services. A shared decision-making mode where GPs collaborate with patients on treatment options and exercise strategies should be the ultimate goal rather than being paternalistic by merely telling patients what to do (28).

However, exercise advice provided by physicians is reported to be rare (29) and not specific (9), which aligns with the findings of this study where only one participant recollected receiving adequate information on exercise and being referred to an exercise programme. It is suggested that specific advice, including the type, frequency, intensity and duration of exercise, can lead to a greater increase in physical activity among older people than general advice with no specifics on where to go and what to do (30).

Education and awareness programmes tailored to GPs could be introduced to inform and encourage them to advise their older patients about available physical activity programmes or to refer patients to allied healthcare experts more frequently, as a lack of knowledge is reported to be the main reason why GPs do not advise their patients about exercise (31). The Enhanced Primary Care Program (currently active in Australia), for example, allows supported referrals to exercise physiologists and represents a unique opportunity to tackle frailty.

Difficulty in accessing information on exercise for older people has been reported previously, as well as the need for healthcare providers and local communities to promote exercise for older people more actively (32). This study underlines this need and has identified clearly the difficulty in accessing information related to exercise and available physical activity programmes for community-dwelling pre-frail and frail older people living outside of retirement villages.

Data from this study revealed that retirement villages and their associated services appear more successful in promoting exercise, as all of the participants in this study who were living in a retirement village received information on exercise and available physical activity programmes. There might be a health promotion strategy to be learnt from the retirement villages which local governments could use to integrate pre-frail and frail older people into community-based physical activity programmes. Furthermore, since brochures related to exercise and physical activity programmes were recorded as being the most popular source of information by participants in this study, local communities could strategically send out brochures to their older residents to promote available physical activity programmes and encourage participation.

Healthcare services also play a crucial role in encouraging older people to take up exercise as evidenced by the comments from participants in this study. These tertiary services provided information about available physical activity programmes, and the majority (four out of five participants) continued with exercise after treatment. Healthcare services, like physiotherapy, could therefore be seen as an opportunity to introduce pre-frail and frail older people to physical activity programmes, as it has been reported before that rehabilitation or exercise programmes in a recovery setting impact positively on older people's exercise beliefs (16).

Limitations and future studies

Recruiting community-dwelling frail older people to the study at the time of a geriatric consultation proved difficult due to the presence of severe medical conditions resulting in participants feeling too fatigued to be interviewed and declined to participate. This resulted in the recruitment of mostly pre-frail older adults, with the majority (9 out of 12) scoring only one deficit on the FRAIL Screen. The fact that participants were recruited from geriatric clinics only, were mostly pre-frail, were English speaking and had an average level of education limits the generalizability of the study results. Including more frail older adults with different cultural and educational backgrounds may have led to more diverse opinions in relation to exercise and being advised about exercise. Regarding sample size and data saturation, the sample size of qualitative studies depends more on the data in terms of richness and thickness rather than on the sample size (22). Twelve participants were sufficient as data saturation was reached after interviewing the ninth participant. Furthermore, half of the participants were active (PASE), despite being pre-frail or frail, suggesting that additional tools are required to identify pre-frail and frail older adults.

The fact that our recruitment method was successful in recruiting pre-frail but not frail participants requires reflection, and future studies should allow more time and resources for recruitment, target more frail individuals (with scores of ≥2 on the FRAIL Screen) and explore why GPs are reluctant to give advice or refer patients to exercise programmes.

Conclusion

The results of this study suggest that GPs should capitalize on older people's positive attitudes towards exercise and their readiness to follow the GP's advice by promoting exercise and available physical activity programmes more actively. Additionally, tertiary healthcare services, like rehabilitation and therapy services, should also be seen as an opportunity where pre-frail and frail older people could be linked long term into exercise programmes. Retirement villages with health promotion strategies are a resource from which the wider community can learn. Further research into health promotion strategies used in retirement villages would be of interest, as well as to explore why GPs are reluctant to give advice or refer patients to exercise programmes. The findings suggest that to facilitate exercise in pre-frail and frail older people further effort to inform and promote exercise is vital.

Declaration

Funding: ADJ is a recipient of the Beacon PhD Scholarship from the University of Adelaide.

Ethics: This study received ethics approval from the University of Adelaide Human Research Ethics Committee (HREC reference number H-2015–161).

Conflict of interest: The authors report no conflict of interests.

References

1. Clegg A, Young J, Iliffe S, *et al*. Frailty in elderly people. *Lancet* 2013; 381: 752–62.
2. Xue QL. The frailty syndrome: definition and natural history. *Clin Geriatr Med* 2011; 27: 1–15.
3. Cesari M, Landi F, Vellas B, *et al*. Sarcopenia and physical frailty: two sides of the same coin. *Front Aging Neurosci* 2014; 6: 192.
4. Clark BC, Manini TM. Functional consequences of sarcopenia and dynapenia in the elderly. *Curr Opin Clin Nutr Metab Care* 2010; 13: 271–6.
5. Weiss CO. Frailty and chronic diseases in older adults. *Clin Geriatr Med* 2011; 27: 39–52.
6. Fried LP, Tangen CM, Walston J *et al*.; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; 56: M146–56.
7. Collard RM, Boter H, Schoevers RA, *et al*. Prevalence of frailty in community-dwelling older persons: a systematic review. *J Am Geriatr Soc* 2012; 60: 1487–92.
8. Gill TM, Gahbauer EA, Allore HG, *et al*. Transitions between frailty states among community-living older persons. *Arch Intern Med* 2006; 166: 418–23.
9. Taylor D. Physical activity is medicine for older adults. *Postgrad Med J* 2014; 90: 26–32.
10. Hallal PC, Andersen LB, Bull FC, *et al*.; Lancet Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012; 380: 247–57.
11. Australian Institute of Health and Welfare. 2014. Australia's Health 2014. Australia's Health Series no. 14. Cat. no. AUS 178. Canberra: AIHW.
12. Franco MR, Tong A, Howard K *et al*. Older people's perspectives on participation in physical activity: a systematic review and thematic synthesis of qualitative literature. *Br J Sports Med* 2015; 49: 1268–76.
13. Rantanen T. Promoting mobility in older people. *J Prev Med Public Health* 2013; 46 (Suppl 1): S50–4.
14. Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. *Prev Med* 2004; 39: 1056–61.
15. Costello E, Leone JE, Ellzy M, *et al*. Older adult perceptions of the physicians' role in promoting physical activity. *Disabil Rehabil* 2013; 35: 1191–8.
16. Broderick L, McCullagh R, White EB, *et al*. Perceptions, expectations, and informal supports influence exercise activity in frail older adults. *SAGE Open* 2015; 5: 1–10.
17. Morley JE, Vellas B, van Kan GA *et al*. Frailty consensus: a call to action. *J Am Med Dir Assoc* 2013; 14: 392–7.
18. Charlson ME, Pompei P, Ales KL, *et al*. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987; 40: 373–83.
19. Washburn RA, Smith KW, Jette AM, *et al*. The Physical Activity Scale for the Elderly (PASE): development and evaluation. *J Clin Epidemiol* 1993; 46: 153–62.
20. Joffe H, Yardley L. Content and thematic analysis. In: Marks DF & Yardley L (eds). *Research Methods for Clinical and Health Psychology*. London: Sage Publications Ltd, 2004, pp. 56–68.
21. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; 3: 77–101.
22. Fusch PI, Ness LR. Are we there yet? Data saturation in qualitative research. *Qual Rep 2015; 20: 1408–1416*.
23. Archer T, Fredriksson A, Schütz E, *et al*. Influence of physical exercise on neuroimmunological functioning and health: aging and stress. *Neurotox Res* 2011; 20: 69–83.
24. Lee C. Attitudes, knowledge, and stages of change: a survey of exercise patterns in older Australian women. *Health Psychol* 1993; 12: 476–80.
25. Rich SC, Rogers ME. Stage of exercise change model and attitudes toward exercise in older adults. *Percept Mot Skills* 2001; 93: 141–4.
26. Courneya KS. Understanding readiness for regular physical activity in older individuals: an application of the theory of planned behavior. *Health Psychol* 1995; 14: 80–7.
27. Whitlock EP, Orleans CT, Pender N, *et al*. Evaluating primary care behavioral counseling interventions: an evidence-based approach. *Am J Prev Med* 2002; 22: 267–84.
28. Charles C, Gafni A, Whelan T. Decision-making in the physician-patient encounter: revisiting the shared treatment decision-making model. *Soc Sci Med* 1999; 49: 651–61.
29. Glasgow RE, Eakin EG, Fisher EB, *et al*. Physician advice and support for physical activity: results from a national survey. *Am J Prev Med* 2001; 21: 189–96.
30. Kerse N, Elley CR, Robinson E, *et al*. Is physical activity counseling effective for older people? A cluster randomized, controlled trial in primary care. *J Am Geriatr Soc* 2005; 53: 1951–6.
31. Forman-Hoffman V, Little A, Wahls T. Barriers to obesity management: a pilot study of primary care clinicians. *BMC Fam Pract* 2006; 7: 35.
32. Bethancourt HJ, Rosenberg DE, Beatty T, *et al*. Barriers to and facilitators of physical activity program use among older adults. *Clin Med Res* 2014; 12: 10–20.

Appendix 4

Statement of Authorship and published manuscript (Chapter 5)

Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people

Statement of Authorship

Title of Paper	Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Jadczak AD, Tam KL, Yu S, Visvanathan R. Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people. Australasian Journal on Ageing. 2017; 36(3):E7-E13. DOI: 10.1111/ajag.12412.

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak		
Contribution to the Paper	Designed survey, collected all data, constructed study database, performed statistical data analyses, wrote manuscript, and acted as corresponding author.		
Overall percentage (%)	80%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	09/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Khai Loon Tam		
Contribution to the Paper	Advised on medical curriculum, provided Table 1 and facilitated data collection.		
Signature		Date	9/10/17

Name of Co-Author	Solomon Yu		
Contribution to the Paper	Edited manuscript and facilitated data collection.		
Signature		Date	9/10/17

Name of Co-Author	Renuka Visvanathan		
Contribution to the Paper	Supervised development of work, helped with study design and ethics application, edited manuscript and provided input in regards to data interpretation and manuscript evaluation.		
Signature		Date	27/9/17

DOI: 10.1111/ajag.12412

Research

Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people

Agathe Daria Jadczak, Khai Loon Tam, Solomon Yu and Renuka Visvanathan

Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, School of Medicine, Faculty of Health Sciences, University of Adelaide; Aged and Extended Care Services, Central Adelaide Local Health Network, The Queen Elizabeth Hospital; and National Health and Medical Research Council Centre of Research Excellence: Frailty and Healthy Ageing, University of Adelaide, Adelaide, South Australia, Australia

Objective: *To determine the effects of a 4.5-week geriatric medicine course on fifth year medical students' perception of the importance of and their competence in prescribing exercise to older people.*

Methods: *The modified Exercise and Physical Activity Competence Questionnaire was administered to 81 students before and after the course. Scores ranged from 0 to 6. One open-ended question about perceived barriers to exercise prescription was asked.*

Results: *Students' perceptions of the importance of designing an exercise prescription (P = 0.038), determining the training heart rate (P = 0.021), determining the body mass index (P > 0.001), referring an older person to an exercise program (P > 0.001) and identifying age-related limitations (P = 0.029) improved significantly after the course. Students' self-perceived competence improved significantly across all items (P > 0.001). Barriers to exercise prescription included lack of: knowledge (57%), patient compliance (39%) and time (33%).*

Conclusion: *A geriatric medicine course contributes to improved senior medical students' perceptions of importance of and their competence in prescribing exercise to older people.*

Practice Impact: Given the ageing of the population and the benefits of exercise in older people, the enhancement of medical curriculums is a critical strategy in building the future capacity of our medical workforce, thus equipping them with the necessary skills and knowledge to effectively counsel and motivate older people to participate in exercise.

Key words: *competence, exercise prescription, geriatric medicine, medical students.*

Correspondence to: Ms Agathe Daria Jadczak, University of Adelaide. Email: agathedaria.jadczak@adelaide.edu.au

Introduction

Exercise is a key intervention when managing the health of older people. It contributes to healthy ageing and is important in preventing health complications and maintaining independence [1]. Exercise has demonstrated benefits for controlling and ameliorating numerous age-related diseases and chronic health conditions [2]. Regular exercise is reported to help maintain and restore muscle strength, improve balance and physical performance, prevent loss of independence and reduce the risks of falls and fractures, thus contributing to enhanced quality of life [1–3].

Although the benefits of exercise are well known, the uptake of exercise in older people is limited. Participation in exercise decreases as people age, with 45% of people aged over 65 years and 75% of people aged 75 years and older not meeting their respective recommended levels of physical activity [4]. On the whole, globally, people are increasingly sedentary and sedentary behaviour is thought to contribute to health complications and premature deaths [5,6]. Older people report that health issues, environmental barriers, a lack of personal knowledge and also a lack of doctor's advice are the main reasons for not participating in adequate exercise [7].

Doctors are an integral member of any health-care team and, therefore, have a role to play in encouraging older people to exercise [8,9]. They can do this by increasing patient awareness of the importance of exercise, allaying patient fears, helping patients to overcome perceived barriers and by providing direction about where to go and what to do [10]. Exercise advice provided in prescription form, including the type of activity, frequency, intensity and duration following a medication prescription format has been shown to be acceptable and effective in increasing older peoples' physical activity levels [9,11]. Doctors may be able to undertake a basic prescription with general advice and encouragement prior to referral to allied health experts, such as exercise physiologists and physiotherapists who have expertise in prescribing tailored exercise programs.

Despite the efficacy of exercise prescription, doctors rarely focus on the need for exercise when recommending treatment, with only one-third of physicians recommending exercise to their patients [12]. A commonly cited reason for doctors not prescribing exercise or counselling about physical activity is due to the lack of training during medical school [13]. Recent studies confirm that 44% of medical schools in the UK are not teaching the government-recommended guidelines for physical activity [14] and that over half of doctors trained in the United States do not receive formal education relating to exercise [15].

In this context, a cross-sectional study conducted by Vallance et al. [16] investigated undergraduate medical students' perceived competence in prescribing exercise. This research confirmed that medical students perceived that it was important to prescribe exercise, but only demonstrated moderate competence in completing an exercise prescription [16]. It is important to note that the survey was not specifically about exercise prescription for older people, but was designed to investigate perceived importance and competence in relation to exercise prescription for healthy adults and the response rate was only 27%.

Nevertheless, Jones et al. [17] and Conroy et al. [18] confirmed that specific exercise courses during medical school significantly increase medical students' beliefs in regard to the importance of exercise and their confidence and ability to counsel healthy adults about exercise. It is anticipated that a specific exercise curriculum, including lectures in medical school, could contribute to medical students' competence and confidence by ensuring that they understand the benefits of this treatment modality, are more enthusiastic in promoting exercise and can and do offer counselling to encourage the uptake of exercise [17,18]. However, targeted research investigating the impact of medical school teaching programs in relation to exercise prescription for older people is sparse.

The aims of this study, therefore, were to: (i) determine the level of importance that fifth year medical students attribute to exercise and their perceived competence in prescribing exercise to older people; and (ii) to examine whether the current 4.5-week geriatric medicine course improves medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise.

Methods

Participants and procedures

All fifth year medical students (a six-year undergraduate program) from the University of Adelaide at the Queen Elizabeth Hospital (TQEH) campus in 2015 were invited to participate in this study. An independent researcher administered questionnaires at the commencement and end of the course. Students provided informed consent and were advised that participation was voluntary. All returned questionnaires were confidentially kept in an envelope and processed after the students had completed their course.

Geriatric medicine course

The University of Adelaide Geriatric Medicine Course is a 4.5-week course (Table 1) and is a core component of the fifth year undergraduate medical teaching program. There are six rotations per annum of between 12 and 14 students per rotation. Students are allocated to four teaching campuses – three metropolitan hospitals and a rural clinical school. The clinical course is delivered differently at the four campuses.

Table 1: University of Adelaide Geriatric Medicine 2015 curriculum (adapted from Tam et al.[19])

Tutorials (tutors)	Time commitment in hours (total 28.5 hours)
The topics for the tutorials and the clinical exposure are based on recommendations by the Australian and New Zealand Society for Geriatric Medicine position statement [20]	
Introduction and orientation, distribution of course materials (geriatrician)	0.5
Rehabilitation, Transition Care, Discharge Options, and Day Therapy Services (geriatrician)	1.0
Falls (geriatrician)	1.0
Urinary incontinence in older people (geriatrician)	1.0
Polypharmacy and iatrogenesis (geriatrician)	1.0
Depression in older people (psychogeriatrician)	1.5
Cognition (geriatrician)	
Dementia	4.0
Delirium	
Capacity assessment and legal directives	
Management of behavioural and psychological symptoms of dementia and acute agitation	
Caring for Patients with Dementia (Alzheimer's Australia Consultant)	3.0
Nutrition in older people (geriatrician)	1.0
Osteoporosis and bone health (geriatrician)	1.0
Parkinson's disease in older people (geriatrician)	1.0
Pharmacology in elderly (clinical pharmacist)	1.0
Oral health in older people (dentist)	1.0
Management of dysphagia and dysphasia (speech therapist)	1.0
Physiotherapy assessments, role in Geriatric Medicine and Discharge Planning (physiotherapist)	1.0
Occupational therapy functional, safety and cognitive assessments, discharge planning (occupational therapist)	1.0
Malnutrition and Nutritional Supplements in Elderly (Dietician)	1.0
Elder abuse (Aged Rights Advocacy Service)	1.0
Advance care planning, respecting patient choices (specialist nurse)	1.0
Aged Care Assessment Programs and Community Services (geriatrician and Domiciliary Care Service)	2.5
Campbelltown Keep Fit Class for elderly (Exercise Professional)	1.0
Student presentation and discussions regarding exercise history from consumers (geriatrician and psychologist)	1.0
Physiology of ageing – Brief notes and headings provided to guide student in their study	Self-directed learning

Clinical attachments with preceptors (geriatrician) – Two blocks of 2-week clinical attachments (one preceptor for each 2-week block). End of rotation assessments (MCQs – 50 questions 60 minutes to answer; OSCE – 10 stations 10 minutes per station with immediate feedback included). Student grading for rotation: MCQ 25%; OSCE 25%; first preceptor assessment 25%; second preceptor assessment 25%. MCQ, multiple choice question; OSCE, objective structured clinical examination.

In the TQEH program, there are no specific tutorials focused on exercise prescription, although medical students have exposure to therapy programs, including a compulsory visit to a community-based exercise class where the students interview older people about their participation in exercise and present this to their tutor. Students are also encouraged to read or revise the current physical activity guidelines for older people and an online article about the effects of multifactorial interventions on frailty as part of their self-directed learning. Students are aware that any part of the course can be assessed.

Study questionnaires

The questionnaire included questions to record the students' demographic information, medical students' current physical activity levels (introduced in the third rotation), previous exposure to a geriatric medicine course, their perceptions of the importance of exercise and their perceived competence in prescribing exercise, as well as perceived barriers to exercise prescription faced by medical practitioners in clinical practice.

Medical students' physical activity levels were assessed using the Leisure Score Index (LSI) from the Godin Leisure Time Exercise Questionnaire (GLTEQ), as personal exercise habits are said to correlate positively with physical activity counselling practices [21]. The GLTEQ consists of two questions; however, only question one was applied in this study to determine the amount of physical activity [22,23].

Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise were assessed using the Exercise and Physical Activity Competence Questionnaire (EPACQ). The EPACQ includes six fundamental skills related to exercise prescription and assesses the importance of being able to prescribe exercise, as well as perceived competence in prescribing exercise, according to self-evaluation [24]. Medical students indicated their responses on a six-point Likert scale ranging from 0 (not important or competent) to 6 (very important or competent). The EPACQ was adapted to be relevant to exercise in older people and modified to include four additional items relating to the risks and benefits of exercise, referral to an exercise program and age-related limitations.

Perceived barriers to exercise prescription faced by medical practitioners in clinical practice were assessed via an open-ended question asking the students *In your opinion, what are potential barriers faced by doctors in prescribing exercise for their older patients in everyday practice?*

Statistical analyses

IBM SPSS Version 21 was used to perform the statistical analyses. Associations between a previous attendance of a geriatric medicine course and perceived importance and competence were determined using point biserial correlation. Associations between students' physical activity levels and perceived importance and competence were determined using the Pearson correlation coefficient. A paired t-test was used to determine the difference between responses before and after the course. Descriptive data are presented as mean ± standard deviation (SD). The significance level (alpha) was set at 0.05. Responses to the open-ended question were coded, categorised and underwent an interrater reliability check conducted by an independent researcher [25].

Results

Participants

Eighty-one fifth year medical students attended the Geriatric Medicine Course in 2015 and participated in the study. One student did not complete the importance part of the EPACQ and two students missed one item in the competence questionnaire. About 53% (43 of 81 students) were women. The mean age was 23.4 ± 1.5 years. Twenty-five (31%) students had previously attended a geriatric medicine elective course. Medical students' physical activity levels were available only for 53 students due to the late introduction of this question (i.e. in third rotation). Thirty-seven (70%) students were active and met the current physical activity recommendations for healthy adults.

Perceived importance and competence in prescribing exercise

Analysis revealed that perceived importance of exercise for older people correlated positively with previous attendance of a geriatric medicine course ($P = 0.040$; $r = 0.23$). There was no correlation between previous attendance of a geriatric medicine course and perceived competence in prescribing exercise to older people ($P = 0.079$). There was also no significant correlation between students' personal physical activity levels and their perception of importance ($P = 0.860$) or competence ($P = 0.960$) in prescribing exercise to older people.

Overall, the medical students perceived exercise for older people to be important (4.8 ± 0.7) but reported only moderate competence (3.0 ± 0.6) in prescribing exercise to older people in responses to the initial EPACQ.

Following their participation in the course, the overall perception of the importance of exercise for older people increased significantly ($P < 0.001$) from being important (4.8 ± 0.7) to being highly important (5.0 ± 0.6). Students' perceptions of the importance of designing an exercise prescription ($P = 0.038$), determining the training heart rate ($P = 0.021$) and determining the body mass index ($P < 0.001$), as well as referring an older person for an exercise program ($P = 0.001$) and identifying age-related limitations ($P = 0.029$), improved significantly. Overall perceived competence in prescribing exercise for older people increased significantly ($P < 0.001$) from feeling moderately competent (3.0 ± 0.6) to feeling competent (4.4 ± 0.6).

Students' perceived competence improved significantly across all ten skills listed in the EPACQ ($P < 0.001$).

The largest mean score improvements were shown in the perceived competence of referring an older person to an exercise program (2.0 ± 1.4; $P > 0.001$), designing an exercise prescription (2.0 ± 1.2; $P > 0.001$) and determining the nutritional needs of an older person (2.0 ± 1.3; $P > 0.001$). However, five of the ten competence skills listed in the EPACQ remained below the competence score of 4.0.

Descriptive statistics for both perceived importance and competence in prescribing exercise to older people before and after a geriatric medicine course are shown in Tables 2 and 3.

Perceived barriers to exercise prescription

Seventy-five (93%) students responded to the open-ended question. The barrier to exercise prescription most commonly noted was lack of knowledge ($n = 43$; 57%), including not being aware of available exercise programs and not having the skills to prescribe exercise for older people. Twenty-nine (39%) students identified a lack of patient compliance. Twenty-five (33%) students identified a lack of time as a barrier to exercise prescription in clinical practice. Twelve (16%) students stated that a patient's personal and physical limitations could potentially be a barrier to exercise prescription. Seven (9%) students stated that other health-care professionals might be more qualified to prescribe exercise to older people. Six (8%) students stated that a doctor's perception of the importance of exercise might negatively affect their counselling practice.

Discussion

To the best of our knowledge, this is the first study that specifically examines the effects of a geriatric medicine course on senior medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people.

Three key findings emerged from the study. Firstly, results indicated that senior medical students perceive exercise for older people as important, although they only feel moderately competent to prescribe exercise to older people. Secondly, the geriatric medicine course attended by the medical students contributed to an improved perception of the importance of exercise and self-perceived competence in prescribing exercise to older people. This second finding was further supported by the correlation between previous exposure to geriatric medicine as an elective and perceived importance, indicating that medical students who

Table 2: Medical students' perceived importance in being able to prescribe exercise for older people

Skills		*n*	Minimally important *n* (%)	Moderately important *n* (%)	Important *n* (%)	Precourse Postcourse Mean (SD)	Difference (pre − post) Mean (SD)	*P*-value
Conducting a physical examination to approve an older person to begin an exercise program	Pre	81	3 (4)	14 (17)	64 (79)	5.0 (1.0)	0.0 (0.1)	0.913
	Post	80	1 (1)	4 (5)	75 (94)	5.0 (0.9)		
Determining the maximum heart rate for an older person	Pre	81	7 (9)	47 (58)	27 (33)	4.1 (1.2)	0.1 (0.1)	0.295
	Post	80	5 (6)	18 (23)	57 (71)	4.2 (1.1)		
Calculating the training heart range for an older person	Pre	81	9 (11)	46 (57)	26 (32)	4.0 (1.1)	0.3 (0.1)	0.021*
	Post	80	5 (6)	12 (15)	63 (79)	4.3 (1.0)		
Determining the body mass index for an older person	Pre	81	4 (5)	21 (26)	56 (69)	4.7 (1.0)	0.6 (0.1)	<0.001*
	Post	80	NA	1 (1)	79 (99)	5.3 (0.7)		
Determining the daily caloric and nutritional needs of an older person	Pre	81	3 (4)	18 (22)	60 (74)	5.0 (1.0)	0.2 (0.1)	0.053
	Post	80	1 (1)	2 (3)	77 (96)	5.2 (0.8)		
Designing an exercise prescription including frequency, duration and intensity for an older person	Pre	81	9 (11)	27 (33)	45 (56)	4.4 (1.2)	0.3 (0.1)	0.038*
	Post	80	9 (11)	2 (3)	69 (86)	4.7 (1.2)		
Explaining the benefits of exercise to an older person	Pre	81	NA	8 (10)	73 (90)	5.4 (0.7)	0.1 (0.1)	0.300
	Post	80	NA	NA	80 (100)	5.5 (0.6)		
Explaining the risks of exercise to an older person	Pre	81	1 (1)	12 (15)	68 (84)	5.2 (0.8)	0.2 (0.1)	0.122
	Post	80	NA	NA	80 (100)	5.4 (0.6)		
Referring an older person to an exercise program	Pre	81	2 (3)	19 (23)	60 (74)	5.0 (1.0)	0.3 (0.1)	0.001*
	Post	80	NA	2 (3)	78 (97)	5.3 (0.7)		
Identifying age-related limitations to exercise that may exist in older people	Pre	81	1 (1)	20 (25)	60 (74)	5.0 (0.9)	0.2 (0.1)	0.029*
	Post	80	NA	1 (1)	79 (99)	5.2 (0.7)		
Overall mean score	Pre	81	NA	NA	NA	4.8 (0.7)	0.2 (0.1)	0.001*
	Post	80	NA	NA	NA	5.0 (0.6)		

*Significant $P \leq 0.05$. Skills rated on a scale from 1 (not important) to 6 (very important). Minimally important, <2.0; moderate important, 2.01–3.99; important, ≥4. Data collected January–October 2015 from University of Adelaide fifth year medical students. NA, not applicable; SD, standard deviation.

Table 3: Medical students' perceived competence in prescribing exercise for older people

Skills		*n*	Minimally competent *n* (%)	Moderately competent *n* (%)	Competent *n* (%)	Precourse Postcourse Mean (SD)	Difference (pre − post) Mean (SD)	*P*-value
Conducting a physical examination to approve an older person to begin an exercise program	Pre	81	57 (70)	23 (28)	1 (1)	2.1 (1.0)	1.6 (1.1)	<0.001*
	Post	81	12 (15)	15 (19)	54 (67)	3.7 (1.0)		
Determining the maximum heart rate for an older person	Pre	81	36 (44)	29 (36)	16 (20)	3.0 (1.4)	0.9 (1.3)	<0.001*
	Post	81	13 (16)	14 (17)	54 (67)	3.9 (1.2)		
Calculating the training heart range for an older person	Pre	81	58 (72)	19 (24)	4 (5)	2.1 (1.2)	1.2 (1.4)	<0.001*
	Post	81	21 (26)	28 (35)	32 (40)	3.3 (1.2)		
Determining the body mass index for an older person	Pre	81	4 (5)	24 (30)	53 (65)	4.7 (1.3)	0.8 (1.3)	<0.001*
	Post	80	NA	2 (3)	78 (98)	5.5 (0.7)		
Determining the daily caloric and nutritional needs of an older person	Pre	81	61 (75)	19 (24)	1 (1)	2.0 (1.0)	2.0 (1.3)	<0.001*
	Post	81	12 (15)	10 (12)	59 (73)	4.0 (1.1)		
Designing an exercise prescription including frequency, duration and intensity for an older person	Pre	81	63 (78)	17 (21)	1 (1)	1.8 (0.9)	2.0 (1.2)	<0.001*
	Post	81	12 (15)	11 (14)	58 (72)	3.8 (1.1)		
Explaining the benefits of exercise to an older person	Pre	81	1 (1)	37 (46)	43 (53)	4.5 (0.9)	0.9 (1.0)	<0.001*
	Post	81	NA	NA	81 (100)	5.4 (0.7)		
Explaining the risks of exercise to an older person	Pre	80	12 (15)	46 (58)	22 (28)	3.8 (1.1)	1.2 (1.2)	<0.001*
	Post	81	NA	5 (6)	76 (94)	5.0 (0.9)		
Referring an older person to an exercise program	Pre	81	39 (48)	35 (43)	7 (9)	2.6 (1.2)	2.0 (1.4)	<0.001*
	Post	81	3 (4)	8 (10)	70 (86)	4.6 (1.0)		
Identifying age-related limitations to exercise that may exist in older people	Pre	81	16 (20)	50 (62)	15 (19)	3.4 (1.1)	1.5 (1.3)	<0.001*
	Post	81	NA	2 (3)	79 (98)	4.9 (0.7)		
Overall mean score	Pre	81	NA	NA	NA	3.0 (0.6)	1.4 (0.7)	<0.001*
	Post	81	NA	NA	NA	4.4 (0.6)		

*Significant $P \leq 0.05$. Skills rated on a scale from 1 (not competent) to 6 (very competent). Minimally competent, <2.0; moderate competent, 2.01–3.99; competent, ≥4. Data collected January–October 2015 from University of Adelaide fifth year medical students. NA, not applicable; SD, standard deviation.

previously attended a geriatric medicine course perceive exercise for older people to be more important than students who did not attend a geriatric medicine course. Thirdly, it was confirmed that students perceive that a lack of knowledge acts as the main barrier to prescribing exercise.

The findings in this study are consistent with the findings of Vallance et al. [16] who determined that first to fourth year medical students perceive exercise related prescription to be important (score 4.43 on the EPACQ 6-point Likert scale) while demonstrating only moderate competence (score 3.45 on the EPACQ 6-point Likert scale) in completing an exercise prescription. Vallance et al. [16] and Frank et al. [26] observed that medical students in third and fourth year indicate lower perceived importance of exercise than first and second year students. We were unable to determine whether the same phenomenon existed at our medical school as we only included fifth year students in our study. Furthermore, we had not investigated whether there were differences across our teaching campuses.

Even if senior medical students perceive exercise for older people as important, they only feel moderately competent in prescribing it. The precourse perceived competence scores (mean 3.01 on a 6-point scale) in this study were lower than the results of Vallance et al. [16]. The lower perceptions of competence in prescribing exercise to older people might demonstrate that among senior medical students, exercise and exercise prescription for older people are perceived to be more complex than exercise prescriptions for healthy or younger adults.

The significant impact of the geriatric medicine course on fifth year medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people is consistent with the results from other studies. For example, specific exercise courses during medical school have been shown to significantly increase medical students' beliefs in the importance of exercise and their confidence and ability to counsel healthy adults about exercise [17,18]. Jones et al. [17], for example, investigated the positive effects of just four lectures about exercise medicine on medical students' confidence about advising patients on exercise, while Conroy et al. [18] investigated the impact of a 28-hour course in preventive medicine and nutrition on medical students' ability to assess and counsel about exercise. Although the geriatric medicine course in this study had no specific tutorial focused on exercise prescription, the results of the study indicate that components of the course, such as the interaction with older people who exercise, a visit to a community-based exercise class, reading material related to the physical activity guidelines and the effects of exercise on frailty through self-directed learning, significantly affected medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people. However, the perceived competence scores remained low after the geriatric medicine course and therefore more can be done. Specific tutorials with regard to assessments and exercise prescription for older people are needed to increase medical students' confidence and understanding of exercise prescription for older people. By better understanding the concept of exercise prescription, medical students will be better positioned to encourage and reinforce older people to begin and continue with an exercise program. It is also envisaged that as a direct result of this better understanding, graduating doctors will be more likely to refer older patients to allied health professionals, such as exercise physiologists or physiotherapists who have expertise in exercise prescription. Working as a team and in partnership with the older person, an effective exercise program is more likely to be achieved.

Barriers to exercise prescription identified by students were similar to those identified by Kennedy and Meeuwisse [27] who investigated barriers to exercise counselling by family physicians, as well as Forman-Hoffman et al. [13] who investigated barriers to counselling obese patients about exercise by primary care physicians. Lack of knowledge and the lack of education during medical school were cited as the main barriers to exercise prescription and our study confirmed this. Therefore, strengthening the undergraduate program and providing for continuing professional development are possibly two interventions that could translate to improved participation in exercise by older people. It could be expected that graduating doctors with improved knowledge and greater confidence will be more likely to prescribe exercise, which could result in a larger number of older people being motivated to participate in exercise programs.

The limitations of the present study include the reliance on self-report and that the study was conducted at only one teaching campus.

Conclusion

This study provides first-hand evidence that a geriatric medicine course for senior medical students results in improved perceptions of the importance of exercise and greater perceived competence in prescribing exercise to older people. However, half of the competency skills remained low after the course, suggesting that there is an opportunity to improve the course by including specific tutorials on exercise prescription. We suggest that this will lead to better self-perceived competence scores among medical students, and we plan to investigate this theory in the future. The provision of such evidence might help other academics argue for teaching space relating to this topic in the undergraduate medical student curriculum. Considering our ageing population and the benefits of exercise in older people, such as better health and greater independence, there is an imperative that medical teaching programs assign time and provide the resources necessary to ensure that our graduating doctors are equipped to motivate and counsel older people to participate in exercise.

Acknowledgements

The authors would like to thank Dr Joanne Dollard for conducting the interrater reliability check with the responses to the open-ended question, Dr Olga Theou for providing advice during study preparation and critically reviewing the manuscript and Ms Kylie Lange for assisting with the statistical analysis. The authors declare no conflicts of interest.

References

1 Taylor D. Physical activity is medicine for older adults. *Postgraduate Medical Journal* 2014; 90: 26–32.
2 Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet* 2013; 381: 752–762.
3 Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. *Archives of Internal Medicine* 2006; 166: 418–423.
4 Hallal PC, Andersen LB, Bull FC et al. Global physical activity levels: Surveillance progress, pitfalls, and prospects. *Lancet* 2012; 380: 247–257.
5 World Health Organization. *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Geneva: World Health Organization, 2009.
6 Xue QL. The frailty syndrome: Definition and natural history. *Clinics in Geriatric Medicine* 2011; 27: 1–15.
7 Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. *Preventive Medicine* 2004; 39: 1056–1061.
8 Franco MR, Tong A, Howard K et al. Older people's perspectives on participation in physical activity: A systematic review and thematic synthesis of qualitative literature. *British Journal of Sports Medicine* 2015; 49: 1268–1276.
9 Lawton BA, Rose SB, Elley CR et al. Exercise on prescription for women aged 40–74 recruited through primary care: Two year randomised controlled trial. *British Medical Journal* 2008; 337: a2509.
10 Andersen RE, Blair SN, Cheskin LJ, Bartlett SJ. Encouraging patients to become more physically active: The physician's role. *Annals of Internal Medicine* 1997; 127: 395–400.
11 Phillips EM, Kennedy MA. The exercise prescription: A tool to improve physical activity. *Physical Medicine and Rehabilitation* 2012; 4: 818–825.
12 Glasgow RE, Eakin EG, Fisher EB, Bacak SJ, Brownson RC. Physician advice and support for physical activity: Results from a national survey. *American Journal of Preventive Medicine* 2001; 21: 189–196.
13 Forman-Hoffman V, Little A, Wahls T. Barriers to obesity management: A pilot study of primary care clinicians. *BMC Family Practice* 2006; 7: 35.
14 Weiler R, Chew S, Coombs N, Hamer M, Stamatakis E. Physical activity education in the undergraduate curricula of all UK medical schools: Are tomorrow's doctors equipped to follow clinical guidelines? *British Journal of Sports Medicine* 2012; 46: 1024–1026.
15 Cardinal BJ, Park EA, Kim M, Cardinal MK. If exercise is medicine(R), where is exercise in medicine? Review of U.S. Medical Education Curricula for Physical Activity-Related Content. *Journal of Physical Activity and Health* 2014; 12: 1336–1343.
16 Vallance JK, Wylie M, MacDonald R. Medical students' self-perceived competence and prescription of patient-centered physical activity. *Preventive Medicine* 2009; 48: 164–166.
17 Jones PR, Brooks JH, Wylie A. Realising the potential for an Olympic legacy; teaching medical students about sport and exercise medicine and exercise prescribing. *British Journal of Sports Medicine* 2013; 47: 1090–1094.
18 Conroy MB, Delichatsios HK, Hafler JP, Rigotti NA. Impact of a preventive medicine and nutrition curriculum for medical students. *American Journal of Preventive Medicine* 2004; 27: 77–80.

19 Tam KL, Chandran K, Yu S, Nair S, Visvanathan R. Geriatric medicine course to senior undergraduate medical students improves attitude and self-perceived competency scores. *Australasian Journal on Ageing* 2014; 33: E6–E11.
20 Australian Society for Geriatric Medicine. Position statement no. 4 education and training in geriatric medicine for medical students – revised 2006. *Australasian Journal on Ageing* 2006; 25: 218–222.
21 Lobelo F, Duperly J, Frank E. Physical activity habits of doctors and medical students influence their counselling practices. *British Journal of Sports Medicine* 2009; 43: 89–92.
22 Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. *Canadian Journal of Applied Sport Sciences* 1985; 10: 141–146.
23 Godin G. The Godin-Shephard Leisure-Time Physical Activity Questionnaire. *Health and Fitness Journal of Canada* 2011; 4: 18–21.
24 Connaughton AV, Weiler RM, Connaughton DP. Graduating medical students' exercise prescription competence as perceived by deans and directors of medical education in the United States: Implications for Healthy People 2010. *Public Health Reports* 2001; 116: 226–234.
25 Joffe H, Yardley L. Content and thematic analysis. In: Marks DF, Yardley L, eds. *Research Methods for Clinical and Health Psychology*. London: Sage Publications Ltd., 2004: 56–68.
26 Frank E, Galuska DA, Elon LK, Wright EH. Personal and clinical exercise-related attitudes and behaviors of freshmen U.S. medical students. *Research Quarterly for Exercise and Sport* 2004; 75: 112–121.
27 Kennedy MF, Meeuwisse WH. Exercise counselling by family physicians in Canada. *Preventive Medicine* 2003; 37: 226–232.

Appendix 5

Statement of Authorship and accepted manuscript (Chapter 6)

Educating medical students in counselling older adults about exercise: the impact of a physical activity module

Statement of Authorship

Title of Paper	Educating medical students in counselling older adults about exercise: the impact of a physical activity module
Publication Status	☐ Published ☑ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Jadczak AD, Tam KL, Visvanathan R. Educating medical students in counselling older adults about exercise: the impact of a physical activity module. The Journal of Frailty and Aging. Accepted for publication on 19 September 2017.

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak		
Contribution to the Paper	Designed survey, development and conducted intervention, collected all data, constructed study database, performed statistical data analyses, wrote manuscript, and acted as corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	09/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Khai Loon Tam		
Contribution to the Paper	Edited manuscript and facilitated data collection.		
Signature		Date	9/10/17

Name of Co-Author	Renuka Visvanathan		
Contribution to the Paper	Supervised development of work, edited manuscript and provided input in regards to data interpretation and manuscript evaluation.		
Signature		Date	16/10/17

The Journal of Frailty & Aging©

ORIGINAL PAPER

EDUCATING MEDICAL STUDENTS IN COUNSELLING OLDER ADULTS ABOUT EXERCISE: THE IMPACT OF A PHYSICAL ACTIVITY MODULE

A.D. JADCZAK[1,2,3], K.L. TAM[1,2], R. VISVANATHAN[1,2,3]

1. Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Adelaide Medical School, Faculty of Health and Medical Sciences, University of Adelaide, South, Australia, Australia; 2. Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide, South Australia, Australia; 3. National Health and Medical Research Council Centre of Research Excellence Frailty and Healthy Ageing, University of Adelaide, South Australia, Australia
Corresponding author: Agathe Daria Jadczak, Aged & Extended Care Services - The Queen Elizabeth Hospital, 28 Woodville Road, Woodville South, South Australia 5011, Australia, Tel: +61 8 8133 4012; Fax: +61 8 8222 7872; Email: agathedaria.jadczak@adelaide.edu.au

Abstract: *Background:* Exercise courses during medical school contribute to medical students' confidence in promoting physical activity to their patients. However, there is still a lack of uniform physical activity education across medical school curricula to equip medical students with the necessary skills and knowledge to counsel their patients about exercise. *Objective:* To determine the effects of a 1.5-hour physical activity module including a one-hour exercise tutorial combined with a 30-minute practical counselling session on senior medical students' perceptions of the importance of exercise and their perceived competence in advising older people about exercise. *Design:* Pre-post survey. *Setting:* University campus. *Participants:* 161 senior medical students taking part in the Queen Elizabeth Hospital Geriatric Medicine course in 2015 (control group) and 2016 (intervention group). *Measurement:* The modified Exercise and Physical Activity Competence Questionnaire (EPACQ) was administered before and after a 4.5-week Geriatric Medicine Course. Scores ranged from 1 (not important or competent) to 6 (very important or competent). The independent T-Test and repeated-measures ANOVA was used to determine differences between intervention and control group. *Results:* Medical students perceived exercise-related skills to be highly important (score ≥4) in both the intervention (4.85 ± 0.37) and control group (4.78 ± 0.67), pre-course. The overall perceived importance could not be significantly increased by the physical activity module (P=0.082). The physical activity module, however, improved medical students' perceived competence in six out of ten exercise-related skills, and increased their overall perceived competence in counselling older people about exercise (P<0.001). *Conclusion:* A 1.5-hour physical activity module improves senior medical students' perceived competence in counselling older people about exercise. This research proves that little teaching space is needed to impact positively on medical students' exercise counselling abilities.

Key words: Physical activity training, medical education, older adults, competence, medical students.

J Frailty Aging 2017;in press
Published online inpress

Introduction

Exercise helps to maintain and restore muscle strength, and reduce the risk of falls and fractures in older people. Frailty, a geriatric syndrome prevalent in clinical practice, as well as falls and fractures threaten the independence of older people, and contribute to a reduced quality of life (2-4). Older people prefer to live in their own homes for as long as possible (5). Therefore, any strategy that might help older people achieve their goals should be actively supported.

Educational programs that ensure that graduating doctors are better placed to promote the uptake of exercise by older people might be one such strategy. Furthermore, with the ageing population, more comprehensive geriatric education programs in medical schools are required if a skilled medical workforce able to cater to the needs of older citizens is to be developed (6). And because older people tend to hold their doctors in high regard, doctors must play a key role in educating older patients about the importance of exercise, and encouraging them to participate in physical activity (PA) programs (2, 7).

In spite of its importance, exercise is not meaningly included in many undergraduate medical curricula (8). A recent review of US medical curricula, for example, suggests that over half of the medical students trained in the United States receive no formal education about exercise (9). Similar findings have also been noted in the United Kingdom (8). Many doctors, not surprisingly, cite the lack of education during medical school as the main barrier for them not counselling their patients about exercise (10).

Even when it is included in the curricula, there is a gap in the delivery of exercise-oriented courses. A recent evaluation of PA training in the curricula of Australian medical schools revealed that while most medical schools report including PA training in their curricula, the quality of content is variable, with key topics, such as the national strength recommendations, missing (11). We know that there is considerable heterogeneity in teaching methods, duration and placement within medical school curricula with regards to PA training (12). Research evidence as to what works and what does not is limited, especially where it relates to older individuals.

We have previously reported that a dedicated 4.5-week geriatric medicine course for senior medical students improved students' perception of the importance of prescribing exercise to older people (13). In relation to their perceived competence,

Received August 17, 2017
Accepted for publication September 19, 2017

however, although improvements were noted across all PA counselling-related skills, students still perceived not being competent in performing half of the listed skills following the course.

As a result of these findings, we introduced a PA module including a one hour exercise tutorial combined with a 30 minute practical counselling session. The aim of this study was to determine the effect of this course improvement on medical students' perceived importance and competence in advising older people about exercise.

Methods

Participants

All University of Adelaide 5th year medical students taking part in the Queen Elizabeth Hospital (TQEH) Geriatric Medicine course in 2015 (control group) and 2016 (intervention group) were invited to participate in this study. The Geriatric Medicine Course is a 4.5 week core component course of the 5th year medical teaching program and includes six rotations of 12 to 14 medical students per annum, resulting in approximately 80 students per year. We previously described the structure of the Geriatric Medicine Course in 2015 (13).

Consent and ethics

Students were advised that participation was voluntary and provided informed consent. The study received ethics approval from the University of Adelaide Human Research Ethics Committee (ethics approval number H-2015-001).

Physical activity module

In 2015, there were no specific tutorials focused on exercise prescription, although medical students did have access to therapy programs, including a community based exercise class with the opportunity to interview older people about their exercise experience. Students were also encouraged to read the current exercise recommendations for older people and a research article on the effects of multi-component exercise interventions on frailty.

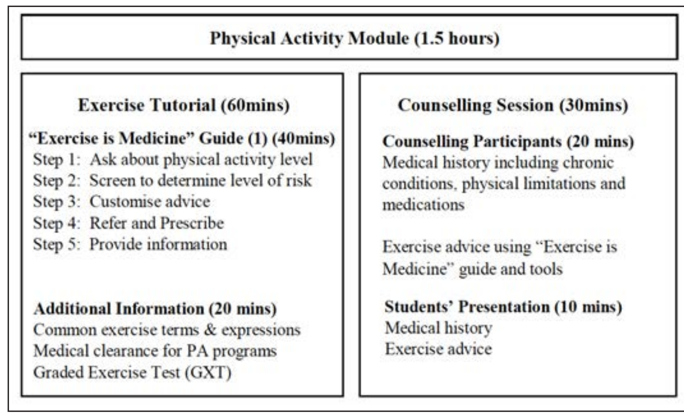
In 2016, a one hour tutorial was introduced to the course by an exercise physiologist and researcher at TQEH. The tutorial included topics relevant to exercise and older people, and was based on information and tools provided by Exercise is Medicine, a global health initiative managed by the American College of Sports Medicine (ACSM). The Exercise is Medicine initiative focuses on motivating health care professionals to include exercise when discussing treatment options with their patients (14). Core components of the one hour tutorial included information and tools on:

- How to assess the physical activity level of an older patient
- How to do a safety screening and identify risk factors
- How to motivate an older patient and determine their readiness to change
- How to write an exercise prescription
- How to provide medical clearance for exercise programs

Students had the opportunity to use the provided tools following a community-based exercise class, counsel the older participants about PA, and present their results to their tutors. The content of the PA module in this study is displayed in Figure 1.

Figure 1

Content of the physical activity module



Study questionnaires

Study questionnaires were handed out pre- and post-course. All returned forms were kept in a sealed envelope and only opened after the students had finished their course.

The study questionnaire included medical students' date of birth, gender, current physical activity level, and previous attendance of a geriatric medicine course.

The physical activity levels were assessed using the Godin Leisure Time Exercise Questionnaire (15, 16). The Exercise and Physical Activity Competence Questionnaire (EPACQ) was used to examine medical students' perceived importance and competence in prescribing exercise to older people (17). The EPACQ is a self-evaluation questionnaire including six skills related to exercise prescription with responses being graded on a Likert scale ranging from 1 (not important or competent) to 6 (very important or competent) (17). A score of ≥4 indicated perceived competence or importance and was considered as satisfactory. The EPACQ was modified to address older people and four additional items were included in relation to the risks and benefits of exercise, the referral to exercise and the identification of age-related limitations.

Statistical analyses

IBM SPSS Statistics Version 24 was used to perform the statistical analyses. Associations between a previous attendance of a geriatric medicine course and perceived importance and competence were determined using point biserial correlation. Associations between students' personal physical activity levels and perceived importance and competence were determined using the Pearson correlation coefficient. The independent

Table 1
Medcial students' baseline characteristics pre-course

Characteristic	Intervention Group (n=80)	Control Group (n=81)	P-Value IG vs CG
Age	23.39 ± 1.43	23.37 ± 1.48	0.917
Gender	41 ♂ (51.2%)	43 ♂ (53.0%)	0.881
Previous Course	n=27 (33.7%)	n=25 (30.9%)	0.657
Physical Active	n=60 (75.0%)	n=43 (81.1%)[1]	0.551
Overall Importance	4.85 ± 0.37	4.78 ± 0.67	0.737
Conducting a physical examination	5.01 ± 0.80	5.01 ± 0.98	0.997
Determining the maximum heart rate	4.22 ± 1.14	4.05 ± 1.15	0.391
Calculating the training heart range	4.22 ± 1.15	3.95 ± 1.13	0.124
Determining the body mass index	4.92 ± 0.85	4.74 ± 1.02	0.224
Determining the nutritional needs	5.08 ± 0.88	5.03 ± 1.05	0.622
Designing an exercise prescription	4.69 ± 1.14	4.44 ± 1.28	0.160
Explaining the benefits of exercise	5.23 ± 0.77	5.38 ± 0.70	0.195
Explaining the risks of exercise	5.18 ± 0.82	5.24 ± 0.83	0.607
Referring an older person to exercise	4.90 ± 0.88	4.99 ± 1.01	0.496
Identifying limitations to exercise	5.09 ± 0.72	5.05 ± 0.89	0.829
Overall Competence	2.94 ± 0.96	3.00 ± 0.64	0.870
Conducting a physical examination	2.13 ± 0.93	2.10 ± 1.00	0.856
Determining the maximum heart rate	3.09 ± 1.44	3.00 ± 1.41	0.695
Calculating the training heart range	2.23 ± 1.21	2.09 ± 1.15	0.452
Determining the body mass index	4.77 ± 1.22	4.73 ± 1.28	0.731
Determining the nutritional needs	2.25 ± 1.13	2.04 ± 0.99	0.200
Designing an exercise prescription	1.78 ± 0.93	1.85 ± 0.95	0.653
Explaining the benefits of exercise	4.10 ± 1.13	4.48 ± 0.96	0.023*
Explaining the risks of exercise	3.43 ± 1.10	3.78 ± 1.06	0.046*
Referring an older person to exercise	2.44 ± 1.23	2.62 ± 1.25	0.375
Identifying limitations to exercise	3.15 ± 1.06	3.43 ± 1.15	0.112

1. data was only available for 53 students; *significant ($p \leq 0.05$)

T-test and repeated-measures ANOVA was used to determine differences between the intervention group and control group pre- and post-course. Descriptive data is presented as mean ± standard deviation (SD). The significance level was set at $\alpha \leq 0.05$.

Results

Participants

The questionnaire was administered to 161 5th year medical students in 2015 (control group [CG]; n=81) and 2016 (intervention group [IG]; n=80). The mean age was 23.4±1.45 years and 52.5% of the students (n=84) were female. Over one-third of the students (n=52; 32.5%) had previously attended a geriatric medicine elective course and the majority of the students (n=103; 78.6%) were active according to the physical activity recommendations for healthy adults. Baseline characteristics between the two cohorts were no different except for the CG reported feeling more competent in explaining the risks (P=0.046) and benefits (P=0.023) of exercise to an older person compared to the IG (Table 1).

Students' perceived importance in prescribing exercise to older people

The previous attendance of a geriatric medicine course correlated positively (P=0.040; r=0.23) with medical students' perceived importance of being able to prescribe exercise to older people in the CG. No correlations could be found in the

Table 2
Effects of a physical activity module on medical students' importance

EPACQ Item		Intervention Group (n=80)	Important ≥4 n (%)		Control Group (n=81)	Important ≥4 n (%)	P-Value IG vs CG
Conducting a physical examination to approve exercise	Pre	5.01 ± 0.80	74 (92.5)	Pre	5.01 ± 0.98	75 (92.3)	0.056
	Post	5.32 ± 0.83	75 (93.8)	Post	5.03 ± 0.92	75 (92.3)	
	Change	0.3 ± 1.0		Change	0.0 ± 1.0		
	P-Value	0.005*		P-Value	0.913		
Determining the maximum heart rate for an older person	Pre	4.22 ± 1.14	57 (71.3)	Pre	4.05 ± 1.15	57 (70.4)	0.040*
	Post	4.75 ± 1.06	70 (87.5)	Post	4.19 ± 1.09	57 (70.4)	
	Change	0.5 ± 1.3		Change	0.1 ± 1.2		
	P-Value	<0.001*		P-Value	0.295		
Calculating the training heart range for an older person	Pre	4.22 ± 1.15	57 (71.3)	Pre	3.95 ± 1.13	56 (69.1)	0.238
	Post	4.77 ± 1.01	70 (87.5)	Post	4.28 ± 1.04	63 (77.8)	
	Change	0.6 ± 1.3		Change	0.3 ± 1.2		
	P-Value	<0.001*		P-Value	0.021*		
Determining the body mass index for an older person	Pre	4.92 ± 0.85	76 (95.0)	Pre	4.74 ± 1.02	72 (88.9)	0.931
	Post	5.52 ± 0.70	78 (97.5)	Post	5.33 ± 0.74	79 (97.5)	
	Change	0.6 ± 1.0		Change	0.6 ± 1.2		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the caloric needs of an older person	Pre	5.08 ± 0.88	75 (93.8)	Pre	5.03 ± 1.05	73 (90.1)	0.656
	Post	5.24 ± 0.72	78 (97.5)	Post	5.26 ± 0.83	77 (95.1)	
	Change	0.2 ± 0.9		Change	0.2 ± 1.1		
	P-Value	0.107		P-Value	0.053		
Designing an exercise prescription for an older person	Pre	4.69 ± 1.14	68 (85.0)	Pre	4.44 ± 1.28	63 (77.8)	0.123
	Post	5.32 ± 0.76	77 (96.3)	Post	4.76 ± 1.26	69 (85.2)	
	Change	0.6 ± 1.2		Change	0.3 ± 1.4		
	P-Value	<0.001*		P-Value	0.038*		
Explaining the benefits of exercise to an older person	Pre	5.23 ± 0.77	75 (93.8)	Pre	5.38 ± 0.70	80 (98.8)	0.087
	Post	5.53 ± 0.70	77 (96.3)	Post	5.46 ± 0.59	80 (98.8)	
	Change	0.3 ± 0.9		Change	0.1 ± 0.8		
	P-Value	0.002*		P-Value	0.300		
Explaining the risks of exercise to an older person	Pre	5.18 ± 0.82	75 (93.8)	Pre	5.24 ± 0.83	79 (97.5)	0.163
	Post	5.51 ± 0.68	77 (96.3)	Post	5.39 ± 0.62	80 (98.8)	
	Change	0.3 ± 0.8		Change	0.2 ± 0.9		
	P-Value	<0.001*		P-Value	0.122		
Referring an older person to an exercise program	Pre	4.90 ± 0.88	73 (91.3)	Pre	4.99 ± 1.01	74 (91.4)	0.647
	Post	5.28 ± 0.75	76 (95.0)	Post	5.33 ± 0.72	78 (96.3)	
	Change	0.4 ± 0.9		Change	0.3 ± 0.9		
	P-Value	<0.001*		P-Value	0.001*		
Identifying age-related limitations to exercise in an older person	Pre	5.09 ± 0.72	76 (95.0)	Pre	5.05 ± 0.89	78 (96.3)	0.890
	Post	5.32 ± 0.76	76 (95.0)	Post	5.26 ± 0.74	79 (97.5)	
	Change	0.2 ± 0.8		Change	0.2 ± 0.9		
	P-Value	0.013*		P-Value	0.029*		
Overall importance	Pre	4.85 ± 0.37	73 (91.3)	Pre	4.78 ± 0.67	72 (88.9)	0.082
	Post	5.25 ± 0.28	77 (96.3)	Post	5.02 ± 0.57	78 (96.3)	
	Change	0.4 ± 0.6		Change	0.2 ± 0.1		
	P-Value	<0.001*		P-Value	0.001*		

IG. There was also no significant correlation between students' personal physical activity levels and their perceived importance in either CG or IG.

Before the course, overall students' perceived importance of being able to prescribe exercise to older people was high (score ≥4) in both the IG (4.85±0.37) and the CG (4.78±0.67). In regards to the proportion of the students, 91.3% (n=73 out of 80) of the IG and 88.9% (n=72 out of 81) of the CG perceived the PA related skills as important (score ≥4).

The PA module significantly improved medical students' perceived importance in nine out of ten skills, while only five out of ten skills significantly improved in the CG (Table 2).

Compared to the initial geriatric course, the PA module presented to the IG only significantly improved the perceived importance of determining the maximal heart rate of an older person (IG 4.75±1.06 vs CG 4.19±1.09; P=0.040).

Table 3
Effects of a physical activity module on medical students' competence

EPACQ Item		Intervention Group (n=80)	Competent ≥4 n (%)		Control Group (n=81)	Competent ≥4 n (%)	P-Value IG vs CG
Conducting a physical examination to approve exercise	Pre	2.13 ± 0.93	6 (7.5)	Pre	2.10 ± 1.00	9 (11.1)	0.001*
	Post	4.39 ± 0.94	68 (85.0)	Post	3.73 ± 0.97	54 (66.7)	
	Change	2.3 ± 1.2		Change	1.6 ± 1.1		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the maximum heart rate for an older person	Pre	3.09 ± 1.44	31 (38.8)	Pre	3.00 ± 1.41	30 (37.0)	<0.001*
	Post	4.94 ± 0.94	74 (92.5)	Post	3.91 ± 1.24	54 (66.7)	
	Change	1.8 ± 1.6		Change	0.9 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Calculating the training heart range for an older person	Pre	2.23 ± 1.21	11 (13.8)	Pre	2.09 ± 1.15	9 (11.1)	<0.001*
	Post	4.71 ± 0.92	73 (91.3)	Post	3.27 ± 1.18	32 (39.5)	
	Change	2.5 ± 1.4		Change	1.2 ± 1.4		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the body mass index for an older person	Pre	4.77 ± 1.22	67 (83.8)	Pre	4.73 ± 1.28	66 (81.5)	0.889
	Post	5.51 ± 0.75	76 (95.0)	Post	5.49 ± 0.72	78 (96.3)	
	Change	0.7 ± 1.3		Change	0.8 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Determining the caloric needs of an older person	Pre	2.25 ± 1.13	14 (17.5)	Pre	2.04 ± 0.99	9 (11.1)	0.747
	Post	4.11 ± 1.07	60 (75.0)	Post	3.96 ± 1.07	59 (72.8)	
	Change	1.9 ± 1.2		Change	1.9 ±1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Designing an exercise prescription for an older person	Pre	1.78 ± 0.93	4 (5.0)	Pre	1.85 ± 0.95	5 (6.2)	<0.001*
	Post	5.10 ± 0.81	76 (95.0)	Post	3.81 ± 1.14	58 (71.6)	
	Change	3.3 ± 1.2		Change	2.0 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Explaining the benefits of exercise to an older person	Pre	4.10 ± 1.13	54 (67.5)	Pre	4.48 ± 0.96	67 (82.7)	0.056
	Post	5.34 ± 0.64	78 (97.5)	Post	5.38 ± 0.66	81 (100.0)	
	Change	1.2 ± 1.2		Change	0.9 ± 1.0		
	P-Value	<0.001*		P-Value	<0.001*		
Explaining the risks of exercise to an older person	Pre	3.43 ± 1.10	34 (42.5)	Pre	3.78 ± 1.06	52 (64.2)	0.065
	Post	5.01 ± 0.76	76 (95.0)	Post	4.98 ± 0.92	76 (93.8)	
	Change	1.6 ± 1.4		Change	1.2 ± 1.2		
	P-Value	<0.001*		P-Value	<0.001*		
Referring an older person to an exercise program	Pre	2.44 ± 1.23	15 (18.8)	Pre	2.62 ± 1.25	18 (22.2)	0.003*
	Post	5.10 ± 0.80	76 (95.0)	Post	4.60 ± 1.05	70 (86.4)	
	Change	2.7 ± 1.4		Change	2.0 ± 1.4		
	P-Value	<0.001*		P-Value	<0.001*		
Identifying age-related limitations to exercise in an older person	Pre	3.15 ± 1.06	31 (38.8)	Pre	3.43 ± 1.15	40 (49.4)	0.032*
	Post	5.10 ± 0.72	78 (97.5)	Post	4.94 ± 0.74	79 (97.5)	
	Change	1.9 ± 1.3		Change	1.5 ± 1.3		
	P-Value	<0.001*		P-Value	<0.001*		
Overall competence	Pre	2.94 ± 0.96	4 (5.0)	Pre	3.00 ± 0.64	8 (9.9)	<0.001*
	Post	4.93 ± 0.42	78 (97.5)	Post	4.40 ± 0.62	66 (81.5)	
	Change	2.0 ± 0.8		Change	1.4 ± 0.7		
	P-Value	<0.001*		P-Value	<0.001*		

However, there was an upward trend for medical students' perceived importance in being able to conduct a physical examination (IG 5.32±0.83 vs CG 5.03±0.92; P=0.056), explain the benefits of exercise (IG 5.53±0.70 vs CG 5.46±0.59; P=0.087), as well as medical students' overall perceived importance (IG 5.25±0.28 vs CG 5.02±0.57; P=0.082).

After the amended course in 2016, 96.3% of the IG (n=77 out of 80) perceived PA-related skills in advising older people about exercise as important (score ≥4), exactly the same percentage as the CG (n=78 out of 81). This was an increase of 5.0% (n=4) in the IG and 7.4% (n=6) in the CG.

Students' perceived competence in prescribing exercise to older people

No correlations could be found between medical students' perceived competence and their previous attendance of a geriatric medicine course or their personal physical activity levels for students in either the IG or the CG.

Before the course, overall medical students' perceived competence in prescribing exercise to older people was low (score <4) in both, IG (2.94±0.96) and CG (3.00±0.64). Only 5.0% (n=4 out of 80) of the students in the IG and 9.9% (n=8 out of 81) of the students in the CG perceived themselves as being competent (score ≥4) in advising older people about exercise.

The initial geriatric medicine course in the CG, as well as the PA module in the IG, significantly improved medical students' perceived competence across all ten skills (Table 3). However, despite these significant improvements, medical students in the CG still did not feel competent in performing half of the skills listed in the EPACQ (score <4), while students attending the PA module perceived themselves to be competent across all domains (score ≥4).

Compared to the initial geriatric course in the CG, the PA module significantly improved the students' perceived competence in six out of ten skills (P>0.050), as well as their overall perceived competence (P<0.001). There was also an upward trend for medical students' perceived competence in explaining the risks of exercise (IG 5.01±0.76 vs CG 4.98±0.92; P=0.065) to an older person.

After the course in 2016, containing the PA module, 97.5% (n=78 out of 80) of the students in the IG perceived themselves as being competent (score ≥4) in advising older people about exercise, an increase of 92.5% (n=74). Among the CG, 81.5% (n=66 out of 81) of the students perceived themselves being competent (score ≥4), an increase of 71.6% (n=58).

Discussion

The key finding from this study is that a short 1.5 hour PA module introduced to senior medical students, including a one hour exercise tutorial combined with a 30 minute practical counselling session increased medical students' perceived competence in prescribing exercise to older people.

The fact that PA training during medical school has a positive effect on medical students' perceived competence and confidence in advising their patients about PA has been shown for almost three decades (12, 18, 19). A recent systematic review examining the effects of PA training in medical school education confirmed positive changes in students' attitudes toward PA, their PA counselling knowledge and skills, and their confidence to counsel. However, a considerable heterogeneity of teaching methods, duration, and placement within the curriculum was noted and weak research designs limited an optimal evaluation of effectiveness (i.e., few pre-/post-intervention, and/or control comparisons) (12).

This study used an exercise theory tutorial combined with a practical session to not only provide the students with information about the background of PA counselling, but to also offer them practical experience to increase their confidence in advising older people about exercise. Similar teaching methods have been used effectively by other studies, like Mohler et al. (2010) and Bass et al. (2004) (20, 21). In regards to the content of the PA module, it was based on the Exercise is Medicine initiative, which includes quick and simple tools for health care professionals to assist with exercise prescription, as well as behavioural strategies and steps to ensure patients receive the most effective and personalized advice (14). Similar content, including the 5 A's (ask, advise, assess, assist, arrange) of the behavioural change model for chronically ill patients (22), for example, has also proved effective in other studies (12, 23).

In regards to the effectiveness of shorter PA interventions, Mohler et al. (2010) demonstrated that a two hour mandatory interactive educational offering improved medical students' attitudes and awareness of the importance of healthy ageing using an end-of-session evaluation form that was developed for the purpose of the study. The PA training included two theory sessions on PA combined with two counselling sessions between the students and a mentor (20). Bass et al. (2004) confirmed that a two hour interactive lecture and two 15 minute PA counselling practices with a patient significantly improved first year medical students' knowledge, attitudes and confidence in PA counselling using a 13 item pre- and post-knowledge questionnaire that was developed for the purpose of the study (21). In contrast, the present study did not only provide students a practical counselling session with elderly participants, but also distributed a validated pre- and post-questionnaire that had been used in several studies before (17, 24, 25). Our study has, however, only assessed for perceived competence and it remains to be determined if actual competence is improved through this course. It also remains to be determined if this perception is sustained and if it truly translates into changed clinical practice.

This study provides evidence using a rigorous study design (pre/post survey and control group) that only a small teaching space (1.5 hours) is needed to significantly improve medical students' perceived competence in prescribing exercise to older people. Considering the curriculum space for PA training in medical schools across Australia, for example, which was reported to be between 5.0 and 12.3 hours (11), the implementation of a short PA module as described in this study may be feasible.

The limitations of this study were that the survey was conducted at only one teaching campus and at one university, and so the results may not be generalizable.

Conclusion

Considering the benefits of exercise to older people, medical curricula need to ensure quality teaching content on this topic so that the needs of older people in our ageing society can be better met. This study provides evidence that a 1.5 hour PA module presented to senior medical students improves their perceived competence in counselling older people about exercise. It is important that this research is replicated elsewhere to confirm generalisability. Future research should focus on the effectiveness of such programs in improving competency and sustaining these improvements to ensure changed clinical practice in the long term.

Conflict of interest: None declared by the authors.

References

1. Exercise is Medicine. Healthcare Providers' Action Guide [PDF]. Indianapolis: American College of Sports Medicine; 2017 [cited 2017/30/5]. Available from: http://www.exerciseismedicine.org/assets/page_documents/Complete%20HCP%20Action%20Guide.pdf
2. Taylor D. Physical activity is medicine for older adults. Postgrad Med J 2014;90(1059):26-32.
3. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381(9868):752-62.
4. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-23.
5. Elwyn G, Williams M, Roberts C, Newcombe RG, Vincent J. Case management by nurses in primary care: analysis of 73 'success stories'. Qual Prim Care 2008;16(2):75-82.
6. Lucchetti AL, Lucchetti G, de Oliveira IN, Moreira-Almeida A, da Silva Ezequiel O. Experiencing aging or demystifying myths? - impact of different «geriatrics and gerontology» teaching strategies in first year medical students. BMC Med Educ 2017;17(1):35.
7. Lawton BA, Rose SB, Elley CR, Dowell AC, Fenton A, Moyes SA. Exercise on prescription for women aged 40-74 recruited through primary care: two year randomised controlled trial. BMJ 2008;337:a2509.
8. Weiler R, Chew S, Coombs N, Hamer M, Stamatakis E. Physical activity education in the undergraduate curricula of all UK medical schools: are tomorrow's doctors equipped to follow clinical guidelines? Br J Sports Med 2012;46(14):1024-6.
9. Cardinal BJ, Park EA, Kim M, Cardinal MK. If Exercise is Medicine, Where is Exercise in Medicine? Review of U.S. Medical Education Curricula for Physical Activity-Related Content. J Phys Act Health 2015;12(9):1336-43.
10. Forman-Hoffman V, Little A, Wahls T. Barriers to obesity management: a pilot study of primary care clinicians. BMC Fam Pract 2006;7:35.
11. Strong A, Stoutenberg M, Hobson-Powell A, Hargreaves M, Beeler H, Stamatakis E. An evaluation of physical activity training in Australian medical school curricula. J Sci Med Sport 2017;20(6):534-8.
12. Dacey ML, Kennedy MA, Polak R, Phillips EM. Physical activity counseling in medical school education: a systematic review. Med Educ Online 2014;19:.24325.
13. Jadczak AD, Tam KL, Yu S, Visvanathan R. Medical students' perceptions of the importance of exercise and their perceived competence in prescribing exercise to older people. Australas J Ageing 2017; doi: 10.1111/ajag.12412. [Epub ahead of print].
14. American College of Sports Medicine. Exercise is Medicine 2017 [30 May 2017]. Available from: http://www.exerciseismedicine.org/.
15. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. Can J Appl Sport Sci 1985;10(3):141-6.
16. Godin G. The Godin-Shephard Leisure-Time Physical Activity Questionnaire. Health & Fitness Journal of Canada 2011;4(1):5.
17. Connaughton AV, Weiler RM, Connaughton DP. Graduating medical students' exercise prescription competence as perceived by deans and directors of medical education in the United States: implications for Healthy People 2010. Public Health Rep 2001;116(3):226-34.
18. Young A, Gray JA, Ennis JR. 'Exercise medicine': the knowledge and beliefs of final-year medical students in the United Kingdom. Med Educ 1983;17(6):369-73.
19. Jones PR, Brooks JH, Wylie A. Realising the potential for an Olympic legacy; teaching medical students about sport and exercise medicine and exercise prescribing. Br J Sports Med 2013;47(17):1090-4.
20. Mohler MJ, D'Huyvetter K, Tomasa L, O'Neill L, Fain MJ. Healthy aging rounds: using healthy-aging mentors to teach medical students about physical activity and social support assessment, interviewing, and prescription. J Am Geriatr Soc 2010;58(12):2407-11.
21. Bass Iii PF, Stetson BA, Rising W, Wesley GC, Ritchie CS. Development and Evaluation of a Nutrition and Physical Activity Counseling Module for First-Year Medical Students. Med Educ Online 2004;9(1):4359.
22. Glasgow RE, Emont S, Miller DC. Assessing delivery of the five 'As' for patient-centered counseling. Health Promot Int 2006;21(3):245-55.
23. Trilk JL, Phillips EM. Incorporating 'Exercise is Medicine' into the University of South Carolina School of Medicine Greenville and Greenville Health System. Br J Sports Med 2014;48(3):165-7.
24. Vallance JK, Wylie M, MacDonald R. Medical students' self-perceived competence and prescription of patient-centered physical activity. Prev Med 2009;48(2):164-6.
25. Lamarche K, Vallance J. Prescription for physical activity a survey of Canadian nurse practitioners. Can Nurse 2013;109(8):22-6.

Appendix 6

Statement of Authorship and published manuscript (Chapter 7)

The feasibility of standardised geriatric assessment tools and physical exercises in frail older adults

Statement of Authorship

Title of Paper	The feasibility of standardised geriatric assessment tools and physical exercises in frail older adults
Publication Status	☐ Published ☑ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Jadczak AD, Mahajan N, Visvanathan R. The feasibility of standardised geriatric assessment tools and physical exercises in frail older adults. The Journal of Frailty and Aging. Accepted for publication on 31 July 2017.

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak
Contribution to the Paper	Developed study concept and design, collected data, supervised students, performed data analyses, wrote manuscript, and acted as corresponding author.
Overall percentage (%)	85%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 09/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Neha Mahajan
Contribution to the Paper	Contributed to study design, implementation of the study, data interpretation and manuscript evaluation.
Signature	Date 6th Oct '17

Name of Co-Author	Renuka Visvanathan
Contribution to the Paper	Supervised development of work, contributed to study design, implementation of the study, data interpretation and manuscript evaluation.
Signature	Date 16/10/17

BRIEF REPORT

THE FEASIBILITY OF STANDARDISED GERIATRIC ASSESSMENT TOOLS AND PHYSICAL EXERCISES IN FRAIL OLDER ADULTS

A.D. JADCZAK[1,2,3], N. MAHAJAN[1], R. VISVANATHAN[1,2,3]

1. Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Discipline of Medicine, Adelaide Medical School, University of Adelaide, South Australia, Australia; 2. Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide, South Australia, Australia; 3. National Health and Medical Research Council Centre of Research Excellence Frailty and Healthy Ageing, University of Adelaide, South Australia, Australia
Corresponding author: Agathe Daria Jadczak, Aged & Extended Care Services - The Queen Elizabeth Hospital, 28 Woodville Road, Woodville South, South Australia 5011, Australia, Tel: +61 8 8133 4012; Fax: +61 8 8222 7872; Email: agathedaria.jadczak@adelaide.edu.au

Abstract: Geriatric assessment tools are applicable to the general geriatric population; however, their feasibility in frail older adults is yet to be determined. The study aimed to determine the feasibility of standardised geriatric assessment tools and physical exercises in hospitalised frail older adults. Various assessment tools including the FRAIL Screen, the Charlson Comorbidity Index, the SF-36, the Trail Making Test (TMT), the Rapid Cognitive Screen, the Self Mini Nutritional Assessment (MNA-SF) and the Lawton iADL as well as standard physical exercises were assessed using observational protocols. The FRAIL Screen, MNA-SF, Rapid Cognitive Screen, Lawton iADL and the physical exercises were deemed to be feasible with only minor comprehension, execution and safety issues. The TMT was not considered to be feasible and the SF-36 should be replaced by its shorter form, the SF-12. In order to ensure the validity of these findings a study with a larger sample size should be undertaken.

Key words: Frailty, feasibility, geriatric assessment tools.

J Frailty Aging 2017;in press
Published online inpress

Introduction

Frailty is defined as a "clinically recognizable state of increased vulnerability resulting from age-associated decline in reserve and function" (1). It includes clinical indicators, such as deficit accumulation, fatigue, sedentary behaviour, weight loss, and physical function impairment (1). Frailty is associated with a higher risk of disability, hospitalisation, cognitive impairment and reduced quality of life (2). It is estimated that by 2050, four million people in Australia will be either pre-frail or frail (3).

However, frailty is a dynamic syndrome that is treatable and reversible (4). Exercise interventions are considered to be the most effective strategy for preventing, treating and delaying frailty (5). Exercise is beneficial in increasing muscle mass, improving physical function, mobility and cognition in frail older adults, it also contributes to maintaining independence and quality of life (5). Frail older adults are more vulnerable to stressors (i.e. illnesses or falls) compared to healthy older adults, which makes tailored interventions and the use of appropriate geriatric assessment tools crucial in the management of their condition.

Geriatric assessment tools are applicable to the general geriatric population; however, their feasibility in frail older adults is yet to be determined.

The aim of this study was to determine the feasibility of standardised geriatric assessments and standard physical exercises in hospitalised pre-frail and frail older adults.

Methods

Participants and recruitment

Patients from the Geriatric Evaluation and Management Unit (GEMU) at the Queen Elizabeth Hospital in Adelaide, South Australia, aged ≥ 65 years, screened pre-frail or frail on the FRAIL Screen (6) were included in this study. Patients who were not able to communicate in English and/or were diagnosed with a significant cognitive impairment were excluded from the study. Written informed consent was obtained. Ethics approval was sought from the Central Adelaide Local Health Network Ethics Committee (HREC/16/TQEH/10). Recruitment, screening and data collection were performed on three consecutive days in the patient's room.

Assessment tools and physical exercises

The assessment battery included seven standardised geriatric tools including the FRAIL Screen (6), Charlson Comorbidity Index (CCI) (7), 36-Item Short Form Health Survey (SF-36) (8), Trail Making Test (TMT) (9), Rapid Cognitive Screen (RCS) (10), Self Mini Nutritional Assessment (MNA-SF) (11), and the Lawton Instrumental Activities of Daily Living (Lawton iADL) (12) as well as standard physical exercises based on the LIFE study (13) comprising mobility, strength, balance, and flexibility (Appendix 1).

The feasibility was assessed using observational protocols recording time and any prohibitive issues encountered during the assessments (Appendix 2).

Received July 21, 2017
Accepted for publication July 31, 2017

Data analysis

Descriptive statistics in IBM SPSS Statistics Version 21 were used to analyse demographic information. Issues observed during the assessments were collated, categorised and summarised.

Results

103 patients were considered for this study. 38 patients were excluded due to not being able to communicate in English and/or having a significant cognitive impairment. 65 patients were approached. 19 patients were not interested and declined to participate. One patient was not screened as pre-frail or frail and 15 patients withdrew prior to the assessments due to illness, time issues or being discharged from hospital. The sample size included 30 patients (9 males; 30% and 21 females; 70%) with a mean age of 85.37 ± 5.71 years (Table 1).

Table 1
Cut-off criteria and participants' characteristics

Assessments	Cut-Off Criteria	n (%)
FRAIL Screen	1-2 pre-frail	7 (23%)
	≥ 3 frail	23 (77%)
Charlson Comorbity Index	≤ 3 low mortality risk	21 (70%)
	4-5 moderate mortality risk	3 (10%)
	≥ 6 high mortality risk	6 (20%)
Lawton iADL	7-8 independent	11 (37%)
	4-6 moderate dependent	12 (40%)
	0-3 high dependent	6 (20%)
Rapid Cognitive Screen	8-10 normal	7 (23%)
	6-7 mild impaired	8 (27%)
	0-5 dementia	10 (33%)
MNA Short Form	12-14 normal	4 (13%)
	8-11 at-risk	14 (47%)
	0-7 malnourished	11 (37%)

Assessment tools

Areas of difficulty included comprehension, execution and completion issues (Table 2). Comprehension issues were defined as "issues relating to the phrasing of questions and/or instructions". Execution issues were defined as "any problems which impede the completion or smooth progression through the assessments".

Comprehension issues were observed with the FRAIL Screen, the CCI and the SF-36. In regards to the FRAIL Screen, 14 participants (47%) did not know whether they had more than five illnesses and seven participants (23%) could not calculate 5% of their weight. Participants were also unsure about the meaning of the terms "fatigue" (n=5; 17%) and "one flight of stairs" (n=2; 7%). In regards to the CCI, 13 participants (43%) had problems understanding the medical terminology used in the CCI. In relation to the SF-36, eight participants (27%) thought the questions were repetitive.

Issues with execution were observed with the SF-36, the RCS and the TMT. In relation to the SF-36, 16 participants (53%) commented that too many answers were offered, and seven participants (23%) commented that the SF-36 was too long. Participants with visual problems (n=3; 10%), and those with tremors and unsteady hands (n=2; 7%) found the RCS and TMT difficult to complete. In addition, seven participants (28%) had difficulties differentiating between the numeral 1 and letter I on the provided TMT sheet and eight participants (32%) were confused by the test.

Completion issues were mainly observed with the TMT where the majority of participants (n=15; 60%) were not able to complete part B of the test which involves the connection of numbers and letters in a logical order.

Physical exercises

Areas of difficulty included safety, execution and equipment issues (Table 2). Safety issues were defined as "any issues that might include a risk for the patients". Execution issues were defined as "any problems which impede the completion or smooth progression through the exercises". Equipment issues were defined as "any issues observed with the materials used".

In terms of safety, five participants (19%) were unstable with the "sit to stand" and seven participants (28%) had difficulties in attempting the "tandem stand" and the "one leg stand" safely.

In regards to execution, 13 participants (46%) had difficulties with the mobility tasks due to stiff joints, limb oedema or pain. Three participants (11%) had difficulties isolating ankles and muscle groups to execute the mobility and strength exercises correctly and five participants (19%) had difficulties executing the flexibility tasks due to shoulder pain or arm slings.

Equipment issues were observed in two participants (7%) who found it difficult to control the elastic exercise band with their feet while doing the "bicep curls", and three other participants (11%) found it difficult to tie the elastic band around their thigh for the "hip abduction" due to decreased coordination, tremors and rheumatoid arthritis (Table 2).

Discussion

Three key findings emerged from this study. Firstly, the SF-36 was considered to be too long, affecting completion rates, and should be replaced by its shorter form, the SF-12. Secondly, the TMT was not considered to be feasible as the

Table 2
Issues encountered with geriatric assessment tools and physical exercises

Assessment tools	Total n	Time (mins ± SD)	Comprehension issues n (%)	Execution issues n (%)	Completion issues n (%)
FRAIL Screen	30	1:46 ± 0:43	14 (47%)	-	-
Charlson Comorbidity Index	30	2:53 ± 1:04	13 (43%)	-	-
SF-36	30	14:37 ± 5:06	8 (27%)	23 (77%)	-
Lawton iADL	30	3:43 ± 2:00	-	-	-
Rapid Cognitive Screen	29	4:27 ± 2:14	-	5 (17%)	-
Trail Making Test	25	5:36 ± 2:37	-	20 (80%)	15 (60%)
MNA-SF	30	2:30 ± 1:01	-	-	-
Physical exercises	**Total n**	**Time (mins ± SD)**	**Safety issues n (%)**	**Execution issues n (%)**	**Equipment issues n (%)**
Mobility	28	2:08 ± 0:29	-	13 (46%)	-
Strength	27	5:15 ± 0:56	5 (19%)	3 (11%)	5 (19%)
Balance	25	1:24 ± 0:36	7 (28%)	-	-
Flexibility	27	0:34 ± 0:06	-	5 (19%)	-

majority of participants were not able to complete the test. And thirdly, safety and appropriate equipment are key factors in exercise programs for frail older adults.

Assessment tools

In regards to the FRAIL Screen, the findings suggest that questions regarding quantifying illnesses and bodyweight would be more reliably answered by examining patient's medical records which applies for the CCI as well. Issues with comprehension could lead to different interpretations influencing the outcomes of these tools. Providing unambiguous explanations for medical terms could help to reduce the possible heterogeneity in the answers. The Lawton iADL and the MNA-SF, on the other hand, were brief and easy to perform, proving the tools' feasibility for use with frail older adults. The RCS has previously been found to be valid, brief and easy to perform (10). The results of this study confirm these findings, as the tool was found to be quick and acceptable to all study participants. The SF-36 has been used in a variety of populations, including the older age group (14). However, there remain acknowledged issues, such as lower item completeness in disadvantaged age groups, which includes the elderly (14). This study suggests a shorter questionnaire, such as the SF-12, which might be more accurate for use with frail older adults. The TMT is a sensitive instrument that tests for cognitive impairment associated with dementia (9). Despite its clear usefulness, various issues identified in this study indicate that other or additional neuropsychological assessment tools might be useful.

Physical exercises

The main barriers to older people participating in exercise are fear of falling, physical ailments and inertia, confirming that safety is a key factor in the feasibility of exercise programs in older people (15). The results of this study confirm that it might be necessary to consider walking aids, especially in participants who are unstable on their feet and want to perform the exercises at home. Home-based exercises are considered to be effective in improving physical function in frail older people (5). However, safety is crucial in reducing the risk of adverse events. Further, many participants in this study experienced stiff joints, limb oedema or pain confirming that physical limitations and co-morbidities affecting physical movement and vision are other key issues that could limit the successful execution of exercise programs. Regarding equipment, issues can be expected in the use of elastic bands. Using the own body weight or dumbbells could be an alternative.

Conclusion

This study suggests that geriatric assessment tools need to be amended in relation to being brief and comprehensible. Alternative or additional tools for neuropsychological assessments should be considered to accommodate the frail population's physical and mental limitations. This study also indicates that in order to optimise the exercise programs for frail older adults adjustments to the exercises should be made, especially in regards to safety and adequate equipment.

Acknowledgements: The authors would like to acknowledge the contribution of the 2016 University of Adelaide medical students

who participated in the MSA elective program.

Conflict of interest: The authors report no conflicts of interest.

Author contributions: All authors contributed to the study design, implementation of the study, analysing and interpretation of the results and preparation of manuscript. All authors approved the final version of the manuscript.

Sponsor's role: Ms Agathe Daria Jadczak is a recipient of the Beacon PhD Scholarship from the University of Adelaide.

References

1. 1. Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27(1):1-15.
2. Weiss CO. Frailty and Chronic Diseases in Older Adults. Clin Geriatr Med 2011;27(1):39-52.
3. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 2012;60(8):1487-1492.
4. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med 2006;166(4):418-423.
5. Liu CK, Fielding RA. Exercise as an intervention for frailty. Clin Geriatr Med 2011;27(1):101-110.
6. Morley JE, Vellas B, van Kan GA, et al. Frailty consensus: a call to action. J Am Med Dir Assoc 2013;14(6):392-397.
7. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40(5):373-383.
8. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992;30(6):473-483.
9. Salthouse TA. What cognitive abilities are involved in trail-making performance? Intelligence 2011;39(4):222-232.
10. Malmstrom TK, Voss VB, Cruz-Oliver DM, et al. The Rapid Cognitive Screen (RCS): A Point-of-Care Screening for Dementia and Mild Cognitive Impairment. J Nutr Health Aging 2015;19(7):741-744.
11. Kaiser MJ, Bauer JM, Ramsch C, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging 2009;13(9):782-788.
12. Graf C. The Lawton Instrumental Activities of Daily Living (IADL) Scale. Medsurg Nurs 2009;18(5):315-316.
13. Cesari M, Vellas B, Hsu FC, et al. A Physical Activity Intervention to Treat the Frailty Syndrome in Older Persons-Results From the LIFE-P Study. J Gerontol A Bio Sci Med Sci. 2015:70(2):216-222.
14. Bartsch LJ, Butterworth P, Byles JE, Mitchell P, Shaw J, Anstey KJ. Examining the SF-36 in an older population: analysis of data and presentation of Australian adult reference scores from the Dynamic Analyses to Optimise Ageing (DYNOPTA) project. Qual Life Res 2011;20(8):1227-1236.
15. Lees FD, Clarkr PG, Nigg CR, Newman P. Barriers to exercise behavior among older adults: a focus-group study. J Aging Phys Act 2005;13(1):23-33.

Appendix 7

Statement of Authorship and published protocol (Chapter 8)

The EXPRESS Study: Exercise and Protein Effectiveness Supplementation Study supporting autonomy in community dwelling frail older people - study protocol for a randomised controlled pilot and feasibility study

Statement of Authorship

Title of Paper	The EXPRESS Study: Exercise and Protein Effectiveness Supplementation Study supporting autonomy in community dwelling frail older people - study protocol for a randomized controlled pilot and feasibility study
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Jadczak AD, Luscombe-Marsh N, Taylor P, Barnard R, Makwana N, Visvanathan R. The EXPRESS Study: Exercise and Protein Effectiveness Supplementation Study supporting autonomy in community dwelling frail older people - study protocol for a randomized controlled pilot and feasibility study. Pilot and Feasibility Studies. 2018;4:8. DOI 10.1186/s40814-017-0156-5.

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak
Contribution to the Paper	Contributed to study concept and design, responsible for coordinating research staff, collecting data and performing data analyses, constructed study database, wrote the protocol, and acted as corresponding author.
Overall percentage (%)	65%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 09/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Natalie Luscombe-Marsh
Contribution to the Paper	Responsible for study concept and design, for obtaining funding, supervising research students and staff, overseeing data analysis, interpretation, and final manuscript.
Signature	Date 09/10/17

Name of Co-Author	Penny Taylor
Contribution to the Paper	Contributed to the development of the nutrition intervention protocol and assisted with supervision of clinical research dieticians.
Signature	Date 9.10.17

Name of Co-Author	Robert Barnard		
Contribution to the Paper	Contributed to the development of the exercise protocol and facilitated staff and premises for the study.		
Signature		Date	9/10/17

Name of Co-Author	Naresh Makwana		
Contribution to the Paper	Helped with data entry and assisted with recruitment.		
Signature		Date	09/10/2017

Name of Co-Author	Renuka Visvanathan		
Contribution to the Paper	Responsible for study concept and design, for obtaining funding, supervising research students and staff, overseeing data analysis, interpretation, and final manuscript.		
Signature		Date	27/9/17

Jadczak et al. Pilot and Feasibility Studies (2018) 4:8
DOI 10.1186/s40814-017-0156-5

Pilot and Feasibility Studies

STUDY PROTOCOL Open Access

The EXPRESS Study: Exercise and Protein Effectiveness Supplementation Study supporting autonomy in community dwelling frail older people-study protocol for a randomized controlled pilot and feasibility study

Agathe Daria Jadczak[1,2,3*], Natalie Luscombe-Marsh[4], Penelope Taylor[4], Robert Barnard[5], Naresh Makwana[1,2] and Renuka Visvanathan[1,2,3]

Abstract

Background: Research has repeatedly demonstrated that exercise has a positive impact on physical function and is beneficial in the treatment of physical frailty. However, an even more effective strategy for managing physical frailty might be the combination of multicomponent exercise with the intake of high-quality protein supplements, but the efficacy remains unclear for older adults who are already pre-frail and frail. The aim is to examine the feasibility of recruiting frail older adults to participate in a trial designed to determine the potential effects of a 6-month exercise and nutrition intervention on physical function. The feasibility objectives will include frail older peoples' compliance, the safety and tolerability of the trial, the estimation of estimates to aid sample size calculation, and the potential efficacy. Primary outcomes for the main trial will include gait speed, grip strength and physical performance. Secondary outcomes will include frailty status, muscle mass, nutritional intake, physical activity levels, cognitive performance and quality of life.

Methods/design: A randomised, parallel, control pilot and feasibility study will be conducted. All participants will be randomly assigned to either (a) an exercise program + high-quality protein supplement or (b) an exercise program + low-quality protein supplement. Both protein supplements will be matched closely in colour, flavour and packaging so that both the participants and the research staff are blinded. The exercise program will be the same in both groups. Assessments will be conducted at baseline and at 3 and 6 months and include gait speed, grip strength, the Short Physical Performance Battery, Timed Up and Go Test, FRAIL Screen, bioelectrical impedance analyses, 24-h dietary recall, Katz Activities of Daily Living, Lawton Instrumental Activities of Daily Living, the Trail Making Test, Short Form Health Survey-36, and 1 week accelerometer quantification. The data will be analysed using an ANCOVA model.

(Continued on next page)

* Correspondence: agathedaria.jadczak@adelaide.edu.au
[1]National Health and Medical Research Council Centre of Research Excellence Frailty and Healthy Ageing, University of Adelaide, Adelaide, South Australia, Australia
[2]Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Discipline of Medicine, Adelaide Medical School, University of Adelaide, Adelaide, South Australia, Australia
Full list of author information is available at the end of the article

(Continued from previous page)

Discussion: This study is expected to provide much needed insight into the feasibility of recruiting and retaining frail older adults into community-based intervention programs, while providing knowledge relating to the safety, tolerability and benefits of a combined exercise and protein supplement program designed to halt or reverse the transition of physical frailty in the community. If shown to be effective, this strategy could be included in the best practice clinical guidelines for community-dwelling older adults who are pre-frail or frail.

Trial registration: Australian New Zealand Clinical Trials Registry, ACTRN12616000521426

Keywords: Ageing, Frailty, Exercise intervention, Protein supplements

Background

Globally, the number of people aged 65 years and older is expected to triple over the next 30 years [1, 2]. In Australia, it is estimated that approximately 10 million people will be aged over 65 years by 2050 [3]. A common geriatric syndrome associated with ageing is frailty [4]. Frailty is defined as a "clinically recognisable state of increased vulnerability resulting from age-associated decline in reserve and function" [2] and results in increased morbidity, including disability, loss of independence, increased hospitalizations and reduced quality of life [5, 6]. While frailty is measured using different scales, one of the most commonly used instruments is the Fried Frailty Index [7], which defines frailty according to a physical phenotype consisting purely of physical components. This construct of a physical phenotype is regarded as being distinct from disability or co-morbidity, and hence, the Frailty Index is considered to be highly predictive of future decline in physical health.

Due to the appreciation of the Fried Frailty Index as a relatively easy tool with which to determine whether a person is physically frail, there have been a number of studies that have described the prevalence of this phenotype in different regions around the world. The Survey of Health, Aging and Retirement in Europe (SHARE) surveyed older adults across Europe and Israel using the Fried criteria [7], and the prevalence of frailty was reported to be 17% (range from 5.8% in Switzerland to 27.3% in Spain) [8]. Data from a longitudinal cohort of Australian women using similar frailty criteria reported the same prevalence of pre-frail and frail [9] and, by 2050, this is estimated to represent four million Australians [10]. These data provide impetus for the development of strategies that can be used to either halt or reverse the transition of physical frailty and the manifestation of poor health outcomes. Otherwise, increasing poor health and healthcare costs among this population cannot be mitigated [2, 11].

While physical frailty appears to be reversible when early intervention is provided [7, 9], there remains a lack of consensus regarding the management of older people who are frail or have complex health conditions. Evidence indicates that exercise is critical in managing many of the physiological changes that occur as individuals' age [4, 12]. Exercise interventions, particularly those that include resistance training, have the potential to prevent, delay and reverse frailty [13]. For example, numerous studies have demonstrated that exercise maintains and restores one or more health parameters including muscle strength, bone integrity, balance and physical function in study populations that include older people who were relatively healthy (i.e. those without a clinical diagnosis) [14] and those classified as frail according to a variety of methods [12, 15]. However, the strength of the evidence from meta-analyses regarding the benefits of exercise for frail older people was limited by the fact that many of the studies reviewed included small and heterogeneous study populations. Few studies have simultaneously measured markers of muscle mass, strength and function; the type of control activity used as the comparator for an exercise intervention has been highly variable; and the compliance to programs has not been well reported. In addition, a study of 151 community-living pre-frail and frail older adults in Singapore showed that improvements in frailty status and a variety of biomarkers of physical frailty were largely comparable for the nutrition, physical, cognitive and combined treatments and all resulted in greater improvement compared with the control, i.e. standard care from health and aged care services in combination with a placebo nutritional supplement. However, while there were no statistically significant differences between the nutrition, physical, cognitive and combined treatments, the improvements in all measured domains where greatest with the physical and combined groups [16]. Accordingly, more studies are needed to identify feasible exercise programs, alone and in combination with other treatments, for community-dwelling pre-frail and frail older adults.

With respect to the nutritional management of pre-frail and frail older people, very few studies have been conducted to determine the effects of protein supplements, either on their own or in combination with exercise. Numerous studies have demonstrated substantial benefits of protein supplementation in combination with resistance exercise in healthy older adults [17, 18]. However, only three studies have been conducted in frail older adults and have yielded conflicting results for the benefits of protein on muscle mass and markers of strength and mobility [19–21]. One study reported increased mobility, but no increase in skeletal muscle mass or strength when consuming additional protein [19], while another showed that protein supplements do not increase the effects of high-intensity functional exercise [21]. Yet another concluded that resistance training, when combined with protein intake, did lead to increased muscle mass compared to resistance training alone [20]. Discrepant findings are likely to be the results of differences in study protocols and participants, with some study samples being too small, while others provided insufficient protein or administered the protein as a single bolus dose, or did not control for differences in background diet.

In addition to the aforementioned limitations of previous research conducted in the ageing field, another major issue are the varied tools used to identify pre-frail and frail older adults. There remains little agreement regarding the diagnostic test accuracy of any of the simple, common diagnostic tests for community-dwelling people. Although interest in the FRAIL Screen is increasing for a number of reasons, this quick, simple screening tool does not require measurements by health professionals and has been validated in various populations across the globe [22–24]. It includes five questions about fatigue, resistance, ambulation, illness and weight loss, representing the phenotypic definition for frailty [7]. The FRAIL Screen can be completed in 15 s. The brevity and simplicity make it useful as a screening tool for implementation in primary care, and it is said to be capable of detecting changes in frailty bidirectionally, and thus may be useful in monitoring for change [22].

Given the incompleteness of our knowledge relating to the efficacy of protein supplements in combination with exercise interventions on physical function in people aged 65 years and older and who are recognised as pre-frail/frail, more information is required. Without a fuller understanding of the effects of a supplement-exercise regimen on frail community-dwelling older adults, it will continue to be difficult, if not impossible, to successfully manage their condition.

Methods/design

Aim

The primary aim of this 6-month study is to report on the feasibility of recruiting frail adults aged 65 years and older using the FRAIL screen (e.g. source, speed) and retaining them for the entire 6-month intervention (e.g. compliance, safety, tolerability).

Feasibility objectives

The feasibility objectives will include the recruitment of pre-frail and frail older people from the community using several recruitment channels, how well pre-frail and frail older people comply with the exercise and nutritional components of the intervention, their completion of the baseline, 3- and 6-month assessments and the safety and tolerability of the intervention. This information will be used to estimate the sample size required for the main trial and the potential efficacy of the main trial.

Secondary patient-centred objectives

In addition, the study aims to determine the effects of exercise in combination with a protein supplement. The supplement will be either a (a) commercially available high-quality whey protein supplement or (b) a control supplement which is a commercially available lower quality rice protein. Changes in response to exercise in combination with either the low- or high-quality protein supplement will be determined by measurements of the following:

- Primary outcomes, including gait speed, grip strength and physical performance and
- Secondary outcomes, including frailty status, muscle mass, quality of life, nutritional intake, cognitive performance and physical activity levels

The primary and secondary outcomes listed above will potentially be used in the main trial after their feasibility is confirmed in this pilot trial.

Study design

A randomised, parallel, control pilot study will be conducted in a community setting. Participants will be assessed at baseline and at 3 and at 6 months. Participants will be able to withdraw from the study at any time and will have their final assessments completed within 1 week of withdrawal.

Participants

Participants will be eligible for this study if they are aged 65 years and older, able to converse in English, live in the community and are identified as being pre-frail (i.e. have a score ≥1 but <3 out of 5) or frail (i.e. have a score ≥3 out of 5) using the FRAIL Screen [22], including the following five questions:

- Are you fatigued?
- Do you have difficulties walking up one flight of steps?
- Are you unable to walk at least one block?
- Do you have more than five illnesses?
- Have you lost more than 5% of your weight in the past 6 months?

Participants with dementia (i.e. score 5 or less out of 10) as per the Rapid Cognitive Screen [25], severe renal impairment (eGFR ≤30 mmol/L) and those unable to comply with the exercise or nutrition study protocol will be excluded.

Recruitment

Participants will be recruited through social media (e.g. Facebook), public seminars, local newspapers, radio and television advertising as well as flyers displayed in newsletters and the halls of collaborative aged care services, medical centres, GP practices and the Queen Elizabeth Hospital in Adelaide, South Australia, Australia. The flow of participants through the study will be captured as per the CONSORT statement and as depicted in Fig. 1.

Randomisation and blinding

The study coordinator will enrol eligible participants into the study and send a participant's identification number to the study biostatistician who will randomise the participants to one of the two study arms using a stratification system to ensure that an approximately equal numbers of men and women, aged <80 and >80 years, who are pre-frail (score ≥1 but <3 out of 5) and frail (score ≥3 out of 5), are allocated to each arm. The biostatistician will then notify the dietician on the allocated arm prior to the start of the intervention. The participants, as well as the study coordinator and research staff performing the study assessments, will be blinded to the two different types of protein supplements until the end of the trial.

Exercise intervention

The exercise intervention will be undertaken by all participants who will be supervised by trained exercise physiologists. The exercise regimen includes one centre-based group exercise and two home-based exercise sessions, in addition to walking twice a week. During holiday periods or periods of illness, centre-based exercise can be missed, but participants will be asked to do an additional home-based exercise session if possible. These flexible approaches to the exercise regimen will be recorded.

The exercise prescription is based on the LIFE study, a physical activity intervention for community-dwelling

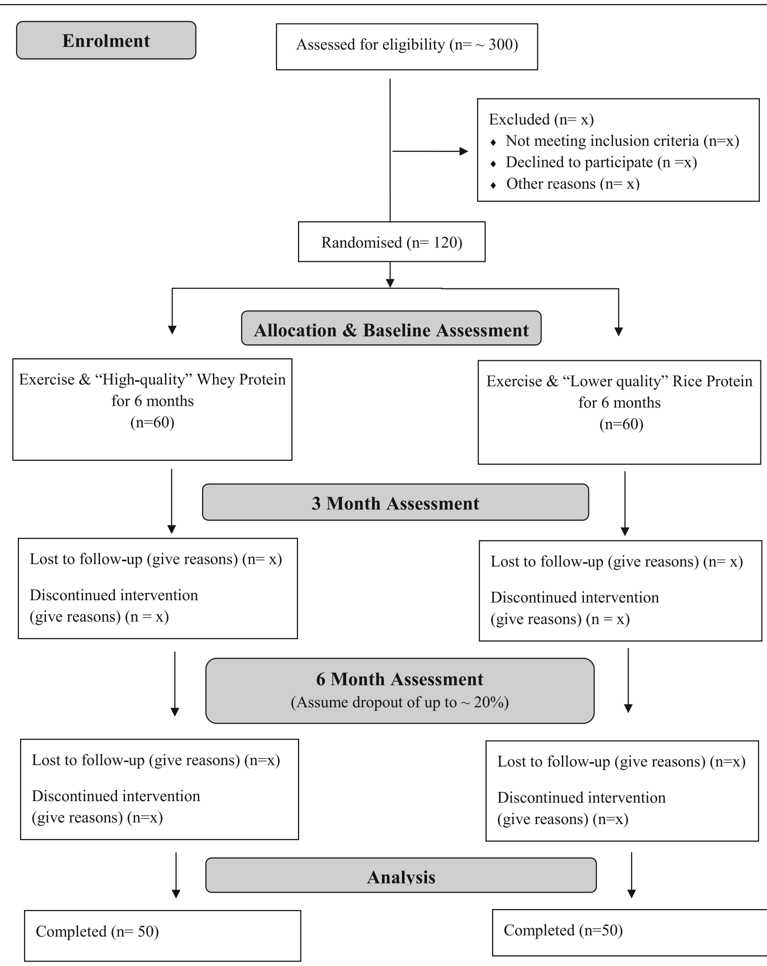


Fig. 1 EXPRESS Study Consort Flow Diagram

frail older people conducted in the USA [13]. Multicomponent exercises incorporating strength, balance, aerobics and flexibility were selected from the LIFE Study and modified for this pilot intervention. Strength exercises will be performed using own body weight, elastic exercise bands and ankle weights. The aerobic modality will be performed using walking exercise. The balance modality will include at least two balance tasks, and the flexibility modality will include the upper and lower extremities. Exercises that are safe and that can be executed in a sitting or safe standing position will be prescribed for the home-based exercise program. Additional exercises that may require more supervision will be included in the centre-based exercise sessions. The intensity of the exercises is based on the LIFE Study design using the Borg Scale [13, 26]. The Borg Scale allows a rating of perceived exertion (RPE) and can be used to monitor and control the intensity of exercise interventions. Strength exercises will be conducted at 15–16 RPE, and walking will be conducted at 12–14 RPE [26].

Nutrition intervention

A qualified dietician will provide the nutrition prescription and instruct participants on how to prepare and consume the protein supplements and how to record them in the provided compliance diaries. All protein supplements will be provided as a powder in individual 26-g sachets to provide 20 g of protein. The protein powder (i.e. whey or rice protein) will be blended with a powdered flavour (i.e. vanilla) and reconstituted in ~150 ml of water by the participants at home. All drinks will be isocaloric (i.e. both supplying ~90 kcal per 26 g protein sachet) and isonitrogenous (~3.5 g of nitrogen per 26 g protein sachet) and of comparable taste, texture and aroma. The protein powder will be packaged in identical pharmaceutical grade silver foil sachets marked with an A or B to ensure that participants and the study coordinator and research staff performing all study assessments are blinded.

The protein load, source and timing of consumption are based on the recommendations by the PROT-AGE group [27] and the aforementioned meta-analyses [17, 18, 28]. Splitting the total load of protein into two supplements per day is based on evidence that a load of 20 g when combined with multicomponent exercise is sufficient to increase muscle protein synthesis in healthy, non-frail older people. During periods of hospitalisation, research staff will interact with the participant and treating health professionals to encourage, where safe to do so, continuation with the supplementation. Also, it is anticipated that participants will take sachets with them on holidays, thus continuing with supplementation.

Screening and assessments

Screening

Participants will be screened for eligibility over the phone using the FRAIL Screen [22] and demographic- and health-related information will be collected. Medical clearance and serum creatinine investigation will then be obtained from the participants' general practitioner before a home visit is scheduled for further screening. The home visit will include the Rapid Cognitive Screen (RCS) [25], the Charlson Co-morbidity Index [29], the Geriatric Depression Screen-5 (GDS-5) [30], Katz Activities of Daily Living (KATZ ADL) [31] and a safety check to ensure that participants exercise in a safe home environment. The screening process over the phone will take approximately 5 min and the home assessments will take approximately 30 min for each participant. The Short-Form Health Survey-36 (SF-36) [32] and the Lawton Instrumental Activities of Daily Living (Lawton iADL) [33, 34] questionnaire will be completed by the participants as self-assessments. At the completion of the screening, inclusion and exclusion criteria will be reviewed by the research team's coordinator, and participants who fulfil all eligibility criteria will be enrolled into the 6-month nutrition and exercise intervention.

Completion of baseline, 3- and 6-month assessments

At baseline and at 3 and 6 months after commencing the nutrition and exercise intervention, assessments will be performed at the participants' closest study centre (currently two locations including the Queen Elizabeth Hospital in the western suburbs and the Centre for Physical Activity in Ageing in the north-east of the city).

Baseline assessments will be conducted approximately 1 week after participants have completed the screening process and been enrolled into the study. These assessments will take approximately 1 h per participant and include the Trail Making Test [35], gait speed, grip strength (using a handgrip dynamometer) [36], Short Physical Performance Battery (SPPB) [37], Timed Up and Go Test (TUG) [38], bioelectrical impedance analyses (BIA) [39], 24 h dietary recall [40] and an accelerometer attached to the participant's thigh [41]. The accelerometer will be collected 1 week later. At that time, participants will commence their exercise program (with the first session being a centre-based exercise class), consuming their allocated twice daily protein supplements.

The RCS [25], the Charlson Co-morbidity Index [29] and the Self Mini Nutritional Assessment (MNA-SF) [42, 43] will be conducted only at baseline to determine the participants' risk of cognitive impairment, 5-year mortality and malnutrition.

A timeline of the screening process, interventions and assessments is displayed in Table 1. An overview of the assessment tools used to measure the potential primary

Table 1 Schedule of enrolment, interventions and assessments

Timepoint	Screening -T2	Home visit -T1	Baseline 0	3 months T1	6 months T2
ENROLMENT					
Eligibilty	X	X			
Blood investigation	X				
Medical clearance	X				
Informed consent			X		
Randomization			X		
Interventions					
Intervention A			←	—	→
Intervention B			←	—	→
Assessments					
Demographic information	X	X			
Charslon Comorbity Index		X			
Rapid Cognitive Screen		X			
MNA - Short Form			X		
FRAIL Screen	X			X	X
Katz ADL		X		X	X
Lawton ADL		X		X	X
SF-36		X		X	X
GDS-5		X		X	X
Trail Making Test			X	X	X
Nutritional recall			X	X	X
Gait speed			X	X	X
Grip strength			X	X	X
SPPB			X	X	X
Timed Up and Go			X	X	X
BIA			X	X	X
Accelerometer			X	X	X

and secondary outcomes related to the patient-centred objectives for the main trial at baseline and at 3 and 6 months is displayed in Table 2.

Compliance and safety

Compliance diaries will be handed out to participants with instructions provided on how to complete them; specifically, they will be asked to record the timing and number of supplements consumed per day. The researchers will check compliance with the supplements and exercise prescription on a weekly basis for the first 2 weeks and then every 2 weeks thereafter if no problems are evident. If the study team identify that a participant's compliance to the planned number of exercise sessions per fortnight, or the planned number of protein sachets, is less than 70% (i.e. <7 exercise sessions attended or <20 sachets consumed), the research exercise physiologist and dietitian will respectively interview the participant to assess any difficulties and identify strategies that could facilitate compliance.

For participants who have glomerular filtration rates (GFR) of >30 but ≤60 ml/min/1.73 m^2, the GFR will be retested at 3 and 6 months, and if deterioration is noted (very unlikely), the medical registrar will liaise with the general practitioner and the participant for further assessment and management. Protein supplementation can be safely prescribed up to 1.2 g/kg body weight/day where GFR is >60 [27].

Adverse events (AEs), that is, any untoward medical occurrences (i.e. pain, discomfort, wind, headaches,

Table 2 EXPRESS Study assessments and cutoff criteria

EXPRESS Study assessments	Cut-off criteria		
Demographic information			
Charslon Comorbity Index	≤3 low risk	4–5 moderate risk	≥6 high risk
Rapid Cognitive Screen	8–10 normal	6–7 mild impaired	5 dementia
Mini Nutritional Assessment-Short Form	12–14 normal	8–11 at-risk	0–7 malnourished
FRAIL Screen	0 robust	1–2 pre-frail	≥3 frail
Katz Activitis of Daily Living	6 full function	4 moderately impaired	≤2 severely impaired
Lawton Instrumental Activities of Daily Living	0–3 high depended	4–6 moderate dependent	7–8 independent
Short-Form Health Survey-36			
Geriatric Depression Scale-5	≥2 answers: depression		
Trail Making Test	Part A: >78 s deficient	Part B: >273 s deficient	
Nutritional recall			
Gait speed	♂ 0.65/0.76 m/s (≤173/>173 cm)	♀ 0.65/0.76 m/s (≤159/>159 cm)	
Grip strength	♂ 29–32 kg according to BMI	♀17–21 kg according to BMI	
Short Performance Physical Battery	Limitation: 0–3 severe, 4–6 moderate, 7–9 mild, 10–12 minimal		
Timed Up and Go	<12 s normal mobility	≥12 s limited mobility	
Bioelectrical impedance analyses			
Accelerometer	Low activity ♂ <383 kcal/week	Low activity ♀ <270 kcal/week	

♂ male ♀ female

noticeable difference in body and memory) will be investigated during all visits, whether or not they are related to the study product or physical regimen. The events will be reviewed by the study's medical registrar and participants will be referred to the research physician as required.

Statistical analyses

Statistical advice has been provided by a co-investigator (KL) who is a professional biostatistician; she will be responsible for overseeing all statistical analysis for the team. Descriptive analyses will be used to assess the completeness and variability of the outcomes using means, medians, standard deviations and ranges as appropriate. Mean and median outcomes within each group will be presented with 95% confidence intervals to help inform power calculations for a possible definitive trial. A preliminary assessment of the efficacy of the treatment will also be conducted via an intention-to-treat analysis. For each study outcome, the change from baseline after 3 and 6 months will be compared between the two study arms. These analyses will be estimated in an ANCOVA model with the 3- and 6-month value as outcome, and the baseline value age, gender and frailty status as covariates. The resulting treatment effect will be reported as the least square mean and 95% confidence interval for the primary outcomes of gait speed, grip strength and physical performance. A plot of changes over time for pre-frail and frail participants will be used to observe whether changes in the frailty status can be seen.

If recruitment is going to take substantially longer than 12 months, an interim analysis will be performed on the numbers of participants who have completed the study within that period, and a decision will be made as to whether the study is feasible to complete within a reasonable timeframe of an additional 12 months.

Discussion

Frailty is a major public health issue. It directly, and also indirectly through increased disability, contributes to increased health and aged care costs of elderly populations around the world [2]. Frailty is a continuum of accumulated lifetime assaults on the body that compromises physical and/or mental equilibrium, predisposing older adults to increased dependency on healthcare resources [4]. Adults who are identified as being pre-frail have an increased risk over the next 3 to 4 years of becoming frail, requiring greater support in performing activities of daily living and maintaining independence [7]. This means the early detection of frailty is pivotal for timely interventions that may assist in managing this geriatric condition and reducing healthcare costs, and to date, there remains a paucity of information about lifestyle interventions that may be beneficial for this target population.

While exercise in combination with protein supplementation has been shown to positively impact a variety of physical and/or psychological health attributes in pre-frail and/or frail older people, several aspects related to the study design of previous research still limit the interpretation of the collective results. Accordingly, the proposed study protocol hopes to extend the current knowledge in this area by specifically examining the feasibility, tolerability, efficacy and safety of consuming twice daily protein supplements in the context of a multicomponent exercise program.

Recruiting and retaining frail older adults into community-based intervention programs is a major issue that prior research has identified and is generally the reason why many studies report relatively small numbers of participants (and especially small numbers of completers) [44]. Accordingly, this study has been designed to represent and test the efficacy of a pragmatic, community-led, exercise and nutrition program which is based on postulated hypotheses that remain to be debated within the fields of nutrition and gerontology [27]. Addressing many of the methodological limitations noted in the background literature, this study protocol should optimise the ability to recruit pre-frail and frail older participants who want to remain independent and engaged within their communities. For example, participants will be diagnosed as being pre-frail or frail using the FRAIL Screen which can be easily used in all primary care settings because it is simple and quick; as such, a variety of recruitment channels will target to promote the study including general practice clinics, age-care organisations, groups that are dedicated to supporting older adults and also the general public via social media channels. Secondly, on a weekly basis throughout the 6-month intervention, our multi-disciplinary research team consisting of geriatricians, age-care nurses, exercise physiologists and dietitians/nutritionists will be supporting each participant—albeit in a group setting—to build a study community that should assist with maintaining participant motivation. Thirdly, the personalised tailoring of the exercise program should also maximise the likelihood that each participant will progressively improve their strength, flexibility, balance and endurance, and thereby improve their physical health and overall wellbeing.

Regarding the protein supplementation part of the program, participants will be instructed to consume the daily protein supplements in close proximity (i.e. <1 h) to the completion of the exercise and in between meals on non-exercise days. The timing of consumption was based on the ongoing theory that resistance training increases amino acid delivery to the muscles, as well as absorption; hence, participants should be consuming an adequate amount of substrate, in a timeframe, that should maximise stimulation of muscle protein synthesis [45]. Moreover, there is consistent evidence that whey protein rather than casein, milk, soy or pea is more superior at promoting muscle protein synthesis or building muscle mass due to its higher quality (i.e. higher free amino acid to total amino acid content and especially its high essential branched-chain and leucine content) [46]. However, other plant-based proteins such as rice or pea protein are popular with consumers and while they are of lower protein quality, evidence regarding their impact on muscle mass, strength or physical performance/function, particularly when consumed over several months, remains scant. Therefore, this study will directly compare a whey protein supplement (i.e. higher quality protein) to a rice protein supplement (i.e. a lower quality protein) to address this concern. Long-term tolerability and safety to both proteins, as well as to the exercise program, will also be an important issue addressed within this study.

Conclusion

This study is expected to provide much needed insight into the feasibility of recruiting and retaining frail older adults into community-based intervention programs, while providing knowledge relating to the safety, tolerability and benefits of a combined exercise and protein supplement program designed to halt or reverse the transition of physical frailty in the community. If shown to be effective, this strategy could be used to inform the design of cost-effectiveness trials which will be necessary if public health policy makers and funders are to be strategically influenced. Evaluation of the collective findings from current and future research will be critical to refine and extend the current best practice clinical guidelines for community-dwelling older people who are pre-frail or frail.

Abbreviations

AE: Adverse event; BIA: Bioelectrical impedance analyses; CT: Computer tomography; GDS-5: Geriatric Depression Screen-5; GFR: Glomerular filtration rates; KATZ ADL: Katz Activities of Daily Living; Lawton iADL: Lawton Instrumental Activities of Daily Living; MNA-SF: Self Mini Nutritional Assessment; RCS: Rapid Cognitive Screen; RPE: Rating of perceived exertion; SF-36: Short Form Health Survey-36; SPPB: Short Physical Performance Battery; TUG: Timed Up and Go Test

Acknowledgements

The authors would like to thank Ms Kylie Lange for the statistical advice, calculating the sample size and setting up the randomisation for this study. We would also like to thank Ms Donna Preston who will be responsible for performing the home assessments and specific aspects of the screening assessments; Ms Kerri Ireland and Ms Teila Jaques, our exercise physiologists, who will conduct the centre-based exercise sessions; Ms Gabrielle O'Dea, Ms Brooke Wymond and Ms Megan Rebuli, our research dieticians, for assisting the study team with the screening of participants and for performing all the work related to the handout of protein supplements, dietary counselling and monitoring of compliance; and Dr Chris Bollen from BMP Consulting and Ms Elizabeth Barnard from the ACH Group for contributing to the development of the recruitment plan for this study.

Funding

This research is funded by the Northern Communities Health Foundation Incorporated and the Nutrition and Health Program of the Commonwealth Scientific Industrial Research Organisation (CSIRO). In addition, in kind support for the staff working on this project has been provided by the

Central Adelaide Local Health Network, the Centre for Physical Activity in Ageing and the NHMRC funded Centre for Research Excellence: Frailty Trans-Disciplinary Research to Achieve Healthy Ageing, Adelaide, South Australia, Australia.

Availability of data and materials
After completion of the study and publication of the results, the data and materials will be available on reasonable request from the corresponding author.

Authors' contributions
Dr NL-M and Prof RV are responsible for the study concept, design and protocol and for obtaining funding for the study and will be responsible for supervising the research students and staff who will execute the work, for overseeing the data analysis and interpretation and for writing the final manuscript. Ms ADJ substantially contributed to the study concept, design, and protocol and will be responsible for coordinating the research staff who will be assisting her to execute the study, for performing the data analysis and interpretation and for writing the final manuscript. Ms PT contributed to the development of the nutrition intervention protocol and assisted NL-M with the supervision of the clinical research dietitians involved in data collection and data entry. Mr RB contributed to the development of the exercise protocol and will be responsible for providing the qualified exercise physiologists to implement and facilitate the exercise program for the study. Dr NM is responsible for the data entry and will assist with recruitment. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
Participants will give written informed consent prior to the beginning of the study. Ethics approval for this research was obtained from the University of Adelaide Human Research Ethics Committee (H-2015-224), the Central Adelaide Local Health Network Ethics Committee (HREC/16/TQEH/10) and the Commonwealth Scientific and Industrial Research Organisation (HREC 10/2016).

Publisher's Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details
[1]National Health and Medical Research Council Centre of Research Excellence Frailty and Healthy Ageing, University of Adelaide, Adelaide, South Australia, Australia. [2]Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Discipline of Medicine, Adelaide Medical School, University of Adelaide, Adelaide, South Australia, Australia. [3]Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, 28 Woodville Road, Adelaide, South Australia 5011, Australia. [4]Nutrition and Health Program, Health and Biosecurity Business Unit, Commonwealth Scientific Industrial Research Organisation (CSIRO), Adelaide, Australia. [5]Centre for Physical Activity in Ageing (CPAA), Central Adelaide Local Health Network, Adelaide, South Australia, Australia.

Received: 17 January 2017 Accepted: 8 June 2017
Published online: 06 July 2017

References
1. Kinsella K, He W. An aging world: 2008. In: US Census Bureau, editor. International Population Reports. Washington, DC: GPO; 2009. p. 95/09-1.
2. Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med. 2011;27:1–15.
3. Kippen R. The future extent of population ageing in Australia. In: Carmichael G, Arunachalam D, editors. Populations of New Zealand and Australia at the Millennium. Canberra and Wellington: Australian Population Association and Population Association of New Zealand; 2002. p. 151–8.
4. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet. 2013;381:752–62.
5. Clark BC, Manini TM. Functional consequences of sarcopenia and dynapenia in the elderly. Curr Opin Clin Nutr Metab Care. 2010;13:271–6.
6. Weiss CO. Frailty and chronic diseases in older adults. Clin Geriatr Med. 2011;27:39–52.
7. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56:M146–56.
8. Michel JP, Cruz-Jentoft AJ, Cederholm T. Frailty, exercise and nutrition. Clin Geriatr Med. 2015;31:375–87.
9. Cameron ID, Fairhall N, Langron C, Lockwood K, Monaghan N, Aggar C, et al. A multifactorial interdisciplinary intervention reduces frailty in older people: randomized trial. BMC Med. 2013;11:65.
10. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc. 2012;60:1487–92.
11. Australian Institute of Health and Welfare. Health expenditure Australia 2008–09. Canberra: AIHW; 2010.
12. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. J Aging Res. 2011;2011:569194.
13. Cesari M, Vellas B, Hsu FC, Newman AB, Doss H, King AC, et al. A physical activity intervention to treat the frailty syndrome in older persons-results from the LIFE-P Study. J Gerontol A Biol Sci Med Sci. 2015;70:216–22.
14. Bouaziz W, Lang PO, Schmitt E, Kaltenbach G, Geny B, Vogel T. Health benefits of multicomponent training programmes in seniors: a systemtic review. Int J Clin Pract. 2016;70:520–36.
15. de Labra CG-P C, Maseda A, Lorenzo T, Millan-Calenti JC. Effects of physical exercise interventions in frail older adults: a systematic review of randomized controlled trials. BMC Geriatr. 2015;15:16.
16. Ng TP, Feng L, Zin Nyunt MS, Feng L, Niti M, Tan BY, et al. Nutritional, physical, cognitive and combination interventions and frailty reversal among older adults: a randomized controlled trial. Am J Med. 2015;128:1225–36.
17. Cermak NM, De Groot LCPGM, Van Loon LJC. Perspective: protein supplementation during prolonged resistance type exercise training augments skeletal muscle mass and strength gains. J Am Med Dir Assoc. 2013;14:71–2.
18. Finger D, Goltz FR, Umpierre D, Meyer E, Rosa LH, Schneider CD. Effects of protein supplementation in older adults undergoing resistance training: a systematic review and meta-analysis. Sports Med. 2015;45:245–55.
19. Björkman MP, Finne-Soveri H, Tilvis RS. Whey protein supplementation in nursing home residents. A randomized controlled trial. Eur Geriatr Med. 2012;3:161–6.
20. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc. 2012;13:713–9.
21. Rosendahl E, Lindelof N, Littbrand H, Yifter-Lindgren E, Lundin-Olsson L, Haglin L, et al. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: a randomised controlled trial. Aust J Physiother. 2006;52:105–13.
22. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. J Am Med Dir Assoc. 2013;14:392–7.
23. Woo J, Leung J, Morley JE. Comparison of frailty indicators based on clinical phenotype and the multiple deficit approach in predicting mortality and physical limitation. J Am Geriatr Soc. 2012;60:1478–86.
24. Woo J, Yu R, Wong M, Yeung F, Wong M, Lum C. Frailty screening in the community using the FRAIL Scale. J Am Med Dir Assoc. 2015;16:412–9.
25. Malmstrom TK, Voss VB, Cruz-Oliver DM, Cummings-Vaughn LA, Tumosa N, Grossberg GT, et al. The Rapid Cognitive Screen (RCS): a point-of-care screening for dementia and mild cognitive impairment. J Nutr Health Aging. 2015;19:741–4.
26. Pritchett RC, Del Pozzi AT, Katica CP, Pritchett KL. Field test validation of the Borg 15-point Categorical Scale for rating of perceived exertion. Med Sci Sports Exerc. 2011;43:86.
27. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. J Am Med Dir Assoc. 2013;14:542–59.
28. Cawood AL, Elia M, Stratton RJ. Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. Ageing Res Rev. 2012;11:278–96.

29. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40:373–83.
30. Yesavage JA. Geriatric Depression Scale. Psychopharmacol Bull. 1988;24(4):709–11.
31. Shelkey M, Wallace M. Katz Index of Independence in Activities of Daily Living (ADL). Director. 2000;8:72–3.
32. Ware Jr JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care. 1992;30:473–83.
33. Graf C. The Lawton Instrumental Activities of Daily Living (IADL) Scale. Medsurg Nurs. 2009;18:315–6.
34. Bourne PA. Activities of daily living, instrumental activities for daily living and predictors of functional capacity of older men in Jamaica. N Am J Med Sci. 2009;1:184–92.
35. Salthouse TA. What cognitive abilities are involved in trail-making performance? Intelligence. 2011;39:222–32.
36. Visser M, Deeg DJ, Lips P, Harris TB, Bouter LM. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. J Am Geriatr Soc. 2000;48:381–6.
37. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol. 1994;49:M85–94.
38. Podsiadlo D, Richardson S. The timed 'Up & Go': a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39:142–8.
39. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol (1985). 2000;89:465–71.
40. Conway JM, Ingwersen LA, Moshfegh AJ. Accuracy of dietary recall using the USDA five-step multiple-pass method in men: an observational validation study. J Am Diet Assoc. 2004;104:595–603.
41. Murphy SL. Review of physical activity measurement using accelerometers in older adults: considerations for research design and conduct. Prev Med. 2009;48:108–14.
42. Huhmann MB, Perez V, Alexander DD, Thomas DR. A self-completed nutrition screening tool for community-dwelling older adults with high reliability: a comparison study. J Nutr Health Aging. 2013;17:339–44.
43. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment Short-Form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging. 2009;13:782–8.
44. Harris R, Dyson E. Recruitment frail older people to research: lessons learnt through experience. J Adv Nurs. 2001;36:643–51.
45. Phillips SM. The impact of protein quality on the promotion of resistance exercise-induced changes in muscle mass. Nutr Metab. 2016;13:64.
46. Devries MC, Phillips SM. Supplemental protein in support of muscle mass and health: advantage whey. J Food Sci. 2015;80 Suppl 1:A8–A15.

Appendix 8

Statement of Authorship (Chapter 9)

The feasibility of a randomised controlled pilot Exercise and Protein Effectiveness Supplementation Study (EXPRESS) supporting autonomy in community-dwelling frail older people

Statement of Authorship

Title of Paper	The Feasibility of a Randomized Controlled Pilot Exercise and Protein Effectiveness Supplementation Study (EXPRESS) Supporting Autonomy in Community-Dwelling Frail Older People
Publication Status	☐ Published ☐ Accepted for Publication ☐ Submitted for Publication ☑ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	

Principal Author

Name of Principal Author (Candidate)	Agathe Daria Jadczak
Contribution to the Paper	Contributed to study concept, design and protocol, constructed study database, recruited participants, collected data, coordinated research staff, performed data analyses and interpretation, and wrote the manuscript.
Overall percentage (%)	65%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 20/10/17

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Natalie Luscombe-Marsh
Contribution to the Paper	Responsible for study concept and design, for obtaining funding, supervising research students and staff, overseeing data analysis, interpretation, and for drafting and revising the final manuscript.
Signature	Date 20/10/17.

Name of Co-Author	Robert Barnard
Contribution to the Paper	Contributed to the development of the exercise protocol, helped with recruitment, and facilitated staff and premises for the study.
Signature	Date 20/10/17.

Name of Co-Author	Renuka Visvanathan		
Contribution to the Paper	Responsible for study concept and design, for obtaining funding, supervising research students and staff, overseeing data analysis, interpretation, and for drafting and revising the final manuscript.		
Signature		Date	20/10/17

Appendix 9

Published Abstracts

Jadczak, AD; Dollard, J; Mahajan, N; Visvanathan, R. The perspectives of older people at-risk of frailty on being advised about exercise. 21st IAGG World Congress of Gerontology and Geriatric, 23-27 July 2017, Moscone Centre, San Francisco, CA, USA. Published in Innovation in Aging, 2017; 1 Suppl: 1395. DOI:10.1093/geroni/igx004.5136.

Jadczak, AD; Tam, KL; Yu, S; Visvanathan, R. Medical students' perceptions of the importance of exercise and their perceived competency in prescribing exercise. World Congress on Active Ageing, 28 June - 1 July 2016, Melbourne Convention and Exhibition Centre, Melbourne, VIC, Australia. Published in the Journal of Ageing and Physical Activity, 2016; 24 Suppl: S59-S60.

adjusted for either: a) height squared, b) height and fat mass; or c) body mass index (BMI)], in combination with low grip strength and lung function in 470 (53.4% women) community dwelling older people. Body composition was assessed using DXA and lung function assessed using spirometry. Forced expiratory volume (FEV_1) and forced vital capacity (FVC) were significantly correlated with grip strength and the three low ASM definitions. After adjustment for age, gender, smoking and physical activity, ASM adjusted to fat mass definitions of sarcopenia remained independent predictors of lower FEV_1 and FVC. Sarcopenia definitions that account for fat mass may therefore be more relevant in clinical practice.

AUSTRALIA'S FRAIL POPULATION—IMPLICATIONS OF PREVALENCE AND SPATIAL DISTRIBUTION

H. Barrie, *The University of Adelaide, Adelaide, South Australia, Australia*

In Australia and globally an unprecedented number of older people will be moving into a 'third age' over the coming decades. There are, however, common conditions associated with growing older that pose serious health risks; *frailty syndrome* is one of these conditions and a major threat to ageing well. The reported international prevalence of frailty is 4% for those aged 65–69 years, increasing to 16% in the 80–84 years age group. One in four older people aged 85 years and older are frail. Using national Australian Census data for 2011 and 2016 this presentation will examine the prevalence and spatial distribution of Australia's likely frail, older population. Spatial analysis of this older, frail population enables us to explore links to health services accessibility and the relationship between frailty and the built environment.

FRAILTY IN AUSTRALIAN RESIDENTIAL AGED CARE FACILITIES: RELATIONSHIP WITH ONE-YEAR OUTCOMES

O. Theou[1], J. Sluggett[2], J. Bell[2], E.C. Tan[2], T. Emery[3], J.E. Morley[5], K. Rockwood[1], R. Visvanathan[4], *1. Dalhousie University, Halifax, Nova Scotia, Canada, 2. Monash University, Melbourne, Victoria, Australia, 3. Resthaven Incorporated, Adelaide, South Australia, Australia, 4. University of Adelaide, Adelaide, South Australia, Australia, 5. Saint Louis University, Saint Louis, Missouri*

This study aimed to investigate the ability of the FRAIL-NH and Frailty Index to predict hospitalization and mortality in residential age care facilities over a 12-month follow up. A total of 383 residents (age 87.5 ± 6.2 years, 77.5% females) of six Australian facilities participated in the study. At baseline 35.9% of residents were classified as most frail based on the 7-item FRAIL-NH scale. Their median 66-item Frailty Index score was 0.33 (IQR 0.24–0.46). During the follow up period, 22.2% of residents died and 34.4% were hospitalized. Residents who died had higher FRAIL-NH (45.2% vs. 35.2% most frail) and Frailty Index [median (IQR) 0.41 (0.29–0.53) vs. 0.31 (0.23–0.42)] scores at baseline. Residents who were hospitalized had lower FRAIL-NH (25.2% vs. 41% most frail) and Frailty Index [median (IQR) 0.31 (0.24–0.41) vs. 0.35 (0.24–0.48)] scores at baseline. The FRAIL-NH scale and Frailty Index may help identify residents most vulnerable to hospitalization and mortality.

THE PERSPECTIVES OF OLDER PEOPLE AT- RISK OF FRAILTY ON BEING ADVISED ABOUT EXERCISE

A.D. Jadczak[1,2,3], J. Dollard[2,3], N. Mahajan[1], R. Visvanathan[1,2,3], *1. Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, School of Medicine, Faculty of Health Sciences, University of Adelaide, Adelaide, South Australia, Australia, 2. Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Woodville South, South Australia, Australia, 3. National Health and Medical Research Council Centre of Research Excellence: Frailty Trans-Disciplinary Research to Achieve Healthy Ageing, University of Adelaide, Adelaide, South Australia, Australia*

Exercise prescription increases older peoples' participation in exercise. However, little is known about older peoples' perspectives on being advised about exercise. Semi-structured interviews were conducted with twelve older (mean age 83.42) participants at risk of frailty. Their attitudes towards exercise, the advice received, their access to relevant information and their perceptions of the general practitioner's (GP's) role in promoting exercise were explored using thematic analyses. The participants had mostly a positive attitude to exercise and indicated a preference for being advised firstly by their GP. The majority of participants reported minimal or no advice from their GPs. Participants also reported difficulties accessing advice on exercise and indicated that community councils and GP practices should promote exercise for older people more actively. This research has identified a gap in current practice and this should be viewed as an opportunity where change might lead to increased participation in exercise by older people.

SESSION 5240 (SYMPOSIUM)

FORMAL AND INFORMAL VOLUNTEERING IN LATER LIFE: TWO SIDES OF THE SAME COIN?

Chair: K.J. Ajrouch, *Eastern Michigan University*
Co-Chair: C. Tesch-Roemer, *German Centre of Gerontology (DZA)*

Formal volunteering comprises activities within an organizational context, while informal volunteering includes activities performed outside of an organizational context. In this symposium, we ask whether formal and informal volunteering compete with one another ("competition hypothesis") or if they are instead two sides of the same coin ("same coin hypothesis"). If the "competition hypothesis" holds true, there would be a negative correlation between formal and informal volunteering (individuals involved in formal volunteering would be less likely to provide informal neighborhood support). One of underlying causes for the "competition hypothesis" might be competing resources (e.g. finite time). If the "same coin" hypothesis holds true, there would be a positive correlation between formal and informal volunteering (an individual involved in formal volunteering is more likely to provide informal neighborhood support). One of the underlying causes for the "same coin hypothesis" might be overlapping motives (e.g. altruism). The relationship between formal and informal volunteering might differ across different societal groups and change with age. Restrictions in resources and entry barriers might lead

World of Wellness: The Active Ageing Phenomenon—"Wellness" from a Context-Based Perspective

Barnard, Robert

Centre for Physical Activity in Ageing, Department of Health and Ageing, South Australia; and Active Ageing Australia, South Australia, Australia; Robert.Barnard@sa.gov.au

Introduction: The rapid shift in the community and by aged care service providers to adopt approaches to wellness is now demonstrated by the prominence of both its mention and presence within program and service offerings. This change is linked to the rise of awareness and desire to achieve wellbeing at the individual level and the stimulus of the MyAgedCare (Australian Government, 2016) program. This presentation provides information from a survey of South Australian organizations with specific emphasis on wellness and Active Ageing options for older adults. Further evidence is provided of possible outcomes following physical activity interventions from Centre for Physical Activity in Ageing (CPAA) data. Model physical activity program options are provided by Active Ageing Australia (AAA, 2016). ***Methods:*** The survey consisted of: identification of included organizations (based on organization characteristics, age group criteria), the presence of wellness descriptors in organizational information, the nature of wellness offerings (program/activities), and evidence of wellness program outcomes. Information was collated into a table format for comparison. Evidence was gathered from the CPAA rehabilitation database (9,868 individual client cases). Model programs were provided from the AAA website and annual report. ***Results:*** Eight NGO aged care organizations and five LG councils were included/surveyed. While all eight aged care organizations mentioned wellness and/or wellbeing and provided programs, there was a significant difference between those organizations with broadest programs compared to those who appear to have maintained a traditional service model. All councils had some mention of wellness/wellbeing, including links to further information, and provided a range of associated services; however, there was difficulty in accessing information in most cases. The physical benefits expected from participating in exercise have been widely demonstrated by CPAA client pre–post outcome measures. AAA program models exist widely across aged care and community settings. ***Conclusion:*** While opportunities for older adults to access wellness programs are widely available across SA, significant differences in offerings suggest that there may be a need to consider the authenticity (Landry, 2015) and outcomes of these programs. Physical activity offers an easily provided and positive contribution towards wellness, and Australia continues to play a leading role in the development of such programs.
References: Australian Government: Department of Social Services. (2016). My Aged Care. Available from https://www.dss.gov.au/our-responsibilities/ageing-and-aged-care/programs-services/my-aged-care. Active Ageing Australia. (2016). www.activeageing.org.au. Landry, R. (2014). *Live Long, Die Short: A Guide to Authentic Health and Successful Aging.* Austin, TX: Greenleaf Book Group Press.

Care, Client, and Community in Aged Care—Why Invest in Active Ageing?

Patchett, Allison

Uniting Age Well, Melbourne, VIC, Australia; APatchett@unitingagewell.org

Strong evidence of the multiple benefits of exercise and strength training exists. From quality of life to cognitive function and falls prevention, physical exercise can assist in slowing down the ageing process. A number of lifestyle factors such as physical activity, diet, vascular risk factors, and brain training can help in slowing down the cognitive decline in older healthy individuals (Ngandu et al., 2015). The increased number of clients with dementia can be a burden to aged care, therefore it is of interest to encourage active living even in the older frail person. The inclusion of wellness centres in all aged care facilities, nursing homes, day therapy centres, and retirement villages has a positive impact for both residents and carers' wellbeing and functions. The processes of setting up and running a successful program requires knowledge and collaboration with a strong vision from a management perspective. Uniting AgeWell, a non-for-profit aged care provider in Victoria and Tasmania, has taken a strong active ageing approach. With two installed and fully-functional gyms for both residential and community clients, and more planned, the results show that the investment has been worthwhile financially and ethically. The participants have reported a positive impact on health and wellbeing. All participants state that their strength and fitness had improved since using the HUR gym and the majority also reported that it was easier to perform tasks around the home. The participants reported increased energy levels. Since opening the gym in July 2015, Uniting AgeWell has built a steady client base of 175 clients from the community, with the addition of residential clients also attending. This number, with the interests shown by many in the community, will continue to grow and has brought revenue of $25K to date. The inclusion of active ageing and wellness in the business vision is one of investment in health, independence, wellness, and quality of life. Whilst government support allows for funding on some aspects of care and entrepreneurship to others, it is of interest for all, both staff and clients, to invest in wellness. ***References:*** Ngandu, T., Lehtisalo, J., Solomon, A., Levälahti, E., Ahtiluoto, S., Antikainen, R., . . ., Kivipelto, M. (2015). A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. *Lancet, 385*(9984):2255–2263.

Oral Presentations

Medical Students' Perceptions of the Importance of Exercise and their Perceived Competency in Prescribing Exercise

Jadczak, Agathe Daria[1]; Tam, Khai Loon[1,2]; Yu, Solomon[1,2]; Visvanathan, Renuka[1,2]

[1]*Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Discipline of Medicine, School of Medicine, University of Adelaide, Adelaide, Australia;* agathedaria.jadczak@adelaide.edu.au, solomon.yu@adelaide.edu.au, renuka.visvanathan@adelaide.edu.au

[2]*Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide, Australia;* Khai.Tam@sa.gov.au

Introduction: Exercise is beneficial in the prevention of frailty. Medical practitioners have the potential to increase older peoples' participation in exercise by providing advice or prescribing exercise. Physicians however commonly cite a lack of education as a barrier, but yet there has been little research on how best to address this. The aim of this study was to evaluate the effects of a 4.5-week geriatric medicine course on fifth year medical students' perceptions of the importance of exercise and their perceived competency in prescribing exercise. ***Methods:*** The modified Exercise and Physical Activity Competence Questionnaire (EPACQ) was administered at the beginning and end of the course. Scores ranged from 0 (not important or competent) to 4 (important or competent) and 6 (very important or competent). One open-ended question about perceived barriers to exercise prescription was also added. Paired t-test was used to determine change. Data is presented as mean ± standard deviation. ***Results:*** 81 students (43 female, 38 male; mean age 23.4 ± 1.5 years) participated. Students' perceptions of the importance of designing an exercise prescription (4.44 ± 1.29 to 4.76 ± 1.27; P = .038), determining the training heart rate (3.95 ± 1.14 to 4.28 ± 1.04; P = .021), calculating the body mass index (4.74 ± 1.03 to 5.33 ± 0.74; P < .001), referring an older person to an exercise program (4.99 ± 1.01 to 5.33 ± 0.73; P = .001), and identifying age-related limitations (5.05 ± 0.90 to 5.26 ± 0.74; P = .029) improved. Students' self-perceived competency in prescribing exercise improved significantly across all ten items (P > .001). Post-course scores ranged from 3.27 ± 1.18 to 5.49 ± 0.73 compared to between ± 0.95 and 4.48 ± 0.96 pre-course. Barriers to exercise prescription included lack of knowledge (58.0 %), lack of patient compliance (34.6%), and lack of time (33.3%). ***Conclusion:*** We have demonstrated for the first time that a geriatric medicine course for senior medical students contributes to improved student perception of the importance of exercise as well as their perceived competency in prescribing exercise. Nevertheless, there are opportunities for further gains, especially with respect to self-perceived competency scores that will be investigated following course improvement.

Post Diagnosis Physical Activity Engagement in Prostate Cancer Survivors: Perceived Motives, Benefits, and Barriers for Physical Activity

Patel, Asmita[1,2]; Schofield, Grant[1]; Keogh, Justin[3]

[1]*Auckland University of Technology, Auckland, New Zealand;* asmita.patel@aut.ac.nz, grant.schofield@aut.ac.nz

[2]*New Zealand College of Chinese Medicine, Auckland, New Zealand*

[3]*Bond University, Gold Coast, Australia;* jkeogh@bond.edu.au

Introduction: Regular physical activity can result in a number of health-related benefits for prostate cancer patients and survivors (Antonelli et al., 2009). Regular physical activity can also help reduce some of the negative side effects related to androgen deprivation treatment (ADT). The aim of this study was to identify perceived motives, benefits, and barriers for physical activity in prostate cancer survivors. ***Methods:*** Sixteen prostate cancer survivors from the Auckland region of New Zealand were individually interviewed. Participants ranged in age from 57 to 88 years of age (71.3 ± 7.4 years). Time since diagnosis ranged from one year to 17 years (6.5 ± 5.6 years). Six men were currently on ADT treatment. Time on ADT treatment ranged between one and 17 years (5.3 ± 5.8 years). The remaining 10 men were in complete remission and were treatment free. Interviews were audio-taped and transcribed. Data were analysed using an inductive thematic approach. ***Results:*** Four main themes were identified regarding perceived motives for physical activity post diagnosis: (1) health-related reasons, (2) stress management, (3) social reasons, and (4) past history of physical activity. Three main themes were identified relating to perceived benefits for physical activity post diagnosis: (1) health-related benefits, (2) psychological benefits, and (3) cognitive benefits. Four main themes were identified relating to perceived barriers for physical activity post diagnosis: (1) incontinence and bowel issues, (2) pre-existing chronic health conditions, (3) lack of time, and (4) age-related decline. ***Conclusion:*** These findings indicate that some prostate cancer survivors are engaging in regular physical activity for physical health-related benefits, as well as for psychological benefits. If more men with prostate cancer are to benefit from being physically active, alterations in usual care practices and support services may be needed to offset some of their primary barriers and to maximise their motives for physical activity. ***References:*** Antonelli, J., Freedland, S.J., & Jones, L.W. (2009). Exercise therapy across the prostate cancer continuum. *Prostate Cancer and Prostatic Diseases, 12*, 110–115.

Influence of Poverty on Mobility and Fall Risks in Older Adults

Wollesen, Bettina; Bischoff, Laura; Mattes, Klaus

University of Hamburg, Hamburg, Germany; bettina.wollesen@uni-hamburg.de, laura.bischoff@uni-hamburg.de, klaus.mattes@uni-hamburg.de

Introduction: Socioeconomic inequalities are associated with reduced health and increasing morbidity with increasing age. There is evidence that a lower income might provoke frailty, morbidity, and institutionalization (Huisman et al., 2013). Moreover, social and economic factors are a risk factor for falls, especially in developing countries (Williams et al., 2015). The present study analyzes whether health characteristics of elderly persons differ due to their income situation in a comparatively wealthy neighborhood. ***Methods:*** N = 323 elderly adults were included in a quantitative survey (e.g., SF36, Barthel index, IADLs, general depression scale, fall risk assessment). The analysis considered household, age, gender, and income situation. Age, gender, and socioeconomic influences on falls, morbidity, and mobility were examined by chi^2-tests and multifactorial analysis of variance (e.g., gender × factor; status × factor) with IBM SPSS. ***Results:*** There were higher values of diseases for lower income than for higher income groups (F[316] = 2.971; p = .008; ηp^2 = .053). Lower income groups were more often classified into long-term care level 2 (Chi^2 = 25.36; p = . 009; C = 0.283), associated with reduced mobility, less physical and mental wellbeing, and a poorer health status. Falls risks were already cumulated for independent living seniors (> 5 risk factors) and increased for lower income levels (F[316] = 4.988; p = .007; ηp^2 = .032). Moreover, there were socioeconomic differences for physical wellbeing (F[225] = 3.4; p =. 034; ηp^2 = .029), GD (F[305] = 3.48; p = .032 ηp^2 = .022), and IADLs (F[305] = 3.14; p =. 045; ηp^2 = .02). Gender differences, with reduced performance for men, were only found for the IADLs. ***Conclusion:*** Even in a wealthy neighborhood, socioeconomic inequalities correlate with health risks, where multimorbidity reduced mobility and decreased daily functions. Interestingly, there were already high fall risks for independent living seniors, which increase with lower income. Moreover, we found reduced IADLs for the examined men. These findings lead to the suggestion of individual and setting-specific interventions to improve mobility and to prevent falls. Endeavors should be undertaken to improve prevention strategies to retain independence and quality of life for these older adults. ***References:*** Huisman, M., Read, S., Towriss, C.A., Deeg, D.J., & Grundy, E. (2013). Socioeconomic inequalities in mortality rates in old age in the World Health Organization Europe Region. *Epidemiologic reviews, 35*(1), 84–97. Williams, J.S., Kowal, P., Hestekin, H., O'Driscoll, T., Peltzer, K., Yawson, A., ... & Wu, F. (2015). Prevalence, risk factors and disability associated with fall-related injury in older adults in low-and middle-income countries: results from the WHO Study on global AGEing and adult health (SAGE). *BMC medicine, 13*(1), 1.

Why Older Adults Spend Time Sedentary and Break Their Sedentary Behaviour: A Mixed Methods Approach

Dontje, Manon L; Leask, Calum F; Harvey, Juliet; Skelton, Dawn A; Chastin, Sebastien FM

Glasgow Caledonian University, Glasgow, UK; Manon.Dontje@gcu.ac.uk, Calum.Leask@gcu.ac.uk, Juliet.Harvey@gcu.ac.uk, Dawn.Skelton@gcu.ac.uk, Sebastien.Chastin@gcu.ac.uk

Appendix 10

Poster Presentations

Jadczak, AD; Dollard, Joanne; Mahajan, Neha; Visvanathan, Renuka. Older peoples' perspectives on being advised about exercise - a qualitative study. 10th Florey Postgraduate Research Conference, 29 September 2016, National Wine Centre of Australia, Adelaide, SA, Australia.

Jadczak, AD; Tam, KL; Yu, S; Visvanathan, R. Medical students' perception of the importance of exercise and their perceived competency in prescribing exercise. 9th Florey Postgraduate Research Conference, 24 September 2015, National Wine Centre of Australia, Adelaide, SA, Australia.

Older Peoples' Perspectives on Being Advised about Exercise - A Qualitative Study

Agathe Daria Jadczak[1,2,3], Joanne Dollard[1,2,3], Neha Mahajan[1], Renuka Visvanathan[1,2,3]

[1] *Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Discipline of Medicine, School of Medicine, University of Adelaide*
[2] *Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide*
[3] *NHMRC CRE in Trans-Disciplinary Frailty Research to Achieve Healthy Ageing, University of Adelaide, South Australia, Australia*

INTRODUCTION

Exercise is considered the most effective strategy to treat, prevent and delay frailty, a prevalent geriatric syndrome observed in clinical practice

General practitioners (GPs) have the potential to increase older peoples' participation in exercise by providing exercise advice or prescribing exercise

However, little is known about older peoples' perspectives on being advised about exercise

OBJECTIVES

To understand the perspectives of community-dwelling older people who are frail or at-risk of frailty in relation to being advised about exercise and their perceptions of the GP's role in promoting exercise for older people.

METHODS

Semi-structured interviews were conducted with 12 community-dwelling older (mean 83.42 ± 5.99 years) participants screened frail or at-risk of frailty using the FRAIL Screen

Their attitudes towards exercise, the advice received, their access to relevant information and their perceptions of the GP's role in promoting exercise were explored

Thematic analyses was used to analyse data

Demographic information included age, gender, nationality, education, income and current exercise

The Physical Activity Scale For The Elderly (PASE) was used to determine participants' physical activity status

RESULTS

Participants had mostly a positive attitude to exercise and physical activity programs.

They indicated a preference for being advised firstly by their GP and then other health care professionals.

The majority of participants reported no or only limited recollection of exercise advice received from their GPs.

Participants reported difficulties accessing advice and information on exercise, and indicated that community councils and GP practices should promote exercise for older people more actively.

> "It was a lovely atmosphere, the people were lovely and we did exercise outside" (#1)

> "I have been to the local library and places like that, but I've never seen any advertisement. I just don't know where to get information" (#6)

> "At first point, it is our GP who should advise. Older people go to see their physicians naturally. So it is first the GP" (#10)

> "Neither of the doctors have ever discussed exercise with me" (#7)

Table 1: Participants' characteristics

Characteristic	Total participants (n=12)	Active participants (n=6)	Not active participants (n=6)
Age	83.42 (5.99)	83.33 (6.56)	83.50 (5.99)
Gender	8 females 4 males	5 females 1 male	3 females 3 males
FRAIL Screen	10 pre-frail 2 frail	5 pre-frail 1 frail	5 pre-frail 1 frail
Charlson Comorbidity Index	11 low 5-year mortality risk 1 high 5-year mortality risk	6 low 5-year mortality risk - high 5-year mortality risk	5 low 5-year mortality risk 1 high 5-year mortality risk
Income	8 Low 3 Average 1 High	3 Low 2 Average 1 High	5 Low 1 Average - High
Highest education	2 Primary School 5 Secondary School 5 Technical College 1 University	- Primary School 4 Secondary School 2 Technical College - University	2 Primary School 1 Secondary School 3 Technical College 1 University
Nationality	8 Australian 3 European 1 Asian	5 Australian 1 European - Asian	3 Australian 2 European 1 Asian
Participation in an exercise program	6 yes 6 no	5 yes 1 no	1 yes 5 no

Income per year: low (≤ $25,000), average ($25,000-$45,000), high (≥ $45,000)

CONCLUSION

Older community-dwelling people who are frail or at-risk of frailty have similar perceptions in regards to exercise and being advised on exercise as healthy older adults.

Nevertheless, considering the importance of exercise as a critical treatment component for this vulnerable population group and the significant role of GPs in advising older people on exercise, this research identified a gap in current practice.

This should be viewed as an opportunity where change might lead to increased participation in exercise by older people.

THE UNIVERSITY of ADELAIDE

The Institute

the hospital research foundation

Email: **agathedaria.jadczak@adelaide.edu.au**
Phone: **(08) 8133 4012**

Medical students' perception of the importance of exercise and their perceived competency in prescribing exercise

Agathe Daria Jadczak[1], Khai Loon Tam[1,2], Solomon Yu[1,2], Renuka Visvanathan[1,2]

[1] *Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, Discipline of Medicine, School of Medicine, University of Adelaide*

[2] *Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, Adelaide*

INTRODUCTION

With population ageing, there will be a higher prevalence of age-related diseases and subsequently, an increased burden on our health care system

Exercise is thought to be beneficial for numerous chronic diseases associated with ageing

Medical practitioner have the potential to increase older peoples' participation in exercise by providing exercise advice or prescribing exercise

However, physicians often cite the lack of medical school education as a barrier to them prescribing exercise

OBJECTIVE

To evaluate the effects of a 4.5-week geriatric medicine course on 5th year medical students' perception of the importance of exercise and their perceived competency in prescribing exercise.

METHODS

A modified version of the Exercise and Physical Activity Competence Questionnaire (EPACQ) was administered at the beginning and end of the geriatric medicine course in 2015

Scores ranged from 1 (not important or competent) to 6 (very important or competent); a score of ≥4 indicates self-perceived competency or importance

The original EPACQ was modified to include additional items relating to the benefits and risks of exercise, the referral to an exercise program and age-related limitations

One open ended question about perceived barriers to exercise prescription was also added

Paired t-test was used to determine change; significance level was set at $\alpha = 0.05$ (p-value<0.05*)

The questionnaire was administered to 66 students (33 female, 33 male; mean age 23 ± 1.6 SD)

RESULTS

Medical students' perceived competency increased significantly across all ten skills (p<0.001; Fig. 1).

With a higher average score at baseline, students demonstrated significant improvement in their perception of the importance of accurately determining the body mass index (p<0.001), identifying the nutritional needs of an older person (p=0.015), referring to an exercise program (p=0.003) and identifying age-related limitations (p=0.012; Fig. 2).

Barriers to exercise prescription identified by students included lack of knowledge (60.6%), lack of patients' compliance (39.4%) and lack of time (34.8%; Fig. 3).

Figure 1: Medical students' perceived competency

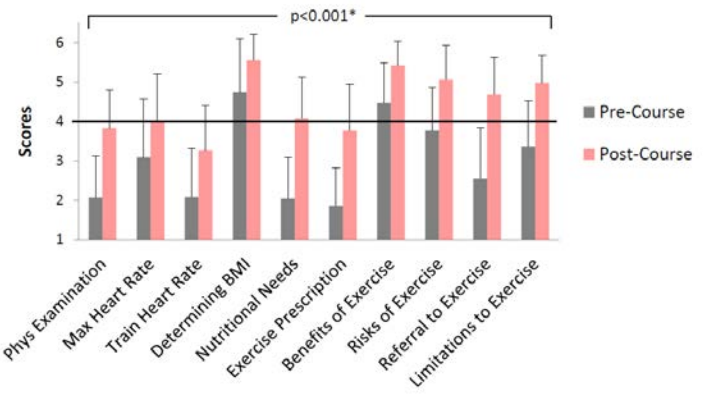


Figure 2: Medical students' perception of importance

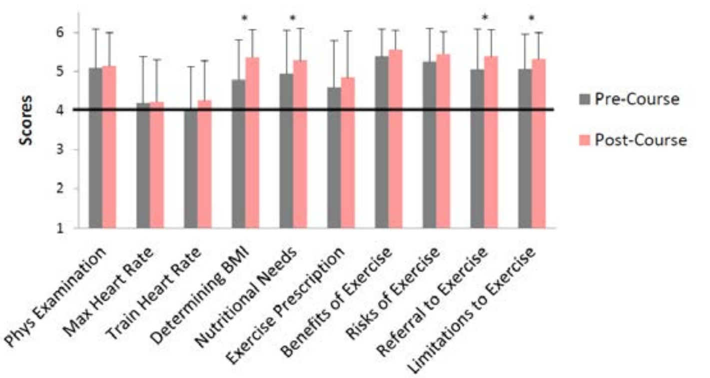
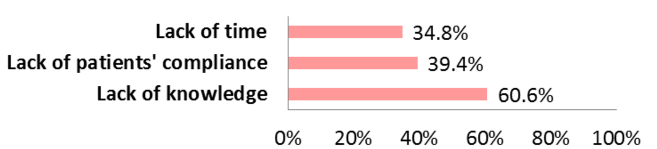


Figure 3: Barriers to exercise prescription



CONCLUSION

A geriatric medicine course for senior medical students contributes to improved student's perception of the importance of exercise as well as their perceived competency in prescribing exercise.

Nevertheless, there remains the opportunity for further gains and this will be investigated following enhancement to the course in relation to the exercise content next year.

Contact: Agathe Daria Jadczak Email: agathedaria.jadczak@adelaide.edu.au Phone: (08) 8133 4012

Appendix 11

Media Articles

Up-skilling our future doctors to prescribe exercise to older people, InformAge 2015, 2(4):12-13

Raising awareness of frailty - Spotlight on PhD, InCentral, 05/2016, p. 13.

UP-SKILLING OUR FUTURE DOCTORS IN PRESCRIBING EXERCISE TO OLDER PEOPLE

Agathe Daria Jadczak

Doctor of Philosophy Candidate
University of Adelaide

Agathe studied Sport Sciences in Germany and has worked as an exercise physiologist in several rehabilitation and therapy centres. She is currently pursuing a Doctor of Philosophy (PhD) with the Adelaide Geriatrics Training and Research with Aged Care (G-TRAC) Centre, School of Medicine, University of Adelaide and is based at the Basil Hetzel Institute in Woodville, South Australia. Her PhD supervisors are Professor Renuka Visvanathan (geriatrician, University of Adelaide, The Queen Elizabeth Hospital) and Dr Natalie Luscombe (CSIRO, University of Adelaide). For more information on the research and work being undertaken by the research team, please visit health.adelaide.edu.au/medicine/g-trac/.

The Word Health Organization expects the number of people aged 65 years and older to triple over the next 30 years. By 2050, nearly one quarter of Australia's population will be aged 65 years and above.[1] With increasing age, there is increased risk of frailty with resulting pressure on health care services as well as a risk of experiencing poorer quality of life. Frailty is a geriatric syndrome that is estimated to impact almost four million Australians by 2050.[2]

Exercise is beneficial for numerous diseases associated with ageing. Weight bearing exercise helps maintain bone and muscle mass, thus reducing the risk of falls and fractures. Balance and strengthening exercise help prevent falls. Aerobic exercise can help to prevent diabetes and impacts positively on blood pressure, thus reducing the risk of future cardiovascular events.[3] Therefore, there is no doubt that exercise is good for older people.

Even if the benefits of exercise are well known, the uptake of exercise in older people, and especially those who are frail, is poor; 45% of people aged over 65 years and 75% of people aged over 75 years don't meet the recommended level of physical activity.[4] People are increasingly leading a more sedentary lifestyle and report that the reasons why they might not exercise is because of health issues, environmental barriers, their own lack of knowledge and, sometimes, because their doctors might not have recommended exercise to them.[5]

General practitioners play an important role in helping increase awareness as well as encouraging older people to participate in exercise.[6] However, exercise for older people is not a focus of many undergraduate medical curriculums and is poorly taught across medical education programs.[7] In keeping with this, a recent review of United States medical curriculums suggests that over half of the physicians trained in the United States receive no formal education in exercise.[8] Another study similarly confirmed that 44% of medical schools in the United Kingdom were not teaching the government recommended guidelines for physical activity,[7] even though the importance of building the skills of medical students in relation to advising or prescribing exercise has been discussed for over 30 years.[9] Therefore, physicians may not be adequately prepared to assist patients with information about exercise and physical activity. It is therefore not surprising that many doctors cite that a lack of formal education courses during medical school is one reason why they might not prescribe exercise.[10]

Given our ageing demographic and the benefits of exercise in older people, the improvement of our medical teaching program is one critical strategy in building the future capacity of our medical workforce, thus equipping them with the necessary knowledge and skills that will ultimately result in greater participation in physical activity by our older consumers. Research investigating the effectiveness of medical school teaching programs relating to 'exercise for older people' is sparse. We know from the literature that more general courses to first and second year students about exercise (as opposed to specific for older people) improve student's perceived competency in prescribing exercise.[11,12]

Our research group therefore wanted to gauge the effectiveness of our current fifth year geriatric medicine teaching program at the University of Adelaide in one teaching campus. In 2015, we administered pre and post course surveys to our fifth year medical students undertaking our geriatric medicine program. Through these surveys we are investigating student perceptions about the importance of exercise for older people and their self-reported competency about prescribing an exercise program for older people. We expect to publish these results in 2016. We now aim to improve our teaching program based on these results, implement it in the 2016 curriculum and re-evaluate for any improvements to the student experience. Additionally, we also aim to determine if the effects of our teaching program are sustained upon graduation at the end of their sixth year. We hope that our research will inform medical curriculum development at universities for the benefit of older consumers. We hope that our medical students graduate with greater knowledge and skills and as future doctors they are likely to advise older people to participate in physical activity.

References

1. Kippen R (2002). 'The future extend of population ageing in Australia', Journal of Population Research, Special ed.:151-9.
2. Collard RM, Boter H, Schoevers RA and Oude Voshaar RC (2012). 'Prevalence of frailty in community-dwelling older persons: a systematic review', Journal of the American Geriatrics Society, 60(8):1487-92.
3. Taylor D (2014). 'Physical activity is medicine for older adults', Postgraduate Medical Journal, 90(1059):26-32.
4. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W and Ekelund U (2012). 'Global physical activity levels: surveillance progress, pitfalls, and prospects', Lancet, 380(9838):247-57.
5. Schutzer KA and Graves BS (2004). 'Barriers and motivations to exercise in older adults', Preventative Medicine, 39(5):1056-61.
6. Lawton BA, Rose SB, Elley CR, Dowell AC, Fenton A and Moyes SA (2008). 'Exercise on prescription for women aged 40-74 recruited through primary care: two year randomised controlled trial', BMJ, 337:a2509.
7. Weiler R, Chew S, Coombs N, Hamer M and Stamatakis E (2012). 'Physical activity education in the undergraduate curricula of the UK medical schools: are tomorrow's doctors equipped to follow clinical guidelines?', British Journal of Sports Medicine, 46(14):1024-6.
8. Cardinal BJ, Park EA, Kim M and Cardinal MK (2014). 'If exercise is medicine®, where is exercise in medicine? Review of U.S. medical education curricula for physical activity-related content', Journal of Physical Activity and Health, Dec 2.
9. Young A, Gray JA and Ennis JR (1983). 'Exercise medicine: the knowledge and beliefs of final-year medical students in the United Kingdom', Medical Education, 17(6):369-73.
10. Forman-Hoffman V, Little A and Wahls T (2006). 'Barriers to obesity management: a pilot study of primary care clinicians', BMC Family Practice, 7:35.
11. Jones PR, Brooks JH and Wylie A (2013). 'Realising the potential for an Olympic legacy; teaching medical students about sport and exercise medicine and exercise prescribing', British Journal of Sports Medicine, 47(17):1090-4.
12. Conroy MB, Delichatsios HK, Hafler JP and Rigotti NA (2004). 'Impact of a preventive medicine and nutrition curriculum for medical students', American Journal of Preventive Medicine, 27(1):77-80.

Raising awareness of frailty – Spotlight on PhD

Working as an Exercise Physiologist in Germany, Agathe Daria Jadczak quickly realised she had a strong connection with the elderly. Wanting to translate her skills into research, Agathe received a scholarship from the University of Adelaide and moved to pursue a PhD project centred on frailty.

Her project is divided into four research aims to ensure patients, medical students and general practitioners are aware of the best way to prevent and treat frailty.

"We are working on different strategies to prevent and treat frailty in the community and we are doing so by addressing it from different perspectives," Agathe said.

"This year I have been working with fifth year medical students to equip our future doctors better in prescribing exercise for older people, and raise awareness on the importance of exercise."

Agathe and her team will soon launch into the main part of the PhD, an exercise and nutrition intervention for frail older people living in the community.

The intervention will run over a period of six months and is based on past research that suggests exercise combined with protein intake might be more effective than exercise itself.

"One of my supervisors and her research team has just finished developing a 'super protein' which will be given to a third of the patients, along with a regular and a low concentrated protein supplement," she said.

"All groups will receive a similar home and centre based exercise program, so we can see what impact the 'super protein' has compared to a regular or a low concentrated protein supplement."

Not only will Agathe's project help decrease the burden on the health care system in the future, it will also allow frail older patients to gain back independence.

Agathe is a perfect fit for research in the area of frailty, having a strong connection with the elderly community.

BACK TO CONTENTS