Interventions for promoting physical activity to women aged 50 years and over

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BAppSc(Phty)

Thesis submitted in fulfilment of the requirements for the degree of

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Supervisor's statement

As the Primary Supervisor of Geraldine Wallbank's doctoral work, I certify that I consider her thesis "Interventions for promoting physical activity to women aged 50 years and over" to be suitable for examination.

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20 August 2025

Candidate's statement

This thesis is submitted to the University of Sydney in fulfilment of the requirement for the Degree of Doctor of Philosophy.

I, Geraldine Wallbank, certify that the intellectual content of this thesis is the product of my own work, and that all assistance received in preparing this thesis and all sources have been acknowledged. This thesis does not contain material which has been submitted in part or in full for any other degree at this or any other institution.

I, Geraldine Wallbank, understand that if I am awarded a higher degree for my thesis entitled "Interventions for promoting physical activity to women aged 50 years and over" being lodged herewith for examination, the thesis will be lodged in the University Library and will be available immediately for use. I agree that the University Librarian (or in the case of a department, the Head of Department) may supply a photocopy or microform of the thesis to an individual for research or study or to a library.

Geraldine Kit-Bing Wallbank

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Publications and Presentations

Parts of the work presented in this thesis has been published or presented in the following forms:

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Wallbank G, Traeger A, Kwok V, Elkins M. Sluggish adoption of simple methods that reduce bias: a longitudinal analysis of 35,653 physiotherapy trials. Oral presentation, World Physiotherapy Congress, Dubai UAE, 2 June 2023.

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Attribution statement regarding use of Artificial Intelligence

During my PhD candidature, Artificial Intelligence (AI) tools have become increasingly available and have expanded their use for learning and research.

In the preparation of this thesis, ChatGPT (https://chat.openai.com/) GPT-4o was used for troubleshooting technical challenges such as the EndNote reference library and Microsoft Suite; and conducting literature searches for a specific article. ChatGPT was used for minor editorial feedback and to refine the academic language of my own work such as grammar checks and providing feedback on sentence structure and clarity.

All AI-generated suggestions were critically reviewed and revised by the author to ensure academic integrity. Although occasional issues, such as fabricated references were encountered, the use of AI tools aided the candidate's learning and facilitated the resolution of formatting and technical challenges.

I, Geraldine Kit-Bing Wallbank, confirm that AI-usage adhered to the University of Sydney guidelines for use of generative AI in learning & assessment and I take full responsibility for the submitted thesis. All research and intellectual content remain entirely my own work unless otherwise cited.

Geraldine Kit-Bing Wallbank, 20 August 2025

Preface

This thesis is arranged in eight chapters, written so that each chapter can be read independently. The University of Sydney allows published papers that arose from the candidature to be included in the thesis.

Chapter 1 is an introduction to the thesis and provides the background to the importance of interventions for promoting physical activity among women aged 50 years and over.

Chapter 2 is a literature review of randomised controlled trials. It overviews the evidence about the features and efficacy of individually targeted remotely delivered interventions that promote choice-based physical activity on physical activity among mid-aged community-dwelling women.

Chapter 3 is a study protocol detailing the methodology for the *Active Women over 50* randomised controlled trial presented in Chapter 4. The protocol is presented as published in *BMC Public Health*.

Chapter 4 is a randomised controlled trial testing the effect of the *Active Women over 50* physical activity support intervention among employed women aged 50 years and over in Sydney, NSW, Australia. The trial is presented as published in *American Journal of Public Health*.

Chapter 5 is a qualitative study evaluating participants' perspectives of physical activity, participation in the *Active Women over 50* trial, and recommendations for future iterations. The study is presented as published in *BMC Public Health*.

Chapter 6 is a study protocol detailing the methodology for the *Active Women over 50 online* physical activity support pilot trial presented in Chapter 7. The protocol is presented as published in *Pilot and Feasibility Studies*.

Chapter 7 is a pilot randomised controlled trial testing the effect of the *Active Women over 50 online* physical activity support intervention among community-dwelling women aged 50 years and over residing across NSW, Australia. The trial is presented as published in *Translational Behavioural Medicine*.

Finally, **Chapter 8** is an overview of the body of work and discusses clinical implications and directions for future practice, research and policy.

Each chapter contains its own reference list. Ethical approval for the studies presented in Chapters 3, 4, 5, 6 and 7 was gained from the Human Research Ethics Committee at the University of Sydney prior to commencement of recruitment.

Abstract

The broad aim of this thesis was to investigate interventions for promoting physical activity to women aged 50 years and over. Interventions explored behaviour change support delivered in-person and remotely to women aged 50 years and over residing in NSW, Australia to increase physical activity participation. Research designs included two randomised controlled trials and a qualitative study of semi-structured interviews.

Physical inactivity is an important global public health challenge. It is directly responsible for premature mortality and increased disability, representing a major human cost. It also imposes a societal burden through increased healthcare expenditure and productivity losses. Physical inactivity is a significant contributor to the growing burden of chronic disease, particularly within an ageing population. Regular physical activity helps to address these challenges. Despite clear guidance from the World Health Organization about the amount and type of physical activity that adults need to undertake for health benefits, a third of the global population do not meet these recommendations.

Midlife is a crucial time to be physically active. It reduces all-cause risk for mortality irrespective of past physical activity levels, delays disability in women aged 70+ by up to 15 years, reduces the risk of falls, several chronic conditions and cancers. However, many women in midlife face unique challenges to being physically active, including multiple competing responsibilities of caring and working and focussing on their own health needs. In addition, there may be personal, cultural and structural barriers in midlife which can impact a woman's capacity to be physically active. Addressing these barriers through

targeted strategies grounded in behaviour change science, could help to increase physical activity in this population.

Women in midlife could benefit from strategies that support autonomy and empower behaviour change. Behaviour change occurs when people have the capability, opportunity, and motivation to act (COM-B), with motivation strengthened by autonomy, competence, and relatedness (Self-Determination Theory). Yet there are important evidence gaps regarding effective interventions for supporting physical activity behaviour change among women in midlife.

This thesis addressed gaps in knowledge by investigating the efficacy of interventions for increasing choice-based physical activity participation among community-dwelling women in midlife. A review of the literature is presented in Chapter 2, which investigated the features and effectiveness of individually targeted remotely delivered interventions that promote choice-based physical activity on physical activity among mid-aged community-dwelling women. Whilst the review found a moderate volume of evidence for interventions of this type, there was a scarcity that specifically targeted women in their mid-aged years. Studies reported a positive impact on physical activity either during the study period or at follow-up. Interventions typically delivered the content via multiple components which could be either scheduled, accessed 'on-demand', or accessed in real-time. The review concluded the lack of evidence for interventions specifically for women aged 50 years and over that promote physical activity and where low baseline physical activity was an eligibility criterion.

The study protocol for a randomised controlled trial is presented in Chapter 3. Objectives, methods, and procedures are outlined for the prospectively registered waitlist-controlled trial testing a 'low dose' physical activity support intervention. The template for intervention and replication (TIDieR) checklist is included for transparency and reproducibility. The population was university and health service employed women aged 50 years and over, residing in Sydney, Australia, who were physically inactive. The intervention included components which could be accessed using minimal technology and included an in-person information session held near the workplace, handbook of physical activity resources, inspirational peer-video case study stories, fortnightly motivational email messages, online private discussion group, loan of a wearable activity tracker. The primary outcome was proportion of women achieving 10,000 or more daily steps at 3 months post-randomisation. Results of the trial (n = 126) are presented in Chapter 4. The trial found a trend of increased daily steps favouring the intervention group (510 more steps/day (95% CI -69.9 to 1090, p = 0.08) following the well-received, simple intervention. At follow-up, all intervention participants had investigated or adopted one or more of the suggested intervention strategies, including the use of technology, and had made physical activity plans of which 90% were partially or fully achieved. It was concluded that a more intensive intervention was likely needed to impact physical activity outcomes in this population.

Perspectives of women aged 50 years and over were investigated in Chapter 5. Women who had participated in the *Active Women over 50* trial were purposively sampled to understand their experiences of physical activity in general, the *Active Women over 50* program, and recommendations for future iterations. The study found several factors shaped participants' capacity to be physically active related to personal, life-stage, cultural

factors and the tension these had with a self-responsibility discourse. Finding a suitable strategy for motivation was deemed critical to being active. The study concluded future programs could support women's agency to be active by facilitating social networks, accountability and positive framing.

Chapter 6 presents the study protocol outlining the refinement of a behaviour change physical activity intervention, and was built upon the work in Chapter 3, Chapter 4 and Chapter 5. The methodology is described and included the TIDieR checklist for the prospectively registered pilot randomised controlled trial. The aim was to test the feasibility and acceptability of a remotely delivered *Active Women over 50* physical activity support intervention. The population was broadened to include community-dwelling women aged 50 years and over across NSW, Australia. The intervention included telephone health coaching, website with tailor-made information, resources and inspirational peer-video stories, choice of SMS or email motivational messages. Primary outcome was a global measure of acceptability – the proportion of participants who would recommend study participation to another person like themselves. Secondary outcomes were feasibility measures such as study processes and intervention uptake; intervention impact measures such as device-measured physical activity, proportion of participants meeting physical activity guidelines; and intervention participant impressions of the intervention and adoption of strategies for physical activity participation.

Chapter 7 presents the results of the pilot trial. Global acceptability was high (83%), the relatively fast recruitment and high retention rates (14.5 weeks for 62 participants, and 96% respectively) and high intervention uptake of each component reflected participants who were motivated to receive physical activity support. Study processes and intervention

delivery were feasible. Telephone health coaching was delivered a median six days from initial invitation. The intervention increased physical activity, with more participants achieving a ≥2,000-step daily increase versus control (OR 6.31, 95% CI 1.22–32.70, p = 0.028). The study concluded that a remotely delivered behaviour change intervention was acceptable to mid-aged women in NSW Australia, was feasible to deliver and showed encouraging results on physical activity, warranting further testing in a fully powered trial.

This thesis addresses key gaps in the literature, providing robust evidence for the effectiveness of behaviour change interventions to support physical activity among women in midlife. This thesis outlines implications for practice, future research and policy. It informs future intervention design and justifies further testing in a fully powered trial of the intervention developed in the thesis for a scalable solution to the problem of physical inactivity among women in midlife.

CHAPTER 1. Introduction.

1.1 Authorship contribution statement

As primary supervisor, I confirm that Geraldine Kit-Bing Wallbank authored Chapter 1, Introduction. Critical feedback was provided from supervisors Professor Anne Tiedemann, Professor Cathie Sherrington and Associate Professor Anne Grunseit.

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank

20 August 2025

1.2. Physical activity

Physical activity provides comprehensive health benefits across the lifespan, regardless of race, sex, and weight status (1, 2). "If physical activity were a drug, we would refer to it as a miracle cure, due to the great many illnesses it can prevent and help treat" (3).

1.2.1 Definition of physical activity

The World Health Organization defines physical activity as "...any bodily movement produced by skeletal muscles that requires energy expenditure and can be performed at a variety of intensities, as part of work, domestic chores, transportation or during leisure time, or when participating in exercise or sports activities" (4). The term 'physical inactivity' describes insufficient physical activity levels and not meeting the global recommendations on physical activity for health (4).

The terms 'exercise' and 'sport' are subsets of physical activity. Exercise is "...planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective... generally referred to as physical activity performed during leisure time with the primary purpose of improving or maintaining physical fitness, physical performance, or health." (4) Sport is physical activity that has a competitive element which "...covers a range of activities performed within a set of rules and undertaken as part of leisure or competition." (4)

1.2.2 Benefits of physical activity

Strong evidence shows that being regularly physically active is key in tackling the problem of chronic diseases. Physical activity can prevent or reduce the risk of all-cause mortality,

cardiovascular disease mortality, dementia, many cancers (bladder, breast, colon, endometrial, adenocarcinoma of the oesophagus, gastric, renal, lung cancer), weight gain, hypertension, type 2 diabetes, reduce the rate of falls and the risk of injury from falls in older adults (5), and improve cognition including in individuals with dementia (4).

In addition to reducing the risk and impact of medical conditions, there is compelling evidence that physical activity improves strength, balance and motor skills (6, 7), maximises bone health, manages pain, improves sleep, physical function, cognitive function, and reduces the risks and symptoms of anxiety, depression and developing cognitive impairment (4). Physical activity also offers immediate benefits for cognitive health and wellbeing. A single bout of physical activity improves attention, memory, processing speed, executive functioning (4), self-esteem, confidence and happiness (8).

Physical activity provides benefits at a societal level, through opportunities for bringing people together thereby reducing social isolation and improving social cohesion. People from diverse backgrounds can connect through physical activity. Economically, physical activity reduces the cost to the health sector through improved health outcomes, and improves employment rates and an individual's employability (8).

1.2.3 Physical activity guidelines

The World Health Organization has set clear guidance on the amount and type of physical activity for all ages and different health conditions to achieve health benefits. Adults are recommended to participate in 150 to 300 minutes per week of moderate-intensity physical activity or 75 to 150 minutes per week of vigorous-intensity physical activity or an equivalent combination of moderate- and vigorous-intensity activity for substantial health benefits (4). It is also recommended that adults undertake muscle strengthening exercises

for all the major muscle groups on at least 2 days per week. Additional benefits are achieved by doing more than the recommended amount of moderate- and vigorous-intensity physical activity (4).

The guidelines describe the level of physical activity intensity in relation to an individual's capacity. Moderate-intensity physical activity is described as moderate or somewhat hard aerobic activity that can be maintained while holding a conversation uninterrupted and subjectively measures 3 or 4 on the Borg Rating of Perceived Exertion (RPE) scale from 0 to 10 (9). Vigorous-intensity physical activity is described as hard aerobic activity in which a conversation generally cannot be maintained uninterrupted and subjectively measures 5 or 6 on the RPE scale (9).

Despite physical activity having wide-ranging benefits for society and there being well-defined guidelines for the amount and type of physical activity required for health benefits (4, 10), global trends for chronic disease reveal that the evidence is not being implemented at scale.

1.3. Chronic diseases

Chronic diseases are a major global health problem (11, 12). Due to their progressive nature, chronic diseases can lead to declining health, increased disability and potentially premature death. In 2021, chronic disease groups such as cardiovascular disease, cancers, diabetes, and chronic respiratory diseases accounted for 74% of all deaths worldwide, killing 43 million people (11, 12). For 17 million people, these deaths occurred before the age of 70 years (12).

The problem of chronic diseases is not fully captured by mortality alone. Living with chronic disease results in loss of health, in disability, and reduced productivity and quality of life for individuals. The number of people living with a chronic disease has increased by 15% over the past 20 years (13) and now an estimated 7.2 billion people die prematurely or live with disability caused by chronic diseases worldwide (11). This corresponds to 1.73 billion disability-adjusted life years lost (DALYs) in 2021, an increase from 50% of total DALYs in 1990 to 60% of total DALYs in 2021 (11), where one DALY measures the loss of one healthy year caused by living with illness and disability.

Australia is a well-resourced country but an estimated 81.4% of Australians live with an illness or disability caused by chronic disease (14), corresponding to a loss of 5.8 million years of healthy life (DALY), or 0.2 DALY per person (15). Unsurprisingly, those with chronic diseases have higher health service usage. In 2015, people with three or more long-term health conditions had 20% more hospitalisations and 15% more emergency department presentations compared to those without long-term health conditions (16).

1.3.1 Risk factors for chronic disease

Various factors contribute to the rise in chronic disease rates, including urbanisation, rise in income, availability of processed foods and changes in diet. These changes have resulted in a mostly overweight and physically inactive population (17). This thesis will focus on two major contributors to the growing challenge of chronic diseases: physical inactivity and an ageing population.

1.4. Physical inactivity

Certain lifestyle behaviours increase the risk of chronic disease by contributing to hypertension, obesity, and elevated blood glucose and lipid levels. Physical inactivity ranks alongside tobacco use, unhealthy diet, and harmful alcohol consumption as leading yet modifiable risk factors for chronic disease (18). Addressing physical inactivity, through increased physical activity may help prevent the onset or lessen the progression of chronic conditions.

Globally, an estimated 33.8% of adults do not participate in sufficient regular physical activity (19). This alone, is responsible for 5.3 million deaths (1). Using International dollars (INT$) to allow comparison between countries based on World Bank purchasing power parity, physical inactivity costs health care systems INT$67.5 billion, and economies INT$13.7 billion in productivity losses through work absenteeism every year (20). Data from a worldwide cohort prevalence study estimates that physical inactivity alone is responsible for between 6-10% of chronic disease from breast cancer, colon cancer, all-cause mortality, type 2 diabetes and coronary heart disease (1). An estimated 4 to 5 million deaths could be avoided if populations were more active (1). Even if the proportion of people meeting physical activity guidelines improved by 25%, an estimated 1.3 million deaths would be prevented each year (1).

1.5. Population ageing

1.5.1 Demography

We are living in unprecedented times where the global population is growing and rapidly getting older (21). Mortality rates have reduced and now people in all world regions can

expect to live to 71 years, twice as long as their ancestors in the 1900s (21, 22). This is a great medical achievement.

Australia is a well-resourced nation with a population average life expectancy of 83.2 years (23). Over the past 40 years the Australian population has grown significantly in both size and age, and this trend is expected to continue. The population has increased by 73%, from 15.7 million in 1984 to 27.11 million today, while the average age has risen from 33.1 years to 39.5 years. In the next 40 years, the population is projected to reach 43.2 million, with average age 43.3 years (24).

1.5.2 Challenges of ageing

1.5.2.1 Chronic diseases

Despite living longer lives, there has not been a corresponding increase in the quality of life during those later years. As people grow older, they are more likely to be living with multiple chronic conditions (25). The proportion of Australians living with 2 or more long-term health conditions rises from 63% for adults aged 25-34 years, to 87% for adults 45-64 years (14). Most Australians aged 75 years and over, live with 2 or more long term health conditions (97%) (14) and those aged 85 years and over live with an average of five long-term health conditions (25). As chronic diseases become more common in an ageing population, there is an urgent need for interventions that improve quality of life, recognising that poor health in older age is not inevitable.

1.5.2.2 Falls

Falls are a major global health problem, ranking as the world's second-highest cause of death by unintentional injury. Falls results in 640,000 deaths annually and are the leading

cause of disability for 172 million people (26). Fall-related injury burden on society shows little sign of easing. In 2021, there were 41,600 fall-related injury hospitalisations in Australia that occupied 395,200 annual bed days and cost the health system $752 million. By 2041, this will rise to a projected 60,300 fall-related injury hospitalisations which will need 543,400 annual bed days, and will cost the health system $1.09 billion per year (27).

Older age is a risk factor for falls. Among older adults who present to hospital emergency departments with an injury, 75% are the result of a fall (28). Of all adults aged 65 years and over, a third have had at least one fall in the community, (29) with 10% of these resulting in injury (27). Unfortunately, individuals admitted to hospital following a fall are 3.5% less likely to return home compared to those admitted for other reasons (30).

The impact of falls can persist even when no injury is sustained. Individuals may report a lasting fear of falling or loss of confidence while walking, which can lead to a cycle of activity avoidance and declining physical functioning. These can result in physical dependency, loss of independence, and a recurring pattern of falls and fall-related injuries (31-33).

However, falls are not a problem confined to older age and there are gender differences in their occurrence. Large cohort studies of more than 18,000 participants show that women in midlife years are 27% more likely to fall than men across Australia, Ireland, the Netherlands and United Kingdom (34). Additionally, women who are physically inactive and experience poor mobility or urinary incontinence face an increased risk of falling (35, 36).

A 2023 analysis of the Australian longitudinal cohort data of over 7,000 women has established the link between physical activity levels and risk of falling (37). Older women who met or exceeded the WHO recommended guidelines of 150 to 300 minutes of weekly moderate intensity physical activity, had a reduction in the odds of falling either with injury (OR, 0.66; 95% CI, 0.53-0.82) or without injury (OR, 0.72 (95% CI, 0.58-0.90) (36, 37). These studies provide compelling data that firstly, physical activity can reduce the risk of falls, and secondly, that the timing of interventions is important. Fall prevention interventions that include physical activity must be applied in midlife, before women reach older age.

1.5.2.3 Physical disability

Physical function declines in older age, and can reach a point of disability resulting in long-term dependence on others for assistance with daily tasks (25, 38). Today, disability affects 39.8% of older Australians (25). The age at which physical disability occurs is not predetermined but can potentially be delayed depending on physical activity levels in earlier years (38, 39). While there is no difference in physical independence between those who are inactive and those who engage in high levels of physical activity in younger years, disparities in independence begin to emerge in midlife. Physically inactive women in midlife begin to experience decline in physical functioning compared to physically active peers. By older age, physically inactive women are more likely to live with disability, have poorer physical functioning, less independence and require assistance with daily tasks. In contrast, physically active older age peers can delay disability by up to 15 years (38, 39).

1.5.2.3 Cognitive decline

Cognitive decline, including impairments in memory and executive function, occurs with age and can range in severity from mild cognitive impairment to dementia. Dementia

profoundly impacts independence and health and affects 5% of older Australians, their families, caregivers, health system and society (25). Physical inactivity is one of 12 modifiable risk factors for developing dementia, alongside factors such as hearing loss, low education, smoking, depression, social isolation, traumatic brain injury, hypertension, air pollution, diabetes, excessive alcohol use, and obesity. Addressing these risk factors could prevent or delay up to 40% of dementia cases. (40). Engaging in regular moderate-to-vigorous physical activity during midlife has been associated with improved cognitive function in later life (40) reducing the risk of dementia over at least a 10-year period (41), particularly among women (42).

1.6 Physical inactivity, ageing and gender

1.6.1 Physical inactivity and ageing

Physical inactivity is a challenge across the lifespan, worsening with increasing age. Of Australians aged 18 to 24 years, one-third (34%) did not meet the recommended physical activity guidelines in 2022 (43). This proportion rose to 42% for adults aged 55 to 64 years, and further to 57% for those aged 65 years and over (43). Over 7 in 10 adults aged 18-64 years did not meet the recommended muscle strengthening guidelines. Of those who do no muscle strengthening, the proportion worsens with age – 89% of people aged 18-34 years and 94% of those aged 55-64 years (43).

Physical activity is key to healthy ageing. Many older Australians may become more physically active in retirement (44-46) particularly if they were sedentary in employment (47). But this may be too late to prevent the onset of disease and disability. Additionally, the trend for retirement age has increased from 62.2 years in 1984 to 65.4 years in 2023 (48)

with the rise of the Australian Age Pension eligibility age to 67 years, which further delays the typical age that people could become more physically active.

1.6.2 Physical inactivity and gender

Compared to males, females are more sedentary (49) and fewer meet the physical activity guidelines (43, 50). This trend exists across the lifespan. For adults aged 18-24 years, 63% of females compared to 68% of males aged 18-24 years meet the guidelines; in adults aged 55-64 years, 56% of females compared to 60% of males meet the guidelines; and among those aged 65 years and over, 40% of females compared to 47% of males meet the guidelines (43). Across all ages, 76% of women fail to reach the muscle strengthening guidelines compared to 71% of men (43).

While many factors may contribute to physical inactivity, particularly for older women, starting regular, sufficient physical activity is crucial for maintaining independence and reducing physical decline with age.

1.7 Physical activity in midlife-aged women

1.7.1 Definition of midlife

'Midlife', 'midlife age', 'mid-age years' is the phase of life between young adulthood and older age, where adults transition from being young to growing old. The mid-age years are characterised by age-related physiological, psychological and social changes (51). This thesis defines older age as 65 years and over, and the preceding stage of adulthood as 'midlife age', 'midlife', or 'middle-age years' which span from 50 to 64 years of age (52).

1.7.2 Physical activity in midlife

While healthy lifestyles and prevention are important across the lifespan, health in midlife is a determining factor of functional capacity in later life (51). Initiating physical activity before the onset of disease, disability, or entry into older age provides the greatest opportunity to support healthy ageing. Midlife represents a key window for preventive action - reducing risk of injury, minimising disability, and promoting long-term health and independence.

Physical activity commenced in midlife reduces the risk of all-cause mortality regardless of a person's established risk factors, history of cardiovascular disease and cancer (53), their physical activity levels in younger years, and regardless of the physical activity intensity undertaken (54). The benefits of physical activity in midlife on health-related quality of life are comparable regardless of body mass index (55). Economically, cost-savings have been reported for women in their 50s and 60s and for the health system when physical activity is maintained or increased over a 3-year period (56). This is great news for people in midlife, particularly for Australians living with health conditions or those who have not previously engaged in physical activity.

1.7.3 Barriers to physical activity for women in midlife

Women in midlife years face complex challenges that are unique to their life stage and gender which often impact their ability to adopt and maintain regular physical activity participation. These include the challenges of time, health and bodily changes, resources and rurality, and societal roles and attitudes.

1.7.3.1 Time

Usage of time can be characterised by the types of activities performed (57). These include necessary activities such as sleeping and self-care; paid work and education; unpaid roles; and free time activities. On average, people spend the same amount of time on necessary activities, but there are differences between the sexes for unpaid time, paid time, and free time activities (57).

1.7.3.1.1 Unpaid time

Unpaid activities are important activities that contribute to households and benefit society, and include carer roles, domestic tasks and voluntary work. While both sexes participate in unpaid activities, data for people aged 15 years and over show that females spend longer in these (4.2 hours per week) compared to males of the same age (2.7 hours per week) (57).

The total number of primary carers increases with increasing age peaking in the middle-age years before tapering off from 65 years and over with more females than males represented across age groups (57). Some age groups have at least twice as many female primary carers as males. For example, in Australia among those aged 55–64-years old, there are 148,000 female primary carers compared to 57,000 males. Also, for primary carers aged 45-54 years, the number of females is nearly three times higher than males (148,300 compared with 50,100) (57). The trend is also seen in domestic activities, where females are more likely to participate in domestic activities (93%) than males (82%). The tendency continues for unpaid voluntary work, whether providing informal support to non-household members or formal volunteering performed through an organisation. A higher proportion of females provide unpaid services to others through volunteering (26%) compared to males (23%) (58).

1.7.3.1.2 Paid time

There is a difference between the sexes for the time spent in paid work and education. On average, males spend more time per day in paid work or education (4.3 hours) compared to females (3.1 hours) (57). Yet a high proportion of women in their midlife are seeking employment. The labour force participation rate considers the proportion of people who are either employed or actively seeking paid work. For females aged 50-64 years the labour participation rate is 73%, 10% higher than across all other female age groups (59). Moreover, almost half (47%) of employed adults describe their day at work as mostly sitting (60) which puts all working adults at risk of conditions associated with physical inactivity (61).

1.7.3.1.3 Free time

Free time activities include social and community interactions (e.g., attending events, dining out, religious or cultural practices) and recreation or leisure pursuits (e.g., exercise, sport, outdoor activity, reading, games, watching TV, internet usage, listening to music; hobbies and arts). People spend most of their free time primarily watching TV and videos followed by doing hobbies and art. Australian males spend an average 5.5 hours per day in free time compared to females (5 hours per day) (57, 62).

Among those who participate in exercise, sport and outdoor activity, Australian females spend less time in physical activity for fitness, recreation, sport or transport in every decade throughout adulthood than males each day (62, 63). The largest difference between the sexes in the time spent participating in exercise, sport and outdoor activity is for people aged 40-54 years with males spending 43 minutes per day more than females (1 hour 54 minutes per day compared with 1 hour 11 minutes respectively) (62).

1.7.3.2 Health and bodily changes

Many midlife-aged Australians live with health challenges. A 2022 snapshot report reveals that among midlife-aged Australians, 60% live with one or more chronic condition (64) and 25% (males 24%, females 27%) live with a disability (25). Regular physical activity can be an additional challenge for people living with health conditions or disability or where assistance may be required to perform everyday tasks.

Physical changes to a woman's body in midlife can present significant obstacles to physical activity and include but are not limited to symptoms of menopause, and urinary, bone, joint and cardiovascular health. Symptoms experienced by women in midlife associated with menopause and perimenopause such as hot flushes, night sweats and mood swings (65), may be a normal part of ageing, but they can affect a woman's capacity to be physically active. Urinary incontinence, experienced by more than a third of midlife-aged women, is also associated with lower physical activity levels, avoidance of exercise and sport (66) and increased risk of falls (35). In midlife, women often experience these symptoms alongside musculoskeletal conditions such as low back pain (67), arthritis and osteoporosis (68) which comprise almost 40% of chronic conditions experienced in Australia in 2022 (69). These conditions are increasing in prevalence globally, particularly among adults aged 45-59 years (70) and among women (71), and can present additional obstacles for participating in physical activity.

1.7.3.3 Resources and rurality

Adequate resources play an important role in determining participation in physical activity (72, 73). Access to physical activity facilities, programs, trained staff or location-specific characteristics may vary greatly depending on place of residence. According to the 2022 National Health Survey, 18% of adults living in areas of socioeconomic disadvantage did no

physical activity and only 22% met the 2014 Australian Physical Activity Guidelines, where aerobic activity was calculated in 10-minute bouts (74). This contrasts to areas of socioeconomic advantage where the proportions were 8% and 30% respectively (14).

Geographical settings show notable disparities in physical activity levels (73). Urban settings with higher population densities, better infrastructure and more facilities commonly offer additional structured opportunities for physical activity. This contrasts with regional and rural settings, which have more natural spaces, but often have fewer facilities, limited infrastructure and transport options, and less access to professional guidance for health. In regional areas, 18% of Australian adults do no physical activity and only 21% meet the physical activity guidelines, compared to 10% and 25% respectively for urban-dwelling counterparts (14).

1.7.3.4 Societal attitudes

Societal attitudes toward women in midlife can hinder their motivation to engage in physical activity. Gendered roles and the cognitive load of domestic responsibilities impact how women allocate their time (75, 76). Many women experience body dissatisfaction due to age-related changes, such as wrinkles, body shape, and physical ability, combined with unrealistic Western beauty ideals (77). Regardless of body mass index, a woman's perception of her body (77, 78) and her attitudes toward physical activity (77) can significantly influence her participation and the location she may choose to be active (79). Finally, there can be systemic barriers within health facilities such as limited availability of class levels or formats tailored to women in midlife, which can further discourage participation in physical activity (80, 81).

A life course perspective of physical activity acknowledges that levels of participation in physical activity can fluctuate throughout the lifespan due to age-specific events (82, 83). For younger women, physical activity can decrease following childbirth (84) and for older women, physical activity decreases as health problems increase (56). In midlife, physical activity levels can decrease alongside age-related physiological changes (51), retirement, death of a spouse, or other stressful events (82). While physical activity may fluctuate during significant life events, the transition to changed life circumstances can also offer a window of opportunity to adapt and adopt new healthier behavioural habits such as physical activity (83).

1.8 A framework for increasing physical activity

The Global Action Plan on Physical Activity 2018-2030 was developed by the World Health Organization with a vision for "more active people for a healthier world" (85). The action plan aimed to provide countries with a framework for increasing physical activity at all levels of societies. The action plan set a target to improve physical activity by 15% in people of all ability levels across the lifespan by 2030 through four objectives: (1) create active societies, (2) create active environments, (3) create active people, and (4) create active systems (85). This thesis centres on the WHO priority 'Creating active people' (85) and investigates individual-level interventions for promoting physical activity participation among women in midlife years.

1.9. Increasing physical activity among women in midlife

Women in midlife could benefit most from physical activity interventions that are not only evidence-based but also tailored to their needs and designed for long-term sustainability (86, 87). A feasible solution to enhance physical activity among this demographic involves

interventions that combine behaviour change models with an efficient and scalable approach, and consideration of contextual needs of women in this age group.

1.9.1 Behaviour change framework

Increasing physical activity requires a change in the behaviour of one's lifestyle and this increase is more likely to occur when behaviour change science informs the intervention (88). Behaviour change theory and frameworks articulate established principles of human behaviour and incorporate tested knowledge to guide solutions. Many well-recognised behaviour change theories are used in health psychology and health promotion to understand and influence health behaviour. This thesis focuses on two frameworks: Self-Determination Theory (89-92) and the Behaviour Change Wheel (93).

Self-Determination Theory (SDT) helps to understand why a person engages in a behaviour. Regarding physical activity, SDT states that being physically active is driven by three psychological needs: autonomy (control over actions), competence (confidence in performing physical activity), and relatedness (feeling supported by others) (89-92). When an individual chooses a physical activity that they enjoy or find meaningful, the likelihood of satisfying the needs for autonomy, competence and relatedness are higher. This also improves the likelihood of sustaining physical activity.

The Behaviour Change Wheel (BCW) assists intervention design by helping to understand how to create conditions to enable a desired behaviour (93). The BCW incorporates the COM-B framework which describes the interaction between necessary conditions: capability (C); opportunity (O); and motivation (M) which drive behaviour (B). The BCW also provides a range of options to address a deficiency in any of these conditions by nine 'intervention functions': education, persuasion, incentivisation, coercion, training,

enablement, modelling, environmental restructuring, and restrictions. The BCW also describes seven categories of policy, such as guidelines, fiscal measures, regulation, service provision, legislation, communication/marketing, and environmental/social planning, that could enable and support intervention functions to occur and be delivered (93). Behaviour Change Techniques (BCTs) are the active ingredients of the intervention, 93 techniques from the BCT v1 taxonomy and grouped into 19 categories, such as goals and planning, feedback and monitoring, social support, shaping knowledge, comparison of behaviour (94).

Collectively, the frameworks of SDT, BCW and COM-B suggest that behaviour change is more likely to be effective when an intervention supports agency and autonomy, such as promoting choice-based physical activity; and includes targeted strategies such as capability-building, motivational support, and environmental restructuring.

1.9.1.1 Choice-based physical activity

Offering participants a choice in how they engage in physical activity supports autonomy and enjoyment, factors known to promote sustained behaviour change, and may enhance intervention uptake, engagement and sustainability. According to the Self-Determination Theory, the key to behaviour change is for an individual to find an activity that they enjoy or find purposeful. An intervention that supports choice-based physical activity, whether it be structured or unstructured, is fundamental to fostering the adoption and adherence to physical activity participation in the long-term (95).

1.9.2 Efficient and scalable interventions

Given the scale of the problem of physical inactivity, it is essential that physical activity interventions are designed pragmatically to reach as many people as possible and to sustain the impact for as long as possible (96). Interventions need pragmatic and resource-efficient solutions which may involve integrating existing services and previously allocated resources instead of reinventing them (97).

Delivering interventions at a 'low dose' or with minimal program support is another possible solution for efficiently allocating resources if proven effective. These could include brief health education sessions that are incorporated to health appointments (98) or the provision of targeted self-help materials (99). Another way to minimise program support is through physical activity interventions that enable self-directed access to intervention content via internet connected digital technologies to access websites, digital messages, online groups, smartphone applications, virtual and augmented reality video games (100, 101).

Efficiency involves selecting resources that are easy to access and use, including readily available technologies that require minimal technical skill. This is an important consideration not only for delivering the intervention, but also for its recipients. Minimising the burden imposed by the intervention on potential participants is essential, as excessive demands may act as a barrier to engagement (102). Interventions that rely on expensive technologies or high-speed internet may unintentionally burden participants to acquire suitable devices, may exclude those living in socioeconomically disadvantaged areas or regions with limited connectivity.

1.9.3 Meeting the needs of women in midlife

To be effective and sustainable, physical activity interventions need to meet the needs of end users. Public health interventions that use a co-design approach and engage end users in the intervention development process can enhance the applicability, efficacy and long-term impact of the intervention (103-106). So it is crucial to include midlife-aged women in the design or refinement to ensure physical activity interventions are appropriate and relevant to their needs. Successful interventions such as culturally tailored approaches have demonstrated the importance of customising the approach for the intended population to enhance effectiveness (107). Incorporating diverse perspectives of women in midlife in the context of physical activity and intervention design, broadens the applicability of the intervention and improves the possible impact on physical activity (87).

1.10. Evidence gaps for increasing physical activity among women in midlife

While the current body of literature provides strong evidence for the benefits of physical activity across the lifespan and health conditions, there are notable gaps in the research for how to best to support the adoption and maintenance of physical activity, particularly for women in midlife.

Evidence gaps remain regarding the efficacy of behaviour change interventions that target women in midlife to increase physical activity. In particular, there is a gap in the evidence for interventions with multiple components that support the participation in choice-based physical activity, either structured or unstructured physical activity (108). There is also an evidence gap for interventions that could be delivered efficiently either in-person or remotely, or that could be applied across diverse resource or geographical settings, or which avoid incentives or gamification. These are important considerations in planning for

sustainable solutions at a population level. Finally, there is a lack of evidence that integrates the perspectives of midlife-aged women about their experiences of physical activity and their recommendations for what would constitute effective support to ensure intervention support was relevant, appropriate and met the needs of the intended population (107).

Addressing these gaps could inform program design, policy and funding, and would reduce societal burden while improving productivity and quality of life by empowering and supporting women for long-term participation in physical activity for healthy and independent ageing.

1.11 Aims and structure of thesis

The broad aim of research in this thesis was to investigate the efficacy of interventions for increasing choice-based physical activity participation among community-dwelling midlife-aged women and contribute to the evidence-base for this demographic. The guiding principles of the physical activity interventions were efficiency, sustainability and flexibility, and underpinned by behaviour change science. Methods used to address this aim included a literature review, two clinical trial protocols, two randomised controlled trials, and a qualitative study.

Specific aims of this thesis are to:

1. Conduct a literature review to identify effective interventions for increasing physical activity in midlife-aged women (Chapter 2).
2. Describe the design and methods of a low-dose physical activity intervention for employed women for effectiveness testing (Chapter 3)

3. Conduct a randomised controlled trial to test the effectiveness of a low-dose physical activity support intervention among employed women compared to a waitlist control group (Chapter 4)
4. Describe the perspectives of women aged 50 and over in the design of physical activity interventions (Chapter 5).
5. Describe a remotely delivered physical activity intervention, designed with end-user input for supporting women aged 50 years and over with physical activity (Chapter 6).
6. Conduct a pilot randomised controlled trial to test the feasibility, acceptability and potential impact of a remotely delivered physical activity intervention for community-dwelling women aged 50 years and over compared to a waitlist control group (Chapter 7).

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CHAPTER 2. Physical activity interventions for community-dwelling women aged 50 years and over. A literature review.

2.1 Authorship contribution statement

As primary supervisor, I confirm that Geraldine Kit-Bing Wallbank authored the chapter, “Physical activity interventions for community dwelling women aged 50 years and over. A literature review.”. I confirm that Geraldine Kit-Bing Wallbank contributed to this study in each of the following areas:

- Conception and design of the research
- Designed the search strategy, conducted the search, screening, data extraction and analysis
- Writing of the manuscript and critical appraisal of the content

Critical feedback was provided from supervisors Professor Anne Tiedemann, Professor Cathie Sherrington, Associate Professor Anne Grunseit.

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank

20 August 2025

2.2 Preamble to Chapter 2

Understanding the current evidence is an important first step in testing interventions to promote physical activity for women in midlife. This chapter provides a review of the literature for interventions promoting physical activity in a community setting. The review sought to understand the characteristics of studies and interventions that were delivered remotely, the intervention content and method of content delivery, efficacy of these interventions, and to identify evidence gaps for physical activity interventions that target women in midlife.

2.3 Background

Physical activity has physical and mental health benefits (1, 2). There is strong evidence that physical activity prevents chronic disease (3), prevents falls and promotes independence in older age (4). However, participation in physical activity worldwide is suboptimal, with 33.8% of adults failing to meet the WHO recommended physical activity guidelines (5). The consequences are significant not only at an individual level but also at a societal level. Each year, physical inactivity is responsible for an estimated 5.3 million deaths worldwide (1), productivity losses through work absenteeism costing INT$13.7 billion, and INT$67.5 billion in costs to health systems (6).

Women in midlife face unique challenges to being physically active. Many balance the demands of caring for their children, grandchildren, and ageing parents whilst dealing with the demands of employment, their own health conditions and age-related menopausal bodily changes (7). These challenges can leave them with limited capacity to focus on their own health and well-being. A physical activity intervention that targets this demographic could provide the support to adopt and maintain physical activity for the long term. Midlife, mid-age, mid-age years is the phase between young adulthood and older age and has been defined in this review as 50 to 64 years of age (8).

Given the widespread problem of physical inactivity, it is essential to implement physical activity interventions that are both efficient and sustainable across various geographic and socioeconomic contexts. An intervention grounded in behaviour change science and designed to support participants' autonomy is more likely to be effective (9). Flexibility in the time and place that the intervention can be accessed is another important feature for this demographic.

Interventions that can be delivered remotely using internet and telecommunication systems, may offer an efficient way to provide physical activity support. These systems offer wide reach across geographic settings, are low-cost to deliver, and offer the convenience of access to the end user. The purpose of the literature review was to determine the current evidence for remotely delivered interventions which support choice-based physical activity for community-dwelling women in their midlife years.

Key questions addressed in this literature review were:

1. What are the characteristics of individually targeted interventions that are remotely delivered and promote choice-based physical activity which report physical activity effectiveness among mid-aged community-dwelling women?
2. Among the identified physical activity interventions, what components were used to deliver them, and what content was delivered through each component?
3. Among the identified physical activity interventions, what was the reported impact on physical activity?
4. What are the recommendations for future remotely delivered physical activity interventions that target community-dwelling women in midlife?

2.4 Methods

This review was conducted using the Cochrane Rapid Reviews Methods guidance (10) as a framework, although not every step was followed in detail. The Medline (Ovid) database search was performed on 13 September 2024 using the PICo framework (11): adults aged 45 and over (Population), physical activity (Intervention), remote delivery of the intervention (Context).

The search strategy (Supplementary File) used keywords relating to community-dwelling adults in their mid-age years (eg. 45 year* or 50 year* or middle age* or post#menopaus* or

community), and physical activity (eg. physical* active* or active ag#ing or exercise*), and theory or behaviour (eg. behavio#r change or self#determinat* theory or motivate* or facilitate* or barrier*) and remote or minimal face-to-face delivery of the intervention (eg. deliver* or program# or health coach* or online or digital or messag* or email or website* or online#group or Facebook). The following limits were applied to the search: English language, human, female, publication date (2015 to current), age (middle age (45 plus years)).

All records from the search were screened by title and abstract according to the study criteria by the candidate alone. Full text articles were screened, and any uncertainties were resolved by discussion and consensus with the candidate's primary supervisor. Articles published by the candidate for presentation in this thesis were excluded from this review.

2.4.1 Inclusion and exclusion criteria

This review included full text quantitative studies from the past decade that tested an intervention where physical activity was an outcome measure. Cross-sectional study designs and secondary studies were excluded. The population included non-clinical community-dwelling adults in their midlife years (50 to 64 years), in order to broadly capture studies targeting this age-group rather than specifying sex or gender. Included interventions were physical activity programs that were choice-based, supported unsupervised or unstructured physical activity, delivered remotely or with minimal in-person contact (1 session), delivered to an individual and used low or minimal resources for delivery. Due to the paucity of articles recruiting exclusively women, studies with non-specific gender targeted recruitment were included in the review due to potential useful demographic and intervention data for the mid-age population.

Exclusion criteria were grey literature, qualitative studies, primary health care setting, cross-sectional study designs and secondary studies where physical activity was not an outcome measure, work team-based challenges, friends group interventions, structured physical activity, group sessions involving more than 1 day, interventions targeting other or multiple health behaviours (eg. diet, tobacco cessation), gamified applications or gamified components as these are not choice-based (eg. points or awards). Systematic reviews were excluded but their reference lists were hand-searched to identify relevant articles. Articles that did not target adults in midlife were included if the reported average age was between 50 to 64 years, or within the standard deviation, or within the target recruitment age range.

2.4.2 Data extraction

The following data were extracted by the candidate alone: publication year, country of study, funding, study design, study duration, study setting, eligibility criteria, participant characteristics, intervention characteristics (duration, personnel involved, components used for delivery, content), and physical activity outcomes.

The methodological quality of included randomised controlled trials was assessed using the Physiotherapy Evidence Database (PEDro) scale score (0 to 10 score) (12). PEDro scores for trials in this review were obtained from the PEDro database (www.pedro.org.au). The PEDro Scale has demonstrated high inter-rater agreement for the total score (Interclass Correlation Coefficient = 0.91) and for individual items (13). At least two independent PEDro-trained raters assess each clinical trial for PEDro (https://pedro.org.au/english/about/faq/), providing rigor and confidence in the finalised score. The PEDro Scale consists of 11 items which evaluate external validity, internal validity, statistical reporting. Items are rated yes or no according to if the criterion is clearly satisfied in the study. If an item is satisfied, a score of 1 is given to that item. The

PEDro score is obtained by adding the scores of Items 2 to 11, for a score between 0 and 10. A score of 8/10 is the highest score for physical activity trials and 6/10 is considered good quality (14).

The intervention content delivered was coded at the category level using the Behaviour Change Technique (BCT) Taxonomy (15). Coding was performed by the candidate alone, who had completed BCT extraction training (online) run by University College London (https://www.ucl.ac.uk/behaviour-change/advanced-modules-behaviour-change) and received certification. The BCT Taxonomy specifies 93 techniques clustered into 16 categories to describe behaviour change interventions. The categories are Goals and planning, Feedback and monitoring, Social support, Shaping knowledge, Natural consequences, Comparison of behaviour, Associations, Repetition and substitution, Comparison of outcomes, Reward and threat, Regulations, Antecedents, Identity, Scheduled consequences, Self-belief, Covert learning (15). Content was also coded by the presence or absence of tailoring, which was defined as personalising the intervention to the participant. Tailoring was defined in this review as the personalisation of intervention content in response to data received from the participant. The use of the participant's name only in the intervention content was not considered tailored.

Physical activity outcomes were coded in relation to the intervention effect. This process was guided by the Cochrane handbook for systematic reviews of interventions which describes approaches for analysing and reporting data from trials without performing a meta-analysis (16). Results were coded as positive significant, positive non-significant, negligible, negative non-significant, negative significant either during the study or at the final follow-up time point.

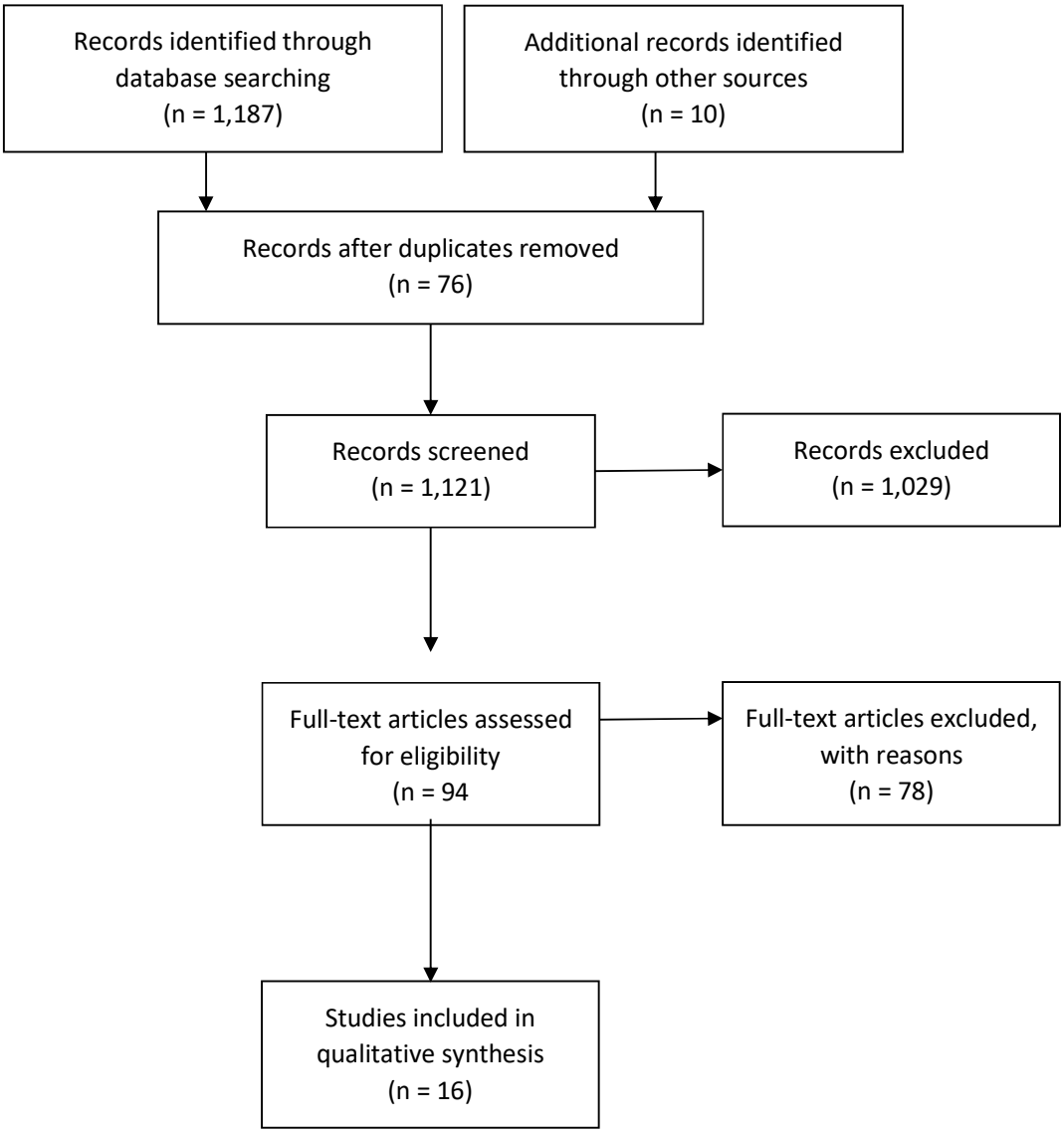
2.4.3 Data synthesis

A descriptive summary of the data and narrative synthesis of the findings were presented according to the themes. Findings summarised were by the study design, the components used to deliver the intervention, the content that was delivered as described by behaviour change techniques (15), the intervention design, and physical activity outcomes, as the effectiveness of the interventions may have differed based on these features. Relationships were explored between the above described intervention features and effectiveness.

2.5 Results

Figure 1 presents the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow of study selections through the review (17). The search identified 15,593 records. After limits and filters were applied and duplicates removed there were 1,111 records. A further 10 records were identified after hand-searching the reference lists of relevant systematic reviews, bringing the total number of potentially eligible records to 1,121. Following title and abstract screening, 95 records remained. A total of 16 articles were identified following full-text screening: 13 randomised controlled trials (18-30), 3 observational studies (31-33). Of these, three trials (22, 25, 27) and one cohort study (32) targeted female participants only but not specifically those aged 50 years and over.

Figure 1. PRISMA flow diagram of study selections



2.5.1 Research question 1. Characteristics of studies and interventions

Studies were conducted in high-income countries USA (22, 23, 25, 26, 32), Australia (18, 20, 27, 31, 33), Netherlands (21, 24, 29), United Kingdom (19, 30), Canada (28)), predominantly in community settings (18, 20-22, 24, 26, 28-29, 32-33) but also in university (23, 25, 30, 31), rural (27, 32) and hospital workplace settings (19). Study duration was a median of 12 weeks and ranged from 6 weeks to 18 months. Study characteristics are summarised in Table 1.

Only half of the included studies required low current physical activity levels as an eligibility criterion (22-27, 31, 33). There was a higher proportion of females represented across studies (median 76% females). Four studies recruited female participants only (22, 25, 27, 32) and two studies recruited adults aged 50 years and over (21, 29). Recruitment was conducted via social media and online communities, workplace intranet and emails, flyers and posters displayed in community locations, local newspapers and radio, participant research registers, and in-person community events.

There were 10,212 participants across all studies (median 253 participants) with median age 50 years (IQR 9.3). Study sizes ranged from 40 participants (31) to over 900 participants in three trials (21, 24, 29). The average retention rate was 70% and ranged between 38% and 97%. No trends for retention were found in studies requiring low baseline physical activity levels.

The methodological quality of most trials was low/fair according to the PEDro score (≤ 5/10), apart from three trials which were good methodological quality (PEDro score 6/10 or higher) (22, 25, 28) (Table 4). Inadequate follow-up of participants and lack of concealed

allocation at randomisation were the most common sources of introduced biases across trials.

There were 34 intervention arms across the studies ranging from 4 to 18 months (Table 2). The comparison group in most trials was a different intervention, but four trials included a control group (18, 20, 25, 26, 27).

2.5.2 Research question 2. How were the interventions delivered?

Interventions delivered in the included studies were summarised by intervention components (Table 2) and the intervention content (Table 3).

2.5.2.1 Intervention components

Intervention components were the methods used for delivering the intervention. Intervention arms in the included studies often used more than one component (median 2) but up to five discrete components to deliver the content (22, 27).

Overall, studies used a combination of 'scheduled' and 'on-demand' components. (19, 21-22, 24, 26-29) Scheduled components were defined as those delivered according to a pre-determined schedule or 'dose', including SMS text messages, email messages, in-person and telephone consultations. Participants received an average of four SMS text messages per week (range: 1 to 9), and an average of 2.8 email messages per month (range: 0.3 to 8). On average, 2.2 telephone consultation sessions were (range 1 to 4) either by a health coach (23) or trained study staff member (22, 27).

On-demand components, including smartphone applications, website information, a website portal, online group, and pedometers, could not be scheduled but they enabled

participants to access them as preferred. Online groups typically were composed solely of participants (26-28, 34), with the exception of one study where research staff regularly shared information about local area physical activity opportunities (22).

The most frequently used components across the studies are listed in Table 4. Most frequently used were pedometers (18, 21, 23, 27, 31-33) and website portals (18, 21-22, 24, 27-29). For the purposes of this review, pedometers were defined as any wearable device (e.g. Fitbit) or smartphone device that had or used a step-counting feature. Website portals were defined as study websites that allowed participants to interact in 'real time' such as logging personal physical activity data (e.g., step counts, plans or goals) via a personal dashboard, in addition to accessing static web-based content. In studies where portals included features such as an online forum or social groups focused on physical activity, an additional component 'online or app group' was coded to reflect the peer interaction element. Components coded as 'online or app group' were either a component associated with a website portal or a standalone component.

Components most commonly delivered in studies that targeted either women only (22, 25, 27, 32), or adults aged 50 years and over (21, 29) were similar, and were messages, a dedicated study website and an online interactive group.

2.5.2.2 Intervention content

Intervention content was the information and material delivered to participants as part of the intervention. Categories of behaviour change techniques (BCTs) delivered in the included studies are summarised in Table 3. Intervention arms delivered between one and eight BCT categories (median of three). Shaping Knowledge (Category 4), which aims to modify knowledge about the performance of physical activity or reframe understanding to

support behaviour change, was the most commonly applied BCT category (18-19, 21-22, 25, 27-33). This was followed by Feedback and monitoring (Category 2)(18, 21-27, 31-33), which aims to provide internal or external input to increase awareness of physical activity behaviour; and Goals and planning (Category 1) (18-27, 29, 33), Social support (Category 3) (18, 22, 23, 26-28) and Associations (Category 7) (20-22, 30, 32-33) which includes prompts and cues.

There was no clear trend between the number or type of intervention components, the BCT categories present in an intervention and the impact on physical activity. The exception was for three studies that delivered the highest number of components, and the highest number of BCT categories, and which demonstrated a significant impact on physical activity either during the study period or at the end of the study period (18, 22, 27).

Intervention content was tailored in nine studies according to a participant's responses to a questionnaire (21, 22, 24, 29), feedback from online data (18, 21, 23, 25), or consultations with study staff (22, 23, 27).

2.5.3 Research question 3. What was the reported impact of the interventions on physical activity?

Physical activity outcome measures are summarised in Table 5. Self-report questionnaires (19, 20, 24, 28-30), device-measured outcomes (18, 22, 23, 25-27, 31-33) or a combination of both (20) were used. Device-measured outcomes included either weekly time in moderate to vigorous intensity physical activity (18, 21-23, 25-27, 31-33) or average number of daily steps (18, 23, 25, 31-33).

Overall, physical activity improved in favour of the intervention group either at the final follow-up measurement point (19, 20, 22, 24, 26, 29, 32, 33) or at a timepoint during the study period (18, 25, 27, 28). No trends in physical activity outcomes were found in studies where low baseline physical activity was an eligibility criterion (22-27, 31, 33).

Physical activity trended an increase at final follow-up when one of the intervention components enabled participant interaction in 'real time', such as smartphone applications (26, 33), website portals (22, 24, 29) and online groups (22, 26). There were no other obvious trends regarding the intervention content, the study design, or participant characteristics.

2.6 Discussion

This review assessed the current evidence about remotely delivered programs that promote choice-based physical activity and target mid-age community-dwelling women. No studies identified in this review specifically targeted women aged 50 years and over and only half of the identified studies targeted people with low baseline physical activity levels. There is a modest volume of fair to low methodological quality evidence for the general population.

Overall, programs used multiple components to deliver content aimed at supporting physical activity, combining both scheduled and on-demand formats. The content focused on shaping knowledge about physical activity, providing feedback and monitoring, goal setting and planning, as well as social planning and associations. Physical activity tended to increase when one of the programs components (e.g., pedometer, web-based portal dashboard, online group) included 'real time' interaction. This finding aligns with evidence from a previous review, which reported that interactive computer-based interventions

(e.g., online goal-setting, chat sessions and message boards) were more effective compared to minimal interventions (e.g. informational pamphlets) in supporting weight loss and represented an efficient use of limited resources (34).

Although this review found no obvious trend supporting tailoring as an effective component of physical activity interventions, there is evidence that tailoring can be used to intensify an intervention (35). Individualised intervention materials can enhance the relevance of the intervention, are generally well-received by health consumers, and may improve overall intervention effectiveness (35). Also, internet-delivered tailored components such as email messages and websites have been reported to be effective across different age groups, genders and behaviours (35).

Many of the included studies had a broad inclusion criterion for age with the possible intention of reaching as many people as possible with the intervention. Broad inclusion may unintentionally convey a generalised one-size-fits-all approach, potentially overlooking specific barriers and motivators of subgroups, thereby reducing personal relevance and overall impact (36). Considering this along with the low retention rates observed across the studies, adopting a targeted recruitment focusing on midlife women may enhance the relevance and engagement with the intervention. Involving this group in the design process and incorporating their perspectives can help ensure the intervention resonates and is appropriate for their demographic.

2.6.1 Implications and recommendations for thesis (Research question 4)

This review informs future efforts to develop solutions for promoting physical activity among women in midlife. Specifically, the findings have implications for population-specific considerations, intervention design, and methodological approaches.

2.6.1.1 Population-specific considerations

This review highlights a lack of evidence for physical activity interventions specifically targeting physically inactive women in midlife. Future research should focus on reaching populations that most need support to engage in physical activity. Given the complexity of behaviour change and the unique barriers faced by women in midlife, it is crucial to strategically involve them in the design and refinement of programs intended for their benefit.

Involvement could be through broad consultations with mid-aged women to ensure their perspectives are included in research and that interventions meet their needs and preferences. Involving end-users and stakeholders also ensures resource efficiency and that program uptake, program retention and long-term engagement can be maximised.

2.6.1.2 Intervention design

This review shows that presenting multiple varied options is a key feature of remotely delivered physical activity interventions. Interventions should provide participants with the flexibility to choose which components to engage with as well as where and when to access them. Providing flexibility enhances engagement, appeals and caters to diverse preferences, and supports agency by empowering women to adopt and sustain physical activity (37, 38).

Additionally, while this review identified a lack of relationship between the number of behaviour change techniques and the effectiveness of the intervention, this could be due to difficulties in clearly identifying whether a behaviour change technique occurred, and inconsistencies with reporting (39). Therefore, designing a program that includes several

behaviour change techniques could potentially increase the effectiveness of the intervention, and is worth investigating in a clinical trial.

2.6.1.3 Methodological approaches

This review highlights the need for high-quality evidence to rigorously test the impact of physical activity interventions among this demographic. As identified in Chapter One, the gender disparity in physical activity combined with the importance of addressing physical inactivity in midlife before disability and chronic conditions become problematic, make midlife women a key demographic to target for physical activity interventions. A well-designed and rigorously conducted clinical trial could also address retention challenges and offer definitive evidence on the effectiveness of remotely delivered programs for physically inactive midlife-aged women.

This review also highlights the importance of comprehensive documentation in the reporting of interventions in order to advance existing knowledge. The Template for intervention description and replication (TIDieR) checklist (40) is available in multiple languages and provides a guide for reporting interventions in sufficient detail to enable replication. A detailed understanding of interventions enhances replicability and helps to minimise research waste.

2.6.2 Strengths and limitations of this review

This review provides an overview of the evidence about remotely delivered interventions for supporting individual choice-based physical activity. A key strength of this review was that it identified the lack of evidence concerning such interventions for women in their midlife years. Other strengths were that the methodological rigor and transparency were ensured through the use of the Cochrane rapid review criteria to guide the methods. This

review designed a priori research questions and adhered to well-established frameworks including the PEDro Scale for assessing methodological quality, and the Behaviour Change Techniques Taxonomy to systematically identify and classify intervention components, in which the candidate had completed certified standardised training for coding Behaviour Change Techniques. The Medline database was search using a rigorous search criteria and hand searching was performed to identify additional studies.

A limitation of this study was that all aspects of the review was conducted by one author. It is possible that some studies may have been missed during screening for eligible studies or data extracted was incomplete since it was unverified. Another limitation was that only one database was used to conduct the search, potentially excluding studies indexed in other databases only. Finally, studies published within the past 10 years were included in this review. Given the rapid technological advancements during this period, types of interventions have also evolved considerably, which complicates direct comparisons across studies.

2.7 Conclusions

This review provides an overview and offers guidance on designing remotely delivered interventions for supporting choice-based physical activity. There is a lack of evidence for physical activity interventions targeting women in their mid-aged years. A flexibly-oriented intervention with multiple discrete but complementary components delivering behaviour change grounded content is likely to be effective for women aged 50 and over. Future work is needed with end-user input to design and test the effectiveness of physical activity interventions for women in midlife.

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Table 1. Characteristics of the studies and study populations for identified studies (total participants, n=10,212).

Study	Country	Study design	Study length	Setting	Participants (n=)	Retention (%)	Age, y Mean (SD)	Female %	Recruitment strategy	Eligibility criteria
Alley 2018	Australia	RCT	18 months	Community	504	57	50.8 (13.1)	65	Letters to past research participants, electoral database	Aged ≥18 years; lived/worked in Rockhampton or south-west Sydney; interested in increasing PA; internet access; English literacy; no medical condition precluding PA
Blake 2015	UK	RCT	16 weeks	Hospital workplace	296	38	33.8 (10.3)	14	Emails via employer intranet, posters	Aged ≥18 years; employee of participating hospital trust; valid e-mail address and mobile phone number; no medical condition precluding PA.
Chapman 2015	Australia	RCT	6 weeks	Community	317	71	NR Range: 18 - 60	71	Emails via public sector employer	Not reported
Collombon 2024	Netherlands	RCT	6 months	Gyms in community	954	79	59.4 (6.4)	86	Social media advertisements and gyms affiliated with the Dutch trade association for sports organizations	Aged ≥50 years; owning a smartphone from 2012 or later; able to use a computer, laptop, or tablet
Connell Bohlen 2024	USA	RCT	6 months	Community	210	57	43.3 (10.3)	100	Facebook, internet-based advertising, in-person community events and organisations, newspapers, radio, television, flyers	Aged 18-65 years; self-identified as female and Latina; reporting less than 60 min/week leisure MVPA; adequate Spanish literacy; access to text-message compatible and internet-connected devices; no medical condition precluding PA; no hospitalisation due to psychiatric disorder in past 3 years; BMI above 45kg/m2; no current/planned pregnancy; not moving from area within study duration

Ellingson 2019	USA	RCT	12 weeks	University campus	91	89	41.7 (9.3)	53	Electronic mailing lists	Aged 24-65 years; regular access to a computer or smartphone; no previous use of but willingness to wear an activity tracker during study; no medical condition precluding PA; no current participation in structured exercise; reporting not meeting PA guidelines
Friederichs 2015	Netherlands	RCT	12 months	Community	4302	72	44.9 (12.8)	69	Newspapers, social media	Aged 18-70 years old; no medical condition precluding PA; had not participated in the study's pilot studies; PA was < 5 days/week for 60 min/day
Gell 2015	USA	RCT	24 weeks	University campus	87	85	47.2 (10.7)	100	Flyers to female employees	Full-time employee; primary work location on campus; willingness to receive text messages to a personal cell phone; not pregnant; answered "no" to all questions on the PAR-Q[%]; obtained medical consent to participate.
Hamilton 2019	Australia	pre/post	12 weeks	University office workers	40	50	43.3 (8.7)	70	Not reported	Full-time university office workers; reported sitting for >6 hours during workday.
Khare 2021	USA	pre/post	12 weeks	Rural community	44	80	53.4 (8.1)	100	Flyers in grocery stores and health department	Aged ≥40 years; English-speaking; women; residing in Stephenson County; owned a mobile phone with texting capability and an unlimited texting plan; no reported respiratory or severe health conditions
King 2016	USA	RCT	8 weeks	Community	95	94	60 (9.3)	75	Emails to mailing lists, in-person local community, senior centres congregate housing settings, flyers, posters on community	Aged ≥45 years; engaged in <60 min/week MVPA; reported sitting for 10+ hours/day; able to participate safely in a PA program[%]; currently using a

									noticeboards, internet advertising	mobile phone but not a smartphone.
Mitchell 2019	Australia	RCT	12 weeks	Rural	171	76	50.6 (12.5)	100	Flyers, local newspapers, radio	Aged 18–70 years; residing in the region for ≥1 year; reported < 20 bouts of PA of ≥20 min in the preceding month
Neil-Sztramko 2020	Canada	RCT	12 weeks	Community	510	71	64.7 (8.3)	84	Portal's home page, weekly email alerts, social media, organisations whose members are middle or older age (e.g., retired teachers)	Aged ≥40 years; English literacy
Peels 2013	Netherlands	RCT	12 months	Community	2140	58	63 (8.2)	51	Direct mailing in communities of the participating council regions	Aged ≥50 years; Dutch literacy
Suggs 2013	UK	RCT	16 weeks	University colleges	331	48	39.5 (11.8)	83	Email and posters	Academic staff; no medical condition precluding PA
To 2021	Australia	pre/post	6 weeks	Community	120	97	49.1 (9.3)	82	Invitations to previous 10,000 Steps program participants	Aged ≥18 years, interested to increase PA; performed <20 min/day MVPA; lived in Australia; have internet access and a smartphone; not participating in another PA program; not owned/used a PA tracking device within past year; able to safely increase their PA levels

Notes:

BMI, body mass index; KA, Korean American; MVPA, Moderate to vigorous intensity physical activity; PA, physical activity; RCT, randomised controlled trial

* Stanford Brief Physical Activity Survey. Reporting participation of less than 3 times a week of moderate or vigorous PA in the preceding 6 months. Taylor Piliae et al, 2006.(41)

^ Physical Activity Stages of Change. Contemplation stage or Preparation stage. Marcus & Forsyth, 2024.(42)

PA guidelines: Physical activity guidelines for moderate to vigorous intensity physical activity is 150 minutes of moderate or 75 minutes of vigorous activity per week.(5)

% PAR-Q: Physical Activity Readiness Questionnaire. Thomas et al, 1992.(43)

Table 2. Components for delivering the intervention and frequency of delivery[∞] for groups in identified studies (Total participants, n=10,212).

Study	Intervention length	Group	Smartphone App*	Website information ^	Website portal[%]	Text SMS[θ] n= (average/week)	Email[Ж] n= (average/month)	Online or app group	In-person contact n=	Telephone contact n=	Paper[σ]	Pedometer[§]
Alley 2018	18 months	CG										
		IG1						ǂ				
		IG2						ǂ				
Blake 2015	12 weeks	IG1				n = 24 (2)						
		IG2					n = 24 (8)					
Chapman 2015	6 weeks	CG										
		IG										
Collombon 2024	12 weeks	IG1				n ~ 103 (9)						
		IG2										
		IG3										
Connell Bohlen 2024	6 months	IG1							n = 1			
		IG2				n = 180 (1)		ΠǂǂΠ	n = 1	n = 2		
Ellingson 2019	3 months	IG1								n = 2		
		IG2								n = 2		
Friederichs 2015	12 months	IG1					n = 4 (0.3)					
		IG2					n = 4 (0.3)					
Gell 2015	24 weeks	CG										
		IG				n = 72 (3)						
Hamilton 2019	6 weeks	IG										
Khare 2021	12 weeks	IG				n = 84 (7)						
King 2016	8 weeks	CG										
		IG1										
		IG2						ǂ				
		IG3										
Mitchell 2019	12 weeks	IG1							n = 1	n = 1		
		IG2						ǂ	n = 1	n = 4		
		CG										

Neil-Sztramko 2020	12 weeks	IG1					n = 12 (4)	‡				
Peels 2013	4 months	IG1										
		IG2										
		IG3					n = 3 (0.75)					
		IG4					n = 3 (0.75)					
Suggs 2013	12 weeks	IG1					n = 12 (4)					
		IG2				n = 24	n = 12 (4)					
To 2021	6 weeks	IG										

Notes:

Green shaded cells: Intervention strategy present; Numbers in the green shaded cells indicate the total number of that strategy delivered across the trial. Number in brackets indicates the average (sd) number of that strategy delivered per week (for SMS) or month (for Email) across the trial; CG, Control group; IG, Intervention group; IG1, Intervention group 1; IG2, Intervention group 2; IG3, Intervention group 3; IG4, Intervention group 4

[∞] Frequency of delivery where reported
*Smartphone app: Smartphone application, functionality may include sending notifications, text messages, accelerometer
^Website information: Unidirectional communication
[%] Website portal: Bi- or multidirectional communication; may include a dashboard to enter personal details, online group discussion board, blogs, internal emails
[θ] Text SMS: text SMS messages to a mobile phone, independent of another delivery platform (eg. smartphone application). Number of messages.
[Ж] Email: Email messages, independent of another delivery platform (eg. website portal) Number of messages.
[σ] Paper: Paper-based information and resources
[§] Pedometer: Pedometer with or without the associated pedometer smartphone application
[‡] Online or app group: Online group or smartphone application for the group, either integrated or independent of a Website portal, for participants only.
[II] Online or app group: Online group or smartphone application for the group, either integrated or independent of a Website portal, including participants and research staff.

Table 3. Intervention content. Presence of behaviour change technique (BCT)[‡] categories delivered in the identified studies (Total participants, n=10,212).

Study	1. Goals and planning	2. Feedback and monitoring	3. Social support	4. Shaping knowledge	5. Natural consequences	6. Comparison of behaviour	7. Associations	8. Repetition and substitution	9. Comparison of outcomes	10. Reward and threat	11. Regulation	12. Antecedents	13. Identity	14. Scheduled consequences	15. Self-belief	16. Covert learning	Total no. BCT categories	Tailored content
Alley 2018	■	■	■	■	■	■											6	Y
Blake 2015	■			■	■												3	N
Chapman 2015	■						■										2	N
Collombon 2024	■	■		■			■		■								5	Y
Connell Bohlen 2024	■	■	■	■			■	■	■	■							8	Y
Ellingson 2019	■	■	■						■								4	Y
Friederichs 2015	■	■															2	Y
Gell 2015	■	■		■	■												4	N
Hamilton 2019	■	■		■													3	N
Khare 2021		■		■			■										3	N
King 2016	■	■	■			■				■							5	Y
Mitchell 2019	■	■	■	■	■			■									6	Y
Neil-Sztramko 2020			■	■													2	N
Peels 2013	■	■		■		■											4	Y
Suggs 2013				■			■										2	N
To 2021	■	■		■			■										4	Y

Notes:

[‡] The behaviour change technique taxonomy specifies 93 techniques clustered into 16 categories which are used in behaviour change interventions. Michie et al 2013 (15)

[§] Tailored content = the personalisation of the intervention content to the participant. Content which used the participant's name only were not considered 'tailored'.

Blue shaded cells = Item present

Y, Yes; N, No

Table 4. Most commonly used components for delivering the intervention in identified studies (Total participants, n = 10,212).

Component	Study
Pedometers*	Alley 2018; Collombon 2024; Ellingson 2019; Hamilton 2019; Khare 2021; Mitchell 2019; To 2021
Website portals‡	Alley 2018; Collombon 2024; Connell Bohlen 2024; Friederichs 2015; Mitchell 2019; Neil-Sztramko 2020; Peels 2013
SMS messages	Blake 2017; Collombon 2024; Connell Bohlen 2024; Gell 2015; Khare 2021; Suggs 2013
Paper resources§	Alley 2018; Chapman 2015; Hamilton 2019; Mitchell 2019; Peels 2013
Email messages	Blake 2017; Friederichs 2015; Neil-Sztramko 2020; Peels 2013; Suggs 2013
Website information	Alley 2018; Blake 2017; Gell 2015; Hamilton 2019
Online or app group⁂	Alley 2018; Connell Bohlen 2024; King 2016; Mitchell 2019; Neil-Sztramko 2020
Smartphone apps	Collombon 2024; King 2016; To 2021
Telephone consultations	Connell Bohlen 2024; Ellingson 2019; Mitchell 2019
In-person consultations	Connell Bohlen 2024; Mitchell 2019

Notes:

* Pedometers were defined as any wearable device (e.g. Fitbit) or smartphone device that had or used a step-counting feature.

‡ Website portals were study websites that allowed participants to interact in 'real time' such as logging personal physical activity data (e.g., step counts, plans or goals) via a personal dashboard, in addition to accessing static web-based content.

§ Paper resources include physical activity planning sheets, logs, information printed on paper.

⁂ Online or app group included an online forum or social group focused on physical activity.

Table 5. PEDro score[§] and Physical activity outcomes for identified studies (Total participants, n=10,212).

Study	Study design	Participant number (n=)	Retention (%)	PEDro score§ (/10)	Physical activity outcome	Follow-up post baseline	Effect of intervention on physical activity	Intervention effect ‡	Study limitations reported
Alley 2018 Australia	RCT	504	57	4	Device-measured MVPA, daily steps	0, 3, 12, 18 months	At 3 months, increased MVPA and daily steps in Web 2.0 group compared to logbook group, particularly for those aged >55 years	+S[ß]	• Possible outdating of Web 2.0 technology used in intervention • High attrition reduced power of the study
Blake 2017 UK	RCT	296	38	5	Self-reported PA - Global Physical Activity Questionnaire (GPAQ)	0, 3, 4 months	At 16 weeks, increased duration and frequency of active travel, increased duration of moderate work or LPA in SMS or email groups. Maintained increase up to 1 month after messaging ended.	+S	• Possible bias with self-report data • Usage of web link for educational materials was not monitored • Difficult to compare identical messages delivered through different channels.
Chapman 2015 Australia	RCT	317	71	4	Self-reported PA – single question of weekly MVPA sessions	0, 6 weeks	At 6 weeks, non-significant increased weekly PA sessions in Implementation (intervention) and health information (control) groups. No between-group difference.	+NS	• Possible bias with self-report data • Limited skills/education levels included in population group • Limited methods of recruiting sedentary individuals
Collombon 2024 Netherlands	RCT	210	79	4	Device-measured MVPA Self-reported PA - Short Questionnaire to Assess	0, 3, 6 months	At 6 months, no between-group differences for activity tracker, ecological momentary intervention, chatbot, and control groups.	Neg	• Conducted during COVID-19 pandemic with limitations on PA behaviours and options • Lack of 12-month long term

					Health-Enhancing Physical Activity (SQUASH)				measurement to assess effects on PA adoption and maintenance • Sample not typical of general population (eg. low PA or lower SES). Results representative of educated females aged 50-65 years already meeting the PA guidelines.
Connell Bohlen 2024 USA	RCT	954	57	7	Device-measured MVPA	0, 6 months	At 6 months, increased PA for participants with low baseline PA in the enhanced group (web + text) compared to the original group (web).	+S	• Effects beyond 6 months unknown • Unknown whether those inactive at baseline need more intense or longer intervention
Ellingson 2019 USA	RCT	91	89	4	Device-measured MVPA, daily steps	0, 4, 8, 12 weeks	At 12 weeks, no between group differences in PA. Participants with lower baseline PA and lack of previous pedometer experience more likely to improve MVPA. MI and habit education more effective for participants with higher baseline PA compared to Fitbit alone.	Neg	• Small sample size of healthy adults • Effects beyond 3 months unknown • Effect of higher health coaching dose unknown • Limited generalisability
Friederichs 2015 Netherlands	RCT	4302	72	5	Self-reported PA - Dutch Short	0, 3, 6, 12 months	At 12 months, increased weekly MVPA for IG1 (I Move)	+S	• Interactivity of a web-based counsellor does not replicate the

					Questionnaire to Assess Health Enhancing Physical Activity (SQUASH)		compared to the control group; increased number of days doing >30 mins daily PA for IG2 (Active Plus) compared to the control group.		empathy and responses of a human counsellor • High attrition reduced power of the study; selective dropout of younger participants • Sample was primarily female and highly educated limiting generalisability • Possible bias with self-report data
Gell 2015 USA	RCT	87	85	6	Device-measured daily steps	0, 3, 6 months	At 3 months, greater average daily steps for text group compared to control. At 6 months, no between group difference.	+S[β]	• Unknown effect of the type of messages or the optimal number of weekly messages • Limited generalisability • Pedometers unable to track non-step PA (eg. swimming, cycling) • No PA restriction on participant eligibility to study
Hamilton 2019 Australia	pre/post	40	50	N/A[Ж]	Device-measured daily steps	0, 7, 12 weeks	At 12 weeks, no increase in step counts.	Neg	• Use of pedometer unable to capture other non-step PA • Lack of a comparison group • Results of small defined sample not generalisable
Khare 2021 USA	pre/post	44	80	N/A[Ж]	Device-measured daily steps	3, 6, 9, 12 weeks	At 12 weeks, non-significant increased proportion meeting PA guidelines in text-	+NS	• Small sample size and lack of a comparison group,

							messaging and pedometer intervention groups.		limited generalisability • Did not capture baseline PA accurately as pedometers were provided at enrolment
King 2016 USA	RCT	95	94	5	Device-measured MVPA	8 weeks	At 8 weeks, increased MVPA in social app user group compared to control and other app user groups (affect app, analytic app).	+S	• Small sample size • Unknown effects and sustainability beyond 12 weeks • Smartphones' built-in accelerometer required participants to wear phone daily • Limited generalisability
Mitchell 2019 Australia	RCT	171	76	3	Device-measured MVPA	0, 3, 6, 12 months	At 12 weeks, increased PA in control and intervention (website and personalised goals) groups. At 6 months, intervention group maintained increased LPA.	+S^{ß}	• MVPA data not comparable to studies using different cut-points
Neil-Sztramko 2020 Canada	RCT	510	71	6	Self-reported PA - Rapid Assessment of Physical Activity (RAPA)	0, 3, 6 months	At 3 months, increased PA in both control (self-serve portal) and intervention (targeted portal, emails) groups.	+S^{ß}	• Possible bias with self-report data • Homogenous study sample of healthy well-educated urban-dwelling adults limiting generalisability
Peels 2013 Netherlands	RCT	2140	58	4	Self-reported PA - Dutch Short	0, 3, 6, 12 months	At 12 months, increased weekly days of PA in IG1, IG2, IG3,	+S	• Possible bias with self-report data

					Questionnaire to Assess Health Enhancing Physical Activity (SQUASH)		IG4 compared to the control group. Effect was moderated by baseline intention to be sufficiently active.		• High attrition reduced power of the study; selective dropout from web-based conditions, younger participants with a lower PA intention
Suggs 2013 UK	RCT	331	48	5	Self-reported PA - International Physical Activity Questionnaire long-form (IPAQ-L).	0, 3, 4 months	At 4 months, non-significant decreased PA for both Email-only and the Email plus text message groups.	-NS	• High attrition reduced power of the study • Participants were already physically active limiting generalisability to those least active who may benefit
To 2021 Australia	pre/post	120	97	N/A[JK]	Device-measured daily steps	0, 6 weeks	At 6 weeks, increased daily steps and total PA following pedometer and chatbot intervention.	+S	• Unable to control for confounders with lack of a control group, such as the use of a pedometer • Limited generalisability • Technical issues caused by Facebook's policy changes and reduced usability, acceptability and effectiveness of the chatbot

Notes:

LPA, Light-intensity physical activity; MVPA, Moderate to vigorous intensity physical activity; Neg, negative effect; NS, not significant; PA, physical activity; RCT, randomised controlled trial; SES, Socioeconomic status; S, significant; IG1, Intervention group 1; IG2, Intervention group 2; IG3, Intervention group 3; IG4, Intervention group 4.

§ PEDro Score: Measure of risk of bias in randomised controlled trials (score 0 to 10) (12). The optimal score for trials evaluating physical activity is 8/10.
‡ Intervention effect for the outcome measure: Results were coded as positive significant (+S), positive non-significant (+NS), negligible (Negl.), negative non-significant (-NS), negative significant (-S) at the final follow-up time point (15)
ß During the study
⁎ N/A: Cohort study. PEDro Score not applicable due to lack of comparator group.

2.9 Supplementary File

OVID Search conducted 13 Sep 2024 (records from 2015 to current)

Search	Records, n =
45 year* or 50 year* or Middle age* or Older adult* or Older worker* or work* or Postmenopaus* or Post menopaus* or Community dwell* or Community living* or Community	7598385
Physical* activ* or Healthy ag#ing or Active ag#ing or exercis*	583910
Behavio#r change or Behavio#r change technique* or Theoretical domains framework or Self#determinat* theory or Health belief model or Self#efficacy	13783
Incentiv* or Motivat* or Facilitat* or Barrier* or Self#regulat* or Maint#n	1437164
3 or 4	1443977
Deliver* or Support* or Intervention or Program#	13197638
Digital or online or social media* or email messag* or text messag* or health coach* or website or mobile app* or Facebook	534379
6 or 7	13484813
1 and 2 and 5 and 8	15593
limit 6 to (english language and female and humans and yr="2010 -Current" and ("middle age (45 to 64 years)" or "middle aged (45 plus years)"))	5888
not (diabet* or cardiovascular or COPD or pain or arthritis or prostate or primary care or respiratory or metabolic or rehabilitation or pulmonary or cardiac or obesity or overweight or cancer or oncolog* or back or birth or prenatal or post#natal or child* or parkinson* or multiple sclerosis or stroke or neurolog* or alcohol or liver or metabol* or pancreas or lung or kidney or mental#ill* or GP or tobacco or cessation or smoking or hospital or emergency or patient or wheelchair or cardio* or ?arthrit* or injur* or NAFLD or PTSD or orthop?d* or hypertens* or diabet* or glyc?m* or radiotherap* or chemotherap* or palliat* or nursing home or percept* or addict* or drug? or dialys* or renal? or asthma* or neck)	1069
limit to yr="2015 -Current"	797
(Digital#group or online#group or online* or forum or online forum or social media or Facebook or social network*).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] (304189)	304189
1 and 2 and 13 (5869)	5869
14 not (diabet* or cardiovascular or COPD or pain or arthritis or prostate or primary care or respiratory or metabolic or rehabilitation or pulmonary or cardiac or obesity or	1818

overweight or cancer or oncolog* or back or birth or prenatal or post#natal or child* or parkinson* or multiple sclerosis or stroke or neurolog* or alcohol or liver or metabol* or pancreas or lung or kidney or mental#ill* or GP or tobacco or cessation or smoking or hospital or emergency or patient or wheelchair or cardio* or ?arthrit* or injur* or NAFLD or PTSD or orthop?d* or hypertens* or diabet* or glyc?m* or radiotherap* or chemotherap* or palliat* or nursing home or percept* or addict* or drug? or dialys* or renal? or asthma* or neck).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] (1818)	
15 not (qualitative or experience* or perspective* or cross#section* or interview* or ecologic* or explor* or college or student* or child* or prefer*).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] (860)	860
limit 16 to (english language and female and humans and yr="2010 -Current") (390)	390
12 and 17	1,187
Duplicates removed (76)	1,111
7 SR reference lists hand-searched	10
Title/abstract screened	1,121 (1,029 irrelevant)
Full text screened	94 (78 excluded, not within scope of study)
Data extraction	16

CHAPTER 3. Active women over 50: study protocol for RCT of a low-dose information and support program to promote physical activity behaviour change.

Chapter 3 is presented in the format of the journal where it was published:

Wallbank G, Sherrington C, Canning C, Hassett L, Shepherd R, Richards B, Mackay C, Tiedemann A. Active women over 50: study protocol for RCT of a low-dose information and support program to promote physical activity behaviour change. BMC Public Health, 2019;19:1225. DOI: 10.1186/s12889-019-7514-6

Authorship contribution statement

As primary supervisor and co-author of the paper “Active women over 50: study protocol for RCT of a low-dose information and support program to promote physical activity behaviour change”, I confirm that Geraldine Kit-Bing Wallbank is the lead corresponding author and has made the primary contribution to this study in each of the following areas in collaboration with co-authors Sherrington C, Canning C, Hassett L, Shepherd R, Richards B, Mackay C, Tiedemann A:

- Conception and design of the research
- Data collection
- Writing of the manuscript and critical appraisal of the content

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank

20 August 2025

Preamble to Chapter 3

This chapter describes in detail the study protocol for the randomised waitlist-controlled trial reported in Chapter 4. The chapter details the methodology in advance of conducting the trial, thereby reducing bias and enhancing rigor. The purpose of the trial was to test an efficient and pragmatic intervention to empower employed women aged 50 years and over to increase physical activity participation. Members of the authorship team who were in the target age and gender group provided end-user input to this formative study which is an additional strength of this study. The trial was designed and conducted prior the rapid expansion and adoption of digital technologies driven by the COVID-19 pandemic. As such, the components used to deliver the intervention content reflect options that were used at the time.

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https://doi.org/10.1186/s12889-019-7514-6

BMC Public Health

STUDY PROTOCOL Open Access

Active women over 50: study protocol for RCT of a low-dose information and support program to promote physical activity behaviour change

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Abstract

Background: There is compelling evidence that physical activity has many physical and mental health benefits and can delay the development of disability in older age. However, uptake of this health behaviour is sub-optimal in working women in their middle age. This trial aims to establish the impact of a low-dose information program, incorporating follow-up support using behaviour change techniques, compared with a wait-list control group, on physical activity among women aged 50+ years.

Methods: 100 female university or health service employees aged 50 years and over who are not sufficiently active according to national guidelines will be recruited and randomised to: [1] attend one information session at the worksite with follow-up email support and provision of resources including use of an activity tracker (*Fitbit*) for 3 months and free trial class at the university sports facility, or [2] a wait-list control to receive the intervention after the 3-month follow-up period. The primary outcome will be the proportion of people achieving 10,000 steps/day at 3 months post randomisation. Secondary outcomes will include the proportion of people achieving national guideline-recommended physical activity levels, the average self-reported hours of physical activity per week, perceived benefits of and barriers to exercise participation, physical functioning, and mood. Analyses will be planned, conducted while masked to group allocation and will use an intention-to-treat approach.

Discussion: This randomised controlled trial will evaluate the impact of a simple intervention using behaviour change techniques to increase physical activity participation in insufficiently active working women over the age of 50.

Trial registration: ACTRN12617000485336, prospectively registered, approved 04/04/2017.

Keywords: Exercise, Behaviour change, Health, eHealth, Workplace, Physical activity

Background

Physical inactivity is an important, but modifiable public health problem that can substantially impact health and independence [1, 2]. Globally 5.3 million deaths per year are attributable to inactivity [3], a public health issue that is growing in size [4] and that has an estimated economic cost to the health-care system of INT$67.5 billion worldwide [5]. Physical inactivity in older age requires urgent attention, with 80% of Australian women over the age of 75 years insufficiently active [6], and the proportion of older people in the population rapidly rising. By 2050 up to 25% of the Australian population (10.5 million people) will be aged 65 years and over [1, 7].

There is compelling evidence that physical activity has many physical and mental health benefits [8–10]. Physical activity has been described as "the best buy in public health" [7] with "large unused potential … in the global prevention of non-communicable diseases, including dementia" [11]. National physical activity guidelines

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provide clear guidance on the amount of physical activity required to maximise health and wellbeing [8]. Australian adults are recommended to accumulate 150 to 300 min of moderate intensity or 75 to 150 min of vigorous intensity physical activity, or an equivalent combination of both moderate and vigorous activities each week, and to do muscle strengthening activities on at least 2 days each week [8].

Health conditions that could be ameliorated with physical activity are particularly common in older people. There is emerging evidence that regular physical activity participation delays the development of disability in older women by up to 15 years [9] but the uptake of this health behaviour remains sub-optimal, particularly among working women compared to their male counterparts [12]. Women are more likely than men to have high daily sitting time [13] which puts them at additional risk for chronic ill health. Almost half of the female workforce are over the age of 50 years [14], and while many become more active with retirement, this may be too late to prevent disability in older age. Commencement of appropriate physical activity by women in their 50s should therefore be a priority and workplaces are an ideal target.

Women over 50 years have unique barriers to becoming more active. They may have changing carer responsibilities from their older and more independent children to their older but more dependent parents, may face the demands of work in senior roles or re-entering the workforce, may be managing chronic health conditions, or may never have incorporated sufficient physical activity in their lives before [14]. Hence, this population requires a targeted and supported approach to ensure behaviour change is sustainable [15].

Work accounts for around 60% of an adults' waking hours [16] and is a contributor to the risk of physical inactivity [17], an additional problem for women who are already more sedentary than their male counterparts. Healthy workplaces that target employee wellbeing, that is, employee physical, emotional, mental and social health, are positively associated with increased productivity, performance, reduced absenteeism, and health care utilisation [18]. The benefits of participating in physical activity addresses employee wellbeing [17], and so makes the workplace an ideal setting to provide an intervention to increase physical activity participation in this target group.

People who are insufficiently physically active can be supported to adopt and sustain physical activity with the implementation of a behavioural change framework. Michie, van Stralen and West [19] developed the Behaviour Change Wheel framework (BCW) and COM-B model of behaviour change; with capability, opportunity and motivation as key factors that interact to influence behaviour. Physical and psychological capability, the physical and social opportunities that lie outside the individual, and a person's habits, emotions and decisions which influence their motivation, all interplay to affect whether a person engages in a behaviour. The BCW framework can be used as a tool to guide the design of interventions aimed at changing behaviour.

Education is an intervention function within the BCW. It can be delivered in different forms (e.g. workshops, printed brochures, the internet) to increase health literacy and support behavioural change. Education can provide a person with the psychological capability to change their behaviour and provide the motivation through addressing their individual beliefs about capabilities and consequences [19]. In the primary care setting, education with brief advice and motivational interviewing increased self-reports of physical activity but practitioners reported it was time consuming to deliver [20]. Providing physical and social opportunities to change behaviour through workplace-based interventions can increase physical activity, but the optimal type of intervention and delivery format is yet to be established [21].

Activity trackers are small, commercially available and relatively inexpensive wearable devices that clip onto clothing or are worn around the wrist and have grown in popularity. They have been shown to be an effective strategy to increase physical activity participation in the general population, particularly when there has been a daily step goal of 10,000 steps [22].

We have designed a scalable, simple low-dose intervention, utilising the BCW, to enhance physical activity participation in women aged 50 years and older. The aim of this randomised controlled trial is to test the impact of the intervention on physical activity participation in working women.

Methods

We will conduct a randomised controlled trial with wait-list control. The design of the trial is illustrated in Fig. 1. This trial has been designed according to the Consolidated Standards Of Reporting Trials (CONSORT) statement [23], and is reported according to the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) statement [24], and with reference to the Template for Intervention Description and Replication (TIDieR) checklist [25].

One hundred women will be randomised to either receive the intervention immediately, or after the 3-month follow-up period. People will be eligible for inclusion in the trial if they are female, aged 50 years and over, employees of The University of Sydney or Sydney Local Health District in Australia. Potential participants will be excluded if they have limited English language skills, or have a medical condition that precludes participation in regular physical activity, or are already sufficiently active

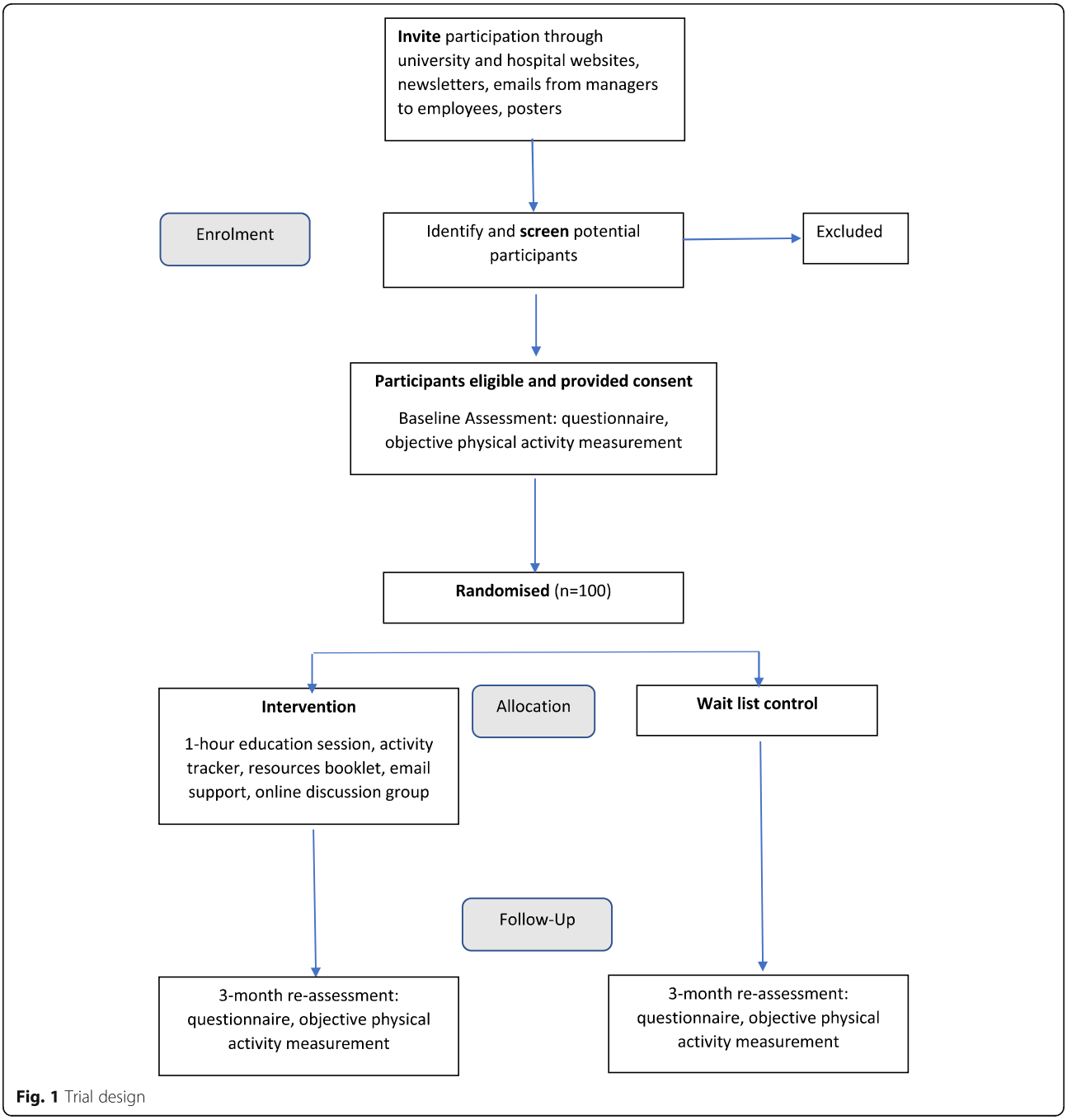

Fig. 1 Trial design

in accordance with the Australian Physical Activity guidelines [8]. Potential participants will be provided with a participant information statement outlining the study procedures. All participants will sign a consent form before participating in the study.

Participant recruitment will be through advertising using the workplace channels at the university and health service. This will be via university newsletters and websites, the health service intranet, posters and email invitations sent to managers of university and hospital departments for distribution to their employees. No workplace incentives will be offered for participation in this study. People who wish to participate in the research project will be screened for eligibility either over the telephone or via email.

Participants will be enrolled into the study after they have completed the initial screening, provided informed written consent to participate in the project, and have completed all baseline questionnaires and measurements of physical activity.

Baseline questionnaires will be sent to participants via an online survey link (*REDCap*) or by post, as preferred by the participant. Baseline physical activity will be measured with an *Actigraph* accelerometer. A research team member who is blind to study group allocation will download the accelerometer data. Each participant will receive a study enrolment number upon completing the baseline questionnaire generated by the *REDCap* database and this will be recorded on all study documents.

Following completion of the baseline measures, participants will be randomly allocated to:

a) participation in one information session plus follow-up support immediately (intervention group) or
b) participation in one information session plus follow-up support after the 3-month follow-up period (control group)

A variable block randomisation schedule will be prepared from a computer-generated list of random numbers by a researcher not involved in recruitment. The randomisation schedule will incorporate stratification for recruitment site (University campus, Sydney Local Health District) or pairs. Where there are two participants who are known to each other or if they are from the same workplace department as revealed by the initial contact, they will be randomised to the same group to reduce cross-contamination of the results. The randomisation schedule will be embedded in a secure online database (*REDCap*) to achieve allocation concealment.

The intervention group will attend a one-hour information session that will provide: 1) information about the importance of physical activity for maximising physical and mental health and preventing disability; 2) group discussion in overcoming the barriers to physical activity; 3) information and handbook of resources about existing opportunities for women over 50 years to participate in; 4) video case-study interviews of four female staff members aged over 50, and one female staff member aged over 80 who have overcome barriers to increase their physical activity; 5) tools to enhance physical activity participation (e.g. physical activity recording charts, guidance on goal setting), 6) the use of a pedometer or internet-connected activity tracker (*Fitbit*) for the duration of the study, to provide motivation and feedback to increase activity levels if desired, and 7) a free trial class at the university sports facility. An online discussion group will be set up for participants who wish to remain in contact, and a fortnightly email from the research team will be sent to provide information, motivation and support. The information session and follow-up email support will emphasise strategies to overcome barriers to participation. These will include incorporating physical activity into daily life through active transport, incidental physical activity and benefits to health and habit formation of even small increases in physical activity. The information session materials and sample physical activity recording charts will also be made freely available to participants.

The handbook of resources includes a list of local physical activity opportunities including on-campus activities and facilities for university and health service staff; websites for physical activity information and opportunities for the over 50s including a telephone-based coaching service; local council services and facilities; and free health and fitness applications available for smartphone devices. Information session participants will receive a pre-exercise screening tool and exercise intensity guidelines produced by *Exercise Sports Science Australia*, *Fitness Australia*, and *Sports Medicine Australia* [26] and will be advised to seek individual advice from a health professional if they have any concerns about increasing their physical activity or if they have an injury.

Participants will attend the information session during their lunch hour at their workplace. For participants who are not able to attend in person, a video conferencing facility will be provided. For participants unable to attend the scheduled session times, a recording of the session will be provided via an online webinar link. These participants will be able to email or phone the presenters with any questions after viewing the webinar. The information session will be presented by physical activity researchers and sports facility staff who will also facilitate discussion. Table 1 summarises the content of the intervention using the TIDieR checklist [25].

Participants randomised to the control group will be allocated to a waiting list and will receive access to the intervention after the 3-month follow-up period.

The primary outcome will be the proportion of people achieving an average of at least 10,000 daily steps, measured objectively with a matchbox-sized waist-worn accelerometer (*Actigraph GT3X+*) at 3-months. *ActiGraph GT3X+* is able to accurately estimate how physically active a person is throughout the day by measuring 3D body accelerations and is a valid instrument that has been extensively researched in the physical activity and public health field [27]. Participants will be instructed to wear the accelerometer on the right hip, attached via an adjustable elastic belt, for seven consecutive days during waking hours (except during water-based activities or bathing), and to complete an activity log. Activity counts per second will be collected at a sampling frequency of 30 Hz and reintegrated to 60s epochs for data analysis.

The primary outcome will be quantified as the average step counts per day. This outcome will detect any increase in incidental physical activity (i.e. less time spent sitting) as well as adoption of more formal exercise regimens. These data will be collected over a 7-day period

Table 1 Intervention description using the Template for Intervention Description and Replication (TIDieR) checklist [25]

1. Brief name	Active Women over 50 physical activity education and promotion intervention
2. Why	Uptake of physical activity is sub-optimal in working women in their middle age. Women over 50 years have unique barriers to becoming more active (eg. higher sedentary time, greater carer responsibilities, work demands).
3. What materials	The education program has been designed for women over the age of 50 using the Behaviour Change Wheel framework and COM-B system model of behaviour change [20] to facilitate and sustain behavioural change. Information will be presented via a Powerpoint slideshow outlining the evidence on benefits of physical activity, overcoming barriers to physical activity, physical activity options available to university and health service staff, getting started and maintaining activity. Video case-study interviews of four female staff members aged over 50 years who have overcome barriers to increase their physical activity will be shown to inspire participants. Participants will receive a printed handbook containing physical activity resources such as internet-based information and programs, local physical activity programs and facilities, suggestions of the numerous free applications for smartphone devices, and a guide to starting physical activity. Participants will also receive a pre-exercise screening tool and exercise intensity guidelines [28]; will be offered the use of a pedometer or internet-connected activity tracker (*Fitbit*) for the duration of the study, to provide motivation and feedback to increase activity levels; will have access to 1) an online discussion group with other participants to share ideas and for motivation, 2) fortnightly emails reinforcing the workshop content and supporting participants to increase their physical activity, 3) a free trial class at the Sydney University Sports Facility, and 4) all the information session materials (slides, video case study interviews, University sports facility brochures) via an email link. The internet-based information resources will include the *Get Healthy* website produced by the NSW Ministry of Health [29] (www.gethealthynsw.com.au), *Make Healthy Normal* website produced by the NSW Ministry of Health (www.makehealthynormal.com.au); internet-based program resources may include the *Active and Healthy* website [30], *parkrun* website promoting free, weekly community walk/runs [31].
4. What procedures	An information session will be used to provide education and support to participants to increase their physical activity through university and health service on-campus and local opportunities. Participants will have the option to loan a *Fitbit* activity tracker for the duration of the study, and/or receive follow up fortnightly emails, and/or access to an online discussion group *Yammer*. All participants will be emailed a link to access the presentation materials, and will have email access to the research team for any further enquiries.
5. Who provided	Research team members with expertise in the field of physical activity research and practice will provide and deliver the information session and facilitate discussion. A University sports facility staff member will outline their available programs at the information session.
6. How	Information sessions will be face-to-face in a group setting of up to 20 people at a time. A video conferencing facility will be offered to participants who are not able to physically attend the session location but will allow them to be able to interact with the group. Information sessions will also be offered via a pre-recorded internet link for participants who are not able to attend the sessions in person, and will have the opportunity to ask any questions to the research team via email or telephone.
7. Where	The information sessions will be held at the workplace at two university campus sites and at one hospital site in Sydney, in a meeting room with data projection and video-conferencing facilities. Remote access will be through a video conferencing facility or through a pre-recorded online link of the webinar.
8. When and how much	The intervention will be one, 1-h information session scheduled during lunch time (12-1 pm). Those attending via the online link will attend at a time of their convenience. Follow up support emails will be sent fortnightly to participants who elect to receive these. There will be no cost.
9. Tailoring	All participants will receive the same information session content and access to the same internet-based resources. Participants will have the opportunity to ask questions during the session or via email or telephone support following it. Participants will be advised to seek individual advice from a health professional if they are concerned about commencing physical activity or have an injury.

to account for day-to-day variation in physical activity levels. The accelerometers will be posted to participants with clear instructions for use and email or telephone support will be available. Participants will be provided with pre-paid envelopes to return the devices to the research centre. Accelerometer data will be manually checked against participant activity logs to verify wear time, and erroneous data will be excluded prior to analysis. Physical activity participation will be assessed at baseline and 3 months after participant randomisation, and *ActiGraph* data will be extracted by a research assistant who is unaware of group assignment (i.e. blinded outcome assessment).

Accelerometer data will be analysed using *ActiLife 6* software. Acceptable wear time will be defined as 4 days or more of 10 h or more per day. Periods of 90 min or more of consecutive zeros (indicating non-use) will be considered as non-wear time.

The secondary outcomes will be assessed at baseline and at 3 months post-randomisation via a self-report questionnaire that will take approximately 30 min to complete. The secondary outcomes will include: 1) the proportion of people achieving adequate physical activity levels as recommended by national physical activity guidelines: 150 to 300 min of moderate intensity physical activity or 75 to 150 min of vigorous intensity physical activity, or an equivalent combination of both moderate and vigorous activities, each week, and to do muscle strengthening activities on at least 2 days each week [7], measured using an *Actigraph* accelerometer; 2) the average total number of hours of physical activity per week, self-reported with the International *Physical Activity*

Questionnaire (IPAQ) [32]; 3) change in perceived benefits of and barriers to exercise participation, as measured by the *Exercise Benefits and Barriers Scale* [33]; 4) physical functioning as measured by the function component of the *Late Life Function and Disability Instrument* (LLFDI) [34]; 5) mood as measured with the *Positive and Negative Affect Schedule* (PANAS) [35]. Participants in the intervention group will also complete a follow-up questionnaire evaluating whether the suggested or other resources were investigated or participated in, whether goals were set, and participants' perceived barriers and plans following the workshop.

Odds ratios will be calculated to assess the effect of group allocation on the dichotomously-scored primary outcome (proportion of people achieving 10,000 steps/ day) and secondary outcome (proportion of people achieving physical activity in accordance with national guidelines). General linear models will assess the effect of group allocation on the continuously-scored secondary outcomes (self-reported physical activity, perceived exercise benefits and barriers, physical functioning and mood), adjusting for baseline scores.

A p-value of < 0.05 will be considered statistically significant. A full statistical analysis plan will be devised by the lead investigator prior to commencement of data analysis. Analyses will be pre-planned, conducted while masked to group allocation and will use an intention-to-treat approach. Analyses will be conducted using the *Stata 14* software package.

A total of 50 participants per group (i.e. 100 participants) will provide 80% power to detect 30% more people in the intervention group reaching the recommended 10, 000 steps/ day than the control group. This calculation assumed a proportion of 27% compliance with the 10,000 steps/ day activity level in the control group, dropout rate of 15% and alpha of 5%. The estimates of the proportion of people achieving 10,000 steps/ day activity level was taken from the baseline results of the University of Sydney staff participating in the Global Corporate Challenge [36]. This sample size is also expected to be sufficient to detect between-group differences in the order of 10–15% for the secondary outcome measures.

Participant data will be collected by survey questionnaires, completed online or in paper format if preferred, and via *Actigraph* activity monitor posted to participants at baseline and 3-month follow-up. An email or phone call will be sent to any participants with incomplete outcome measures to improve participant retention. To ensure participant confidentiality, the final dataset will contain re-identifiable information only. Demographic information linking the participant to the data will be stored on a separate file. All data will be entered onto a password protected database and maintained on a firewall protected local network server at The University of Sydney. Paper files will be stored in a locked filing cabinet in the Chief Investigators office. Access to all data will be limited to authorised study staff. All publications associated with the results of the study will involve de-identified data, so participant confidentiality will be maintained.

The trial protocol has been approved by the Human Research Ethics Committee at The University of Sydney, Australia (approval number 2017/115) and Research Ethics and Governance Office at Sydney Local Health District (Protocol number X17–0316; LNR/17/RPAH/473, LNRSSA/17/RPAH/560, LNRSSA/18/RPAH/46, LNRSSA/18/RPAH/75). The trial is registered (ACTR N12617000485336). Results will be disseminated via peer-reviewed journal articles and international conferences, and a lay summary will be made available to all participants at the completion of the study.

Discussion

The evidence for the physical and mental benefits of physical activity, even in small amounts [9, 37, 28] in delaying the development of disability and chronic disease is compelling, yet the problem of physical activity participation remains a significant global public health dilemma.

This study targets women over the age of 50, a group that is at greatest risk of developing disability in older age, who are insufficiently active according to the national physical activity guidelines [8]. The trial will provide evidence on the impact of a brief, low-dose, low-cost intervention to address the problem of physical inactivity in the workplace setting, an ideal setting due to the amount of time spent at work, the potential risk that work may contribute to inactivity, and possible benefits that the intervention may have on employee wellbeing [17].

The intervention will provide support for behaviour change through the BCW framework. Behavioural change and adherence to the program will be facilitated, enabled and supported by providing the group information session face-to-face or online, opportunities for discussion, inspiration through video case studies, post-workshop support with the provision of a resource handbook, use of an activity tracker (*Fitbit*) and workshop materials, receiving fortnightly email messages, joining an online discussion group, and a free trial class at the university sports facility.

A limitation of this trial is that participants will be recruited based on self-rated physical activity prior to objective physical activity baseline measures. Other limitations are that only land-based physical activities will be measured by the accelerometer, a lack of individual tailoring of the intervention, and limited generalisability of this sample to other workplace settings and to men.

However, if found effective, this low-cost program with supported follow-up, could be scalable, directly implemented into the workplace setting and directly address the problem of physical inactivity. There would also be scope for this intervention to be translated to the broader community by exploring other settings and resource delivery.

An effective and scalable preventive health strategy is needed to ease the burden on health systems already at capacity, and burden on individuals' lives. This simple intervention has the potential to address the problem of physical inactivity to delay the onset of disability in older age.

Abbreviations

BCW: Behaviour Change Wheel; CONSORT: Consolidated Standards Of Reporting Trials statement; SPIRIT: Standard Protocol Items: Recommendations for Interventional Trials statement; TIDieR: Template for Intervention Description and Replication checklist

Acknowledgements

Not applicable.

Authors' contributions

AT, CS, CC, LH, RS conceived of the study. All authors contributed to the study design and implementation methods. GW will be the study manager. BR, CM will assist with participant recruitment. GW, AT, CS, LH will deliver the intervention. GW, AT, CS will conduct the primary statistical analyses. All authors contributed to the refinement of the study protocol and approved the final manuscript.

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Availability of data and materials

Not applicable.

Ethics approval and consent to participate

The trial protocol has been approved by the Human Research Ethics Committee at The University of Sydney, Australia (approval number 2017/115) and Research Ethics and Governance Office at Sydney Local Health District (Protocol number X17–0316). Written informed consent will be obtained from study participants.

Consent for publication

Not applicable.

Competing interests

The authors declare they have no competing interests.

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Publisher's Note

CHAPTER 4. Active Women over 50. Promoting physical activity in women 50+: a randomised trial.

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Authorship contribution statement

As primary supervisor and co-author of the paper “Active Women over 50. Promoting physical activity in women 50+: a randomized trial”, I confirm that Geraldine Kit-Bing Wallbank is the lead corresponding author and has made the primary contribution to this study in each of the following areas in collaboration with co-authors Sherrington C, Canning C, Hassett L, Shepherd R, Richards B, Mackay C, Tiedemann A:

- Conception and design of the research
- Data collection
- Data analysis and interpretation of findings
- Writing of the manuscript and critical appraisal of the content

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank

20 August 2025

Preamble to Chapter 4

This chapter describes the results of the randomised waitlist-controlled trial protocol described in Chapter 3. This trial tested a pragmatic and efficient physical activity support intervention among employed women in Sydney, Australia, prior to the COVID-19 pandemic. The trial also served as a proof-of-concept study to assess uptake and engagement from a sample of the population. As such, a broad approach was taken to the concept of intervention 'efficiency', such as promoting the use of already available physical activity facilities, resources and low technology strategies as opposed to re-creating them.

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Active Women over 50. Promoting Physical Activity in Women Over 50: A Randomized Trial

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Abstract

Purpose: This study aims to test the effect of an information and support intervention on physical activity (PA) in women aged 50+ years.

Design: Randomized wait-list controlled trial.

Setting: Sydney, Australia.

Sample: 126 female university and health service employees, aged 50+.

Intervention: Information session, activity tracker, regular motivational emails.

Measures: Proportion achieving ≥ 10,000 steps/day (primary outcome), daily step count, proportion meeting 150 mins/week of moderate to vigorous PA (MVPA), self-reported PA.

Analysis: Odds-ratios and general linear regression models.

Results: At 3 months, the intervention group reported significantly more vigorous PA (1.04 hours, 95% CI 0.24 to 1.85, $P = .01$, measured by *IPAQ*), were more likely to achieve 300 mins/week of MVPA (OR = 1.98, 95% CI 0.89 to 4.36, $P = .09$, measured by *Actigraph*) than the control wait-list group, and reported adopting PA promotion strategies (technology = 31/58% or goal-setting = 39/74%). No significant between-group differences in the primary outcome were detected (1.39, 95% CI 0.61 to 3.18, $P = .44$).

Conclusions: This low-dose intervention significantly increased self-reported vigorous PA time and non-significantly increased the proportion of people achieving 300 mins/week of MVPA but did not significantly increase the proportion of participants achieving 10,000 steps/day. Relatively small effects may be important at a population level given the minimal resources needed to deliver this intervention.

Keywords

exercise, middle aged, health promotion, workplace

In Brief

This study tested the effect of a low-dose information and support physical activity intervention on the physical activity participation of female employees aged 50 and over in a randomized wait-list controlled trial. Results indicated the intervention group reported significantly more vigorous physical activity was more likely to exceed physical activity recommended guidelines than the wait-list group and adopted physical activity–promotion strategies. Between-group differences in the primary outcome were small. Relatively small effects may be important at a population level given the minimal resources needed to deliver this intervention.

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Purpose

Regular PA provides benefits to physical and mental health throughout the lifespan, and regular PA in middle age (45–65 years) is particularly important for better health in older age.[1] Women in middle age face unique barriers to regular PA[2] and could benefit from support to increase PA. This trial tested the effect of a low-dose information and support intervention, *Active Women over 50 (AWo50)*, on PA for women aged 50+.

Methods

Design

Consenting participants were randomly allocated, 1:1, to the intervention or wait-list control group and followed up after 3 months. Concealed allocation using a computer-generated randomization schedule was prepared by an independent investigator using randomly permuted block sizes of 2–6, stratified by employment site.

Sample

We recruited 126 eligible female employees of The University of Sydney or Sydney Local Health District, Australia, aged 50+ years. Those with limited English language, a health condition precluding regular PA or self-reported to be meeting the lower limit of the WHO MVPA guidelines (150 minutes/week of moderate-PA or 75 minutes/week of vigorous PA)[3] based on two screening questions were excluded. This sample was estimated to provide 80% power to detect 30% more intervention participants reaching ≥ 10,000 steps/day at follow-up compared to controls, assuming 15% dropout and 5% alpha. Baseline rates were estimated from University of Sydney data from the *Global Corporate Challenge*.[4]

Measures

The primary outcome was the difference in the proportion of participants achieving 10,000 daily steps, measured by *Actigraph GT3X+* accelerometer, at baseline and at follow-up (see Supplemental Material).[5] A blinded research assistant extracted, checked and cleaned *Actigraph* data prior to analysis.

Secondary outcomes were (1) difference in the proportion of participants achieving the lower limit of WHO MVPA guidelines,[3] measured by *Actigraph*; (2) difference in number of daily steps, measured by *Actigraph*; (3) difference in duration and intensity of weekly PA, self-reported via the *International Physical Activity Questionnaire (IPAQ)*.[6] Intervention participants completed an additional online questionnaire regarding PA strategies, goal-setting, barriers, and plans following the program.

Intervention

We designed the *AWo50* program to provide information and support in the workplace with the principles of efficiency and scalability. The program content is reported in detail elsewhere[5] and is described here in brief. Intervention participants (n = 65) attended a face-to-face one-hour workplace-based information session, received a handbook of PA resources and fortnightly motivational emails, and access to an online discussion group. Participants were offered an internet-connected activity tracker (*Fitbit*) and a free trial class at the workplace fitness facility. Participants unable to attend the face-to-face information session accessed it via video-conference or a recording. Wait-list control participants (n = 61) continued usual activities and received the programme after follow-up.

Analysis

Analyses were pre-planned, conducted while masked to group allocation and used an intention-to-treat approach. The effect of group allocation at follow-up was calculated using odds ratios for dichotomously scored outcomes and general linear regression models for continuously scored outcomes, with baseline scores included as a covariate. Additional analyses explored the proportion achieving 300 mins/week MVPA.[3] Analyses were conducted with *Stata 14* (see Supplemental Material) and *ActiLife 6* software using the Choi 2011 cut-points.[7] Participants' PA was analysed descriptively.

Results

Participants were on average 57 years (SD = 5.3). Of the 126 recruited participants, 101 (80%) participants completed primary outcome measures (intervention n = 48 and control n = 53). There were no reported adverse events.

Participants' baseline characteristics (Table 1) were similar. On average, at baseline, participants took 8500 daily steps, spent 317 minutes/week in MVPA, and > 80% met 150 mins/week MVPA when device-measured.

No between-group differences were detected in the primary outcome, proportion achieving ≥ 10,000 steps/day (OR = 1.39, 95% CI 0.61 to 3.18, P = .44) or other secondary

Table 1. Participant Baseline Characteristics, All Values Presented as n (%) Unless Otherwise Stated.

	Control (n = 61)	Intervention (n = 65)
Age, years, mean (SD)	57 (5.1)	56 (5.5)
Language spoken at home other than English	3 (5)	6 (9)
Carer responsibilities	20 (33)	16 (25)
1 or more medical conditions	33 (54)	35 (54)
Previously participated in regular structured PA	48 (79)	40 (62)
Hours worked per week, mean (SD)	37 (10.7)	38 (9.2)

Note: PA: physical activity.

Table 2. Mean (SD) of Groups at Baseline and Follow-Up, and between-Group Effects Presented as Mean Difference between Groups or OR (95% CI) With *P*-value.

	Baseline Control	Baseline Intervention	3-Month Follow-Up Control	3-Month Follow-Up Intervention	Between-Group Difference, Adjusted for Baseline
Primary outcome: Proportion achieving ≥ 10 000 steps/day, n (%)[a,c]	12 (20) n = 61	16 (25) n = 65	16 (30) n = 53	18 (38) n = 48	OR = 1.39 (95% CI 0.61 to 3.18), *P* = .44
Actigraph number of steps/day[a,b]	8500 (3184) n = 61	8625 (2364) n = 65	9034 (3515) n = 53	9564 (2178) n = 48	260.27 (95% CI −519.24 to 1039.77), *P* = .51
Actigraph MVPA, mins/week[a,c]	299 (158.4) n = 61	308 (158.4) n = 65	322 (189.0) n = 53	353 (159.0) n = 48	15.84 (95% CI −33.41 to 65.08), *P* = .53
Actigraph VPA, mins/week[a,c]	9.72 (24.23) n = 61	13.28 (33.63) n = 65	11.81 (32.72) n = 53	15.63 (34.70) n = 48	−3.03 (95% CI −10.38 to 4.32), *P* = .42
Proportion meeting lower limit of WHO MVPA guidelines, ≥ 150mins/week, n (%)[a,c]	50 (82) n = 61	54 (83) n = 65	44 (83) n = 53	43 (90) n = 48	OR = 1.76 (.55 to 5.67), *P* = .345
Proportion achieving the upper limit of WHO MVPA guidelines, ≥ 300 mins/week, n (%)[a,c]	28 (46) n = 61	31 (48) n = 65	22 (42) n = 53	28 (58) n = 48	OR = 1.98 (95% CI 0.89 to 4.36), *P* = .09
IPAQ: Total PA, hours/week[a,c]	16 (13.1) n = 61	21 (16.0) n = 65	16 (15.6) n = 51	17 (14.3) n = 50	−.29 (95% CI −5.45 to 4.86), *P* = .911
IPAQ: Vigorous-intensity, hours/week[a,b]	.8 (2.9) n = 61	.6 (2.1) n = 65	.4 (1.2) n = 51	1.4 (2.7) n = 50	1.04 (95% CI 0.24 to 1.85), *P* = .01

Notes: WHO: World Health Organization; MVPA: moderate-vigorous physical activity; VPA: vigorous-intensity physical activity; IPAQ: International Physical Activity Questionnaire; PA: physical activity.
[a]higher score reflects better performance.
[b]between-group differences are from linear regression models.
[c]between-group differences are from logistic regression models.

outcomes. However, at follow-up intervention, participants reported significantly more vigorous PA compared to controls on the questionnaire-based *IPAQ* (1.04 hours, 95% CI 0.24 to 1.85, $P = .01$), a difference which was not significant when device-measured via the *Actigraph* (Table 2). Also, 14% more intervention participants achieved 300 mins/week of MVPA[3] when device-measured (baseline/follow-up change = 10% intervention, −4% control, OR = 1.98, 95% CI 0.89 to 4.36, $P = .09$) but this between-group difference did not reach statistical significance.

Fifty-three (82%) intervention participants gave feedback about their intervention engagement. Of these, 48 (91%) attended the information session, 31 (60%) used an activity tracker, and 10 (19%) investigated the workplace fitness facility. The most popular strategy used to support PA was 'technology-delivered', such as websites, smartphone applications, activity trackers and fortnightly study emails and investigated by 41 (79%) participants and adopted by 32 (62%). Other adopted strategies included exercising with others (25, 48%), structured PA (21, 40%), setting a PA goal (39, 74%), and making future PA plans (53, 100%).

Exploratory subgroup analysis of participants lost to follow-up showed lower average device-measured PA compared to participants with completed measures (Supplemental Material, Table 3).

Discussion

Summary

The *AWo50* program significantly improved self-reported vigorous PA and showed a trend for participants to achieve the upper limit of the WHO MVPA guidelines when device-measured. There were no statistically significant between-group differences for primary and other secondary outcomes. The lack of impact on trial outcomes may be explained by participants' higher baseline PA compared to the national average PA[8] and insufficient intervention dosage. Technology and goal-setting were favoured by participants to support their PA.

Limitations

Despite efforts to recruit insufficiently active participants, a high proportion in the sample met the lower limit of the WHO MVPA guidelines at baseline when device-measured. This was possibly because (1) participants may have been more conscious of their PA being tracked while wearing the *Actigraph* device and felt more intrinsically motivated to increase their usual PA levels at baseline, (2) the sample of participants recruited from the university and health service are more likely to be highly educated and professional women for whom previous population studies have reported higher physical activity levels compared to the general population[9] and (3) the recruitment screening method underestimated baseline self-reported PA measured by *IPAQ*. Additionally, high survey-measured vigorous PA reported by intervention participants may have contributed to self-report bias which has been previously reported.[10] Participant attrition was relatively high (20%) in this study which may have biased the results. On average, participants lost to follow-up were less physically active compared to other study participants, so it is possible the effect of the intervention was overestimated. Yet, since there was no baseline difference between dropouts and those with completed datasets meeting the upper limit of the MVPA guidelines, the validity of this outcome is increased. Our sample size calculation assumed a 30% between-group difference on the primary outcome, which, in hindsight, was too large an assumption for such a low-intensity intervention. A retrospective power calculation for the 8% observed effect size indicated the need for a larger sample of 1400 participants.

Significance

This pragmatic trial uniquely targeted women at an important time in the lifespan for healthy ageing, with a theoretically driven intervention and rigorous methodology. The intervention supported behaviour change by giving participants a range of PA resources and autonomy over their PA behaviour.

Being physically active at more vigorous intensity and longer duration than the minimum weekly guidelines are associated with additional health benefits with no clear upper limits for benefits.[11] This intervention helped those who were already reasonably active to be more active with potential additional health benefits.

So What? What Is Already Known on This Topic?

Establishing regular PA habits in middle age is recommended for healthy older age.

What Does This Article Add?

A resource-efficient low-dose intervention increased self-reported vigorous PA.

What Are the Implications for Health Promotion Practice or Research?

Relatively small effects may be important at a population level given the minimal resources needed to implement this intervention in workplaces. A more intense intervention delivered digitally could incorporate goal-oriented tailoring to enhance engagement.

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Contributor

AT, CS, CC, LH and RS conceived of the study. All authors contributed to the study design and implementation methods. GW was the study manager. BR and CM assisted with participant recruitment. GW, AT, CS and LH delivered the intervention. GW, AT and CS contributed to data analysis and interpretation of the data. GW drafted the manuscript, and all authors contributed to revisions and approved the final manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Informed Consent

Informed consent was obtained from all individual participants included in the study.

Trial Registration

This study is registered at www.anzctr.org.au (ACTRN12617000485336), approved 04/04/2017. Institutional Review Board: This trial has been approved by the Human Research Ethics Committee at The University of Sydney, Australia (approval number 2017/115).

Human Rights

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Welfare of Animals

This article does not contain any studies with animals performed by any of the authors.

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Supplemental Material

Supplemental material for this article is available online.

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CHAPTER 5. Designing physical activity interventions for women aged 50+: a qualitative study of participant perspectives.

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Authorship contribution statement

As primary supervisor and co-author of the paper “Designing physical activity interventions for women aged 50+: a qualitative study of participant perspectives”, I confirm that Geraldine Kit-Bing Wallbank is the lead corresponding author and has made the primary contribution to this study in each of the following areas in collaboration with co-authors Haynes A, Sherrington C, Grunseit AC:

- Conception and design of the research
- Data collection
- Data analysis and interpretation of findings
- Writing of the manuscript and critical appraisal of the content

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank

20 August 2025

Preamble to Chapter 5

A comprehensive understanding of physical activity interventions requires the integration of both quantitative and qualitative evaluation. While quantitative evaluation provides insight into the extent and amount of change, qualitative evaluation helps to uncover contextual factors that explain why or how outcomes were achieved or not achieved. This chapter presents the qualitative evaluation of the randomised waitlist-controlled trial presented in Chapter 3 and Chapter 4, focusing on participants' perspectives.

BMC Public Health

RESEARCH

Open Access

Designing physical activity interventions for women aged 50+: a qualitative study of participant perspectives

Geraldine Wallbank[1,2,4*], Abby Haynes[1,2], Anne Tiedemann[1,2], Catherine Sherrington[1,2] and Anne C. Grunseit[3]

Abstract

Background The *Active Women over 50* trial tested a scalable program for increasing physical activity among women aged 50+. The program included information, activity tracker and email support. This study sought to describe the participant perspectives of the *Active Women over 50* program and considerations for designing physical activity interventions for this demographic.

Methods Women who completed the *Active Women over 50* trial were purposively recruited for maximum variation in age, employment, carer responsibility, medical conditions and physical activity. Individual semi-structured interviews explored their perspectives on physical activity, *Active Women over 50* program components and suggestions for future iterations. Data were thematically analysed.

Results Participants' capacity to be physically active was shaped by an interplay of factors. Our analysis generated four main themes relating to physical activity in general and to the program: Age and gender matters, Physical activity is social, Strategising for physical activity and the Self-responsibility discourse. At this midlife stage, physical activity participation was challenged by personal, life-stage and cultural factors, alongside a tension of the self-responsibility discourse which also impacted the program experience. Social factors and finding a suitable strategy for motivation were deemed integral aspects of being active. Future programs could consider facilitation of social networks and accountability, life-stage health information and positive framing to support self-responsibility.

Conclusion A range of strategies is key to supporting women over 50 to be more physically active due to the variety of circumstances and levels of agency experienced. We offer suggestions that do not need to be resource intensive but could be incorporated into a scaled program.

Keywords Middle-age, Women, Physical activity, Intervention trial, Qualitative methods

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BACKGROUND

Physical inactivity is a pressing global public health problem [1–3], accounting for 5.3 million deaths annually and costing health systems an estimated INT$67.5 billion [4]. One in four adults worldwide are physically inactive and for women this proportion increases to one in three [5]. Regular physical activity commenced in middle age years is associated with longevity benefits [6, 7] and can delay physical disability by up to 15 years in women [2]. Physical activity programs that target inactive people, and specifically middle-aged women, not only ameliorate the risks of inactivity but can promote healthy and independent ageing.

Physical activity programs need to be effective and appealing. While effective physical activity interventions have been reported for middle-aged and older populations [8–10], intensive resources needed can be a barrier to implementation at scale [11]. Programs also need to be compelling and address unique barriers to regular physical activity for women over 50, such as juggling carer and work responsibilities [12, 13], or low confidence with being active particularly if they were inactive in younger years [14].

Researchers at the Institute for Musculoskeletal Health, Sydney, Australia, conducted the *Active Women over 50* trial in response to the need for a scalable solution for physical activity[15, 16] *Active Women over 50* was underpinned by behaviour change theory and tested the effect of a resource-efficient, "low-dose" information and support intervention on physical activity in women aged 50+in the workplace setting[17].

The Active Women over 50 trial

In brief, *Active Women over 50* trial aimed to increase physical activity participation among female university or local health service employees, aged 50+, English speaking and physically inactive by self-report. One hundred and twenty-six trial participants were recruited and randomly allocated to the intervention group or to a 3-month waitlist control. The intervention was based on behaviour change principles, informed by the Theoretical Domains Framework and the Capability, Opportunity, Motivation, Behaviour (COM-B) framework [18]. Intervention was: (1) a face-to-face information session held at the workplace discussing physical activity benefits, overcoming barriers and strategies for being more active, and viewing peer video interviews. The intervention provided access to (2) a study-loaned *Fitbit* activity tracker; (3) physical activity resource book; (4) fortnightly motivational-based email messages; (5) online *Yammer* platform attendee discussion group; (6) workplace sports facility free trial. Intervention participants planned and chose their preferred physical activity type, amount and strategies. Control participants received the intervention after the follow-up assessment.

Compared to controls at follow-up, the intervention group reported significantly more vigorous-intensity weekly physical activity (1.04 h, 95%CI 0.24 to 1.85, p=0.012 measured by *International Physical Activity Questionnaire* [19]) and were more likely to achieve upper limits of the World Health Organization physical activity guidelines for moderate-vigorous physical activity (300 min per week [20]) (OR1.98, 95%CI 0.89 to 4.36, p=0.093). There was no significant between-group difference on the primary outcome of taking 10,000 daily steps (1.39, 95%CI 0.61 to 3.18, p=0.438).

It was considered essential to explore participants' perspectives and contexts during trial evaluation to inform future iterations. Previous qualitative studies have described physical activity barriers and facilitators for middle-aged women [21–23] and participant experiences of physical activity programs [24, 25]. Yet, there is a need for qualitative work that synthesises the broader factors shaping physical activity with participant experiences of a physical activity program to better understand the population and guide program design.

The overall aim of this study was to explore factors to consider when designing a physical activity intervention for women aged 50+. Specific research questions were:

1. What were participants' experiences of physical activity in general?
2. What were participants' experiences of the *Active Women over 50* program?
3. What are the implications for future iterations of this and other physical activity programs targeting this population?

METHODS

Study design and context

We used a qualitative design through semi-structured one-on-one interviews, taking a pragmatist-oriented approach. This approach is atheoretical, socially situated and generates applied knowledge to address the study aims, research questions and adequate action to address the problem [26]. This research study informed the evaluation of the *Active Women over 50*trial[17]. Ethical approval was granted by the Ethics Review Committee at the Sydney Local Health District Research Ethics and Governance Office (X17-0316 & LNR/17/RPAH/473).

Recruitment and data collection

Women who had completed the *Active Women over 50* trial from both the intervention and waitlist control groups were purposively recruited and invited to participate in this study. Participants were targeted for maximum variation in age, hours worked, work area, carer responsibility, medical conditions and pre-trial physical

activity. Potential participants were invited via email during November 2018-January 2019 and interviews were conducted at least three months after the women had completed the *Active Women over 50* trial when waitlist control participants had received the intervention.

Recruitment was a staged process where additional participants were invited to participate following lack of response or declined invitations from earlier rounds of invitations. This process was concurrent with data collection and early analysis and we stopped at the point when data adequacy had been reached i.e., we judged during our analysis that we had sufficient rich data across our sample with which to answer our research questions [27, 28]. Of the 61 women contacted, 18 women (30%) declined the invitation and 23 (38%) did not reply. Twenty women (33%) provided written or verbal consent to participate in the study. GW and AH conducted face-to-face semi-structured interviews at the university research centre, the participant's workplace, or by telephone according to participant preference. Only the interviewer and participant were present at the interviews. No repeat interviews were conducted.

GW was a PhD candidate with a physiotherapy background, the study manager for the *Active Women over 50* trial[17], and had training in interview techniques and qualitative research. While GW had attended some of the workshops in the trial, to minimise the potential impact this may have had on participants' perspectives, GW only interviewed participants who attended workshops where GW was not in attendance. AH was an experienced qualitative researcher with a background in social work and program evaluation and had not been involved in the *Active Women over 50* trial. To minimise the potential impact that GW may have had with participants, AH interviewed participants from the workshops where GW was in attendance. GW and AH were aged in their 40 and 50 s and had not previously collaborated.

GW and AH generated the interview guide in consultation with the research team, informed by interpersonal-level program theory such as Social Cognitive Theory. This theory emphasises the dynamic interaction between people, an individual's prior behaviour and the social and physical environment in influencing future behaviour [29, 30]. Participants were probed on their perspectives of physical activity in general, aspects of the trial such as recruitment, program components and levels of support and suggestions for future iterations. GW and AH completed memos after interviews and met regularly to discuss the data, emergent codes and themes and whether more participants needed to be recruited. Recruitment ceased when 'data adequacy' was reached,

Interviews took 36 min on average (range 22–60 min). Interview audio recordings were professionally transcribed and transcripts were corrected by the interviewer. Transcripts were not returned to participants.

Data analysis

Data were coded by GW using an inductive analytical approach with codes relevant to understanding the participant perspectives and experiences as described by Braun, Clarke and Rance[31]. The initial codes were iteratively grouped into higher level headings by one researcher (GW) and tested for coherence and meaning given the research questions. Coding was discussed with two researchers familiar with the data (AH, AG) early in the analysis for how well the codes captured the participant perspectives and agreement on the coding scheme achieved. One researcher (GW) coded the remainder of the data. Recurrent themes and subthemes were generated from the raw data and were considered in consultation with the wider research team to increase dependability [32]. Themes and subthemes were iteratively reviewed to ensure they reflected the whole dataset, and interpretations were refined. We used [33] software to manage the data. The criteria for reporting qualitative research (COREQ) was used as a guideline[34].

RESULTS

Participant characteristics

All twenty participants were female employees at the university or health service, as per trial eligibility. Participant characteristics are summarised in Table 1. Two were colleagues and four worked in the same department. Participants had a median age of 56 years (IQR 53.8 to 58.0) and worked 35 h per week (IQR 28.0 to 40.0) in the fields of administration, architecture, design and planning, arts and social sciences, business and finance, human resources, library, medicine and allied health, offices of General Counsel and the Vice-Chancellor, science and veterinary science. Four participants worked in a health-related field. Nine had carer responsibilities and nine had participated in regular, structured individual or group physical activity when they were younger. Participants spent a median of 348.5 min/week (IQR 202.2 to 477.0) doing moderate-vigorous physical activity measured by accelerometer pre-intervention. We did not find any systematic divergence of the themes based on participant characteristics.

Main findings

Participants were positive about physical activity. They felt that exercise was good for health and many enjoyed it, and had experienced activity-related physical and psychological benefits. All participants wanted to be more active but felt factors unique to women of their age challenged their ability to enact this desire.

Table 1 Participant characteristics

Participant	Age, years	Weekly hours worked	Career type	Carer responsibilities	Regular physical activity when younger (< 50yrs old)	Workshop mode attended	Pre-trial moderate-vigorous physical activity, mins/week
1	57	35	Academic	No	No	In-person	337
2	56	35	Professional, research	No	Yes	In-person	530
3	53	28	Professional, administration	No	No	In-person	126
4	57	35	Professional, research	No	No	In-person	480
5	54	35	Professional, administration	Yes	No	In-person	563
6	51	65	Professional, administration	Yes	Yes	In-person	712
7	60	24	Professional, administration	Yes	No	In-person	487
8	55	28	Professional, administration	No	Yes	Video conference	185
9	56	35	Professional, administration	No	Yes	In-person	187
10	68	40	Academic	No	Yes	In-person	180
11	50	45	Academic	Yes	Yes	Video conference	221
12	58	28	Professional, administration	Yes	No	In-person	360
13	53	50	Academic	Yes	No	In-person	476
14	50	21	Professional, administration	Yes	Yes	In-person	202
15	60	35	Professional, administration	No	Yes	In-person	202
16	56	36	Professional, research	No	No	In-person	380
17	58	35	Professional, administration	No	No	Recording	471
18	54	22	Professional	Yes	Yes	In-person	475
19	57	40	Professional, administration	Yes	No	Recording	319
20	65	40	Professional, administration	No	No	Recording	234

We generated four themes from the narratives which described how participants viewed their capacity to be physically active and how this intersected with the *Active Women over 50* program. These were: (1) "Age and gender matters", (2) "Physical activity is social", (3) "Strategising for physical activity", and (4) "Self-responsibility discourse". The themes address research questions 1 and 2. Illustrative quotes for each theme are included in Table 2, deidentified to conceal the identity of participants and their workplaces and identified by "P" and participant number only.

Theme 1 – Age and gender matters

A common thread in the narratives was how age and gender shaped physical activity. We identified contextual and personal factors related to age and gender and summarised these under three subthemes: Life-stage demands, Invisibility and hypervisibility, and Bodily changes.

Life-stage demands

Life demands which typically came with participants' age, gender, and stage of career/family life, were often unpredictable and took priority, leaving them with little time for themselves and limited opportunities to be physically active. One such demand was family responsibilities where primary caring duties were typically carried out by women. As members of the *"sandwich generation"* (P19), participants found that inter-generational caring roles necessitated responding to the needs of ageing parents and children, often at the expense of looking after themselves.

Participants described family responsibilities were unpredictable and changeable and since caring duties took priority, physical activity options that required a set time commitment such as gym classes, were not compatible. A similar sentiment was expressed about career-stage demands. Participants reported being of an age where they were working more hours and holding more senior roles which entailed greater responsibility than previously. This included workplace expectations to attend meetings during personal lunchtimes when they could possibly be active.

The demands and unpredictability of family/career responsibilities were so high some participants felt opportunities to be active were not available. Some reported their pattern of physical inactivity persisted when they were no longer in caring roles.

Invisibility and hypervisibility

Participants described their willingness to be active was impacted by how they felt their age group and gender were perceived in physical activity settings. They reported that age-specific exercise classes for people aged 50+at gyms were often scheduled within working hours and made them feel unseen because it assumed their age group did not work.

Table 2 Illustrative quotes for the Themes "Age and gender matters", "Physical activity is social", "Strategising for physical activity" and "Self-responsibility discourse" by subtheme and subtheme definition

Age and gender matters		
Subtheme	**Subtheme description**	*"Particularly in this decade I think where, you know, you're pressing in from both ends of the generation. You're caught in the middle, and you've still got to try and think about yourself, and your health, and how you're going to get through."*(P3)
Life-stage demands	Age and gender-specific demands on life.	*"Because I'm over 50 and I'm inactive…but the life changes, menopause happens. I've got a very big job, busy as we all are…[exercise was] just a waste of time…I can't spend an hour going for a walk"*(P13)
Invisibility and Hypervisibility	Perceived a systemic lack of inclusion due to being a woman or ageing woman or both.	"*It's great if I was 20 years younger, but they [gyms] are not catering for the older person unless they do it [during] work hours, and most older people between 60 and 70 are now working….They need to fix something… to show gyms or exercise places that there are older people who need to do it, but they work."*(P15)
		"When I first started swimming, actually, I must have had time off and I was a bit overweight and I was shy, embarrassed or shy about my body. So I went to a pool that wasn't near work. Which was inconvenient …so I didn't feel as self-conscious."(P4).
		"Often people over 50, in particular, women, are silently ignored and it's really nice to feel special and that we were worth putting a study together like this."(P6)
Bodily changes	Perceived bodily constraints of being a woman or ageing woman or both.	*"I realise the benefits to your health…trying to support my mum and dad…I can see that I'm going to have similar issues if I don't now do something about it in my earlier years…I don't want to end up in that situation."*(P3)
		"Just life's just a bit complicated, and…I want to shift that weight again and that 5, 10 kilos that wasn't there before. Yeah, and now going into my 50s, I've got a different metabolism and body than I had when I was younger, so … It's working with what I've got now." (P14)
Physical activity is social		
Subtheme	**Subtheme description**	*"I used to walk with friends and we always just walked and talked. Finding people that you can relate to that you don't feel you have to be competitive with."* (P14)
Social connection	Physical activity provided opportunities to interact with others.	*"I think just hearing other people's experience was good… The sort of lifestyles that people have and the way that they can build exercise, whether they're working or still have family lives… and the way that I could do it. I think that was really motivating."*(P14)
		"I remember joining a Yammer [social media] group, and ask if anyone was interested in other people who were walking, and I actually didn't get any response to that."(P10)
Social comparison	Physical activity provided opportunities to appraise oneself against the norm of peers.	*"How are you traveling against other 55 year-olds? Not as a competitive thing, but just for you to kind of go, 'Okay, I need to up the ante a little bit', or I need to… You know?… Or 'I'm doing okay. I'm traveling okay.'"* (P18)
		"One thing I really liked about the workshop was the videos…For me, that was much more relatable and I was really glad to see that it wasn't just all these extraordinary woman. It was much more kind of real."(P11)
		"And they [women in video case studies] were highly disciplined people in their jobs. Yeah. So I think [you need] some more realistic type people…"(P15)
Strategising for physical activity		
Subtheme	**Subtheme description**	*"Being accountable on a team is a big deal for me, to not let people down, so yeah. Then in my own day-to-day, I don't feel as accountable to myself. And yet it's probably the most important thing."*(P14)
Accountability	Adopting a strategy for being physically active supports the capacity to be active by being accountable to others.	*"It was basically left to your own devices. Whether you did what was recommended, there was no one to really put you to the task. …. There was no one to really report back to and say "How are you tracking, how are you going?"…You feel like you've achieved something if someone is saying "How are you going? Is it working?" You know."*(P3)
Monitoring	Adopting a strategy for being physically active supports the capacity to be active by monitoring one's own physical activity.	*"It was a good reminder that every time I did a little bit of extra walking it was gonna get recorded. You know? And acknowledged. And it was a good measure of days where things hadn't gone so well and you go, 'Why didn't I get my steps in?'"*(P6)
		"…the following Monday, I come back, and I review what I've done, and I can tick off if I've managed to do those things, and then I set myself new, kind of, goals, for the next week… I just, kind of, thought, 'Okay. I've got to be accountable to myself.'"(P19)
Active Women over 50 as a catalyst and resource	Adopting a strategy for being physically active supports the capacity to be active through *Active Women over 50* program components (e.g. motivational email messages, information session).	*"I just never quite got back into that regular exercise pattern and it bothered me. And then when I saw the target group, women 50 or over or something I thought "Okay I should do this." Because I'd been casting around looking for an impetus to get me going."*(P4)
		"I think I've got far more perspective on it all… I also like the fact that the evidence was that it didn't all have to be hardcore gym…and so that was very good to know that it didn't have to be costing you a fortune in fees and gear, and what have you…I wanted to be able to not have to rely on other people. Just rely on myself." (P6)
		"Initially it was motivating, but after a while it was obviously, because it's self-directed, and you're self-motivating, then yeah. I find that peters out a bit, that self-motivation and encouragement to keep things going."(P3)

Table 2 (continued)

Self-responsibility discourse
"It's so easy to think, and this is my problem, I guess, is that there's 70 other things that I need to do that will just have to wait. So I guess prioritising, I'm not very good at prioritising." (P12)
"…, it's probably more my failure to not use Yammer more and to talk to the other participants online." (P12)
"The participation in the study was really, really powerful for me…It gave me the opportunity to sit and think and look at this stuff and reassess where I was putting activity and fitness into my priorities and I thought, "No, you're worth it." I want to live long." (P6)

Participants reported some practices at gyms sent them a message that the *"gym is more for younger people"*(P16). Noting the progressive replacement of gentler class types with high intensity classes, gyms seemed better suited to younger people. Contributing to the suggestion of youth bias in this setting were encounters with gym staff with limited knowledge about age-related bodily changes or age-appropriate exercises. The impression that women aged 50+were invisible was extended to experiences with other gym patrons. A participant reported others' assertive use of gym equipment and larger physical build meant *"...you just fade into the background"* (P19), felt ignored or excluded and reluctant to return to the gym. The experience of invisibility in the gym setting as a woman over 50 was expressed as the norm rather than an exception, the contrast which was highlighted by mentions of a participant's gym being inclusive of older people or the sense of greater visibility and support for being active when attending a women-only gym.

Physical activity also made some participants feel hypervisible and self-conscious about their body shape, fearing it drew unwanted attention and negative reactions. Hypervisibility drove one participant to exercise at a swimming pool in an alternate but inconvenient location.

Participants were discouraged by what they saw as a systemic lack of inclusion of older adults, women, or both, and so tended to reject gyms as a physical activity option. Noting the scarcity of physical activity options suited to women aged 50+, they welcomed the opportunity to contribute to a study that brought greater visibility to their demographic and offered a program to support their physical activity appropriately. This sentiment was not shared by all women aged 50+. A few participants mentioned that the age and gender specific targeting of *Active Women over 50* made their peers feel uncomfortable, hypervisible and *"a bit kind of resistant…[to]the age thing"* (P5), targeting which flagged them as older and drew unwanted attention.

Bodily changes

Another factor impacting participants' physical activity was their perceived bodily constraints. Participants felt they had reached an age where exercise was crucial to their health. Many wanted to "get in early" and be more active to prevent physical decline and maintain independence having witnessed the physical deterioration and dependence of their ageing parents.

However, there was a tension between recognising the need for physical activity to resist decline and feeling the decline had already commenced which made physical activity hard to do. Participants described the awkwardness of having an ageing body which lacked *"resilience"* (P13), energy, experienced disrupted sleep, or gained weight more easily than earlier years. Participants attributed these bodily changes to menopause, being more sedentary, or being older and made it more difficult to be active.

Participants envisaged *Active Women over 50* would help them lose weight and resolve their problem of physical inactivity. But most participants felt the potential benefit of *Active Women over 50* for losing weight was not met conceding that weight loss was difficult at their age and having to *"...work with what I've got now"*(P14).

Overall, the theme "Age and gender matters" captured a range of contextual and personal factors that challenged participants' desire to be more physically active. The age- and gender-specific targeting of *Active Women over 50* seemed to address some of those challenges by recognising women aged over 50 were a group for whom were worth catering.

Theme 2 - Physical activity is social

Participants felt that physical activity in general not only benefitted physical health, but it also provided opportunities to interact with other people. In particular, they hoped to be with those who had similar interests which would in turn, provide social support and motivation to be active. We identified two subthemes: Social connection and Social comparison.

Social connection

Participants reported physical activity provided opportunities for social interaction and gave a sense of being *"...part of something"*(P18). Participants felt a connection to others gave them the impetus and support to maintain being active, a desire which was felt acutely by a participant who lived alone. However, the mere presence of others was not sufficient to motivate physical activity. Participants cited having mutual interests and similar exercise goals and physical capabilities as providing a supportive social physical activity environment.

Some participants wanted to connect with workplace peers to help support their physical activity but found this difficult due to a predominance of younger employees. Therefore, *Active Women over 50* was valued as an opportunity to meet a "*community*" of "*like-minded*"(P5) women who shared a *"common goal"*(P12) of being active. Participants felt meeting others at a face-to-face workshop at their workplace was particularly appealing. Participants were also attracted to *Active Women over 50* as an age-appropriate and/or family/career-stage-specific modelled solution to being more active within their busy lives.

Participants' anticipation of connecting with others at the *Active Women over 50* workshop was fulfilled. They described how peer case study videos shown at the workshop prompted attendees to share physical activity ideas and experiences specific to their life-demands. However, many participants reported not feeling connected with other attendees beyond the workshop. Participants reported wanting more opportunities for social connection than *Active Women over 50* offered. One participant explained, the term "workshop" used in recruitment suggested to her the program would facilitate such interactions.

Active Women over 50 gave attendees access to a private online discussion group via *Yammer* social media to connect beyond the information session. While participants saw the benefits of connecting online with the group conceptually, they reported *Yammer* did not help them because they were neither used the platform, or were comfortable posting comments online. The difficulty of connecting with other attendees through *Yammer* was further described by one participant, whose invitation to shared physical activity time was met with silence. Therefore, an online platform intended to support social connections did not essentially assist participants.

Social comparison

Physical activity was social but did not necessarily involve directly interacting with others. Participants were curious to compare themselves against the norm of their peers and reported observing others to appraise their own health as they seemed unsure what was "normal" physical activity for their age. Participants hoped to find a peer group through *Active Women over 50*, feeling it would provide them with a benchmark for making or modifying physical activity plans.

Participants compared their physical activity to peers through viewing the *Active Women over 50* case study videos. Yet, these comparisons seemed to depend on how closely participants identified with the exemplars. Participants who saw they had similar physical activity levels as the exemplars felt the videos were affirming and *"relatable"*(P11). Some who reported they were less active than the exemplars felt the stories were eye-opening and were empowered to be strategic about making firm physical activity plans for themselves. Another participant viewed the exemplars as impressive, but unrealistic and unrelatable comparators.

The theme "physical activity is social" illustrates intrapersonal and interpersonal factors were key in shaping participants' capacity and motivation to be active. While *Active Women over 50* attracted participants with the anticipation of social supports, the reality fell short of their expectations with too few face-to-face meetings.

Theme 3 – Strategising for physical activity

Participants felt it was important to have a strategy for being active to provide structure for accomplishing their goals. Importantly, participants reported the strategy needed to fit with their life-demands and preferences. The theme Strategising for physical activity is conveyed through three subthemes: Accountability, Monitoring, and *Active Women over 50* as a catalyst and resource.

Accountability

Overlapping with Theme 2 ("Physical activity is social") was the concept of accountability. Participants valued social connections through physical activity partly because they wanted to be accountable to other people. They described an implicit commitment when exercising with others that set a "*level of expectation*" (P20) for attendance which they did not have when exercising alone. This sense of obligation validated participants' efforts and motivated them to keep being active. Yet accountability required shared physical activity abilities and attitudes for it to be supportive. Participants described that a mismatch of these attributes undid their plans to be active with colleagues.

The expectation of accountability was part of the attraction of *Active Women over 50* for some participants. Participants hoped to be *"put to task"*(P9) and be answerable to the program for their physical activity. Program accountability did not come to fruition for these participants who found the program to be "self-directed" and did not recognise their physical activity efforts.

Monitoring

Another strategy participants described was monitoring physical activity, via a range of methods such as pedometers, activity trackers, mobile phone applications, or charting activity and goals on a spreadsheet. Through receiving quantified physical activity information participants felt affirmed as their efforts were substantiated, but also caused some *"self-reflection"*(P6) and a motivation to continue being active.

This was also expressed by many who took the opportunity to borrow an *Active Women over 50* pedometer or

activity tracker having not using one previously, who felt monitoring their physical activity made them aware of their perceived physical activity levels compared to measured data. A participant reported the fortnightly *Active Women over 50* email messages also acted as a prompt to monitor her physical activity. The messages served as a "*reminder of my intention for going to the workshop originally"* (P4) and cued her to evaluate her physical activity over the past fortnight. Monitoring was therefore a strategy for physical activity that was related to accountability but directed accountability towards the self.

Active Women over 50 as a catalyst and resource

For many participants, the program was a tipping point for getting on track with physical activity. They described how the opportune timing of the program at their life stage, conveniently held at their workplace, catalysed them to finally act on ideas they had been contemplating. An important contributing factor was the credibility of the *Active Women over 50* program which participants deemed to be trustworthy, authoritative and non-commercial, attributed to the reputable team and organisation behind it.

Participants described program features of *Active Women over 50* gave them resources for being active. Targeted messages in the workshop and emails about physical activity strategies and options provided awareness, dispelled misconceptions and information to know how to apply it in practice. Despite this, participants reported wanting more program facilitation and external accountability to sustain the motivation they had for being active when they enrolled.

"Strategising for physical activity" involved having a structure for being active. The program came at an opportune time for participants and functioned as a catalyst to be more active. Yet, overall participants wanted more structure than what the program offered to sustain their initial desire to be more active and to provide them with accountability.

Theme 4 – Self-responsibility discourse

Participants' narratives about their physical activity and experience of *Active Women over 50* revealed a strong discourse of personal responsibility. Despite many describing life-demands which were often outside their control, at the same time, participants viewed their inactivity through a lens of self-blame and defeatism. This discourse was typified by sentiments that physical activity *"really is down to me"*(P10) and thus inactivity was considered a personal failure.

In relation to *Active Women over 50*, some participants attributed their failure to be active to poor choices they had made about program features sooner than deficiencies with the program or wider systemic issues. Many felt they would have been more active if they had simply prioritised physical activity or if they had engaged with program emails or the *Yammer* online discussion group. Ultimately, this discourse attributes personal responsibility for success or failure to be active and seemed to mask the role of any broader contributing factors that may have challenged participants' physical activity. Yet notably, this narrative revealed a sense of agency in some participants who felt participation in the program drove them to reassess their priorities and to take charge of their health and physical activity.

Themes 1 to 4 analysed participants' experiences with physical activity in general and how these intersected the program. The narratives also identified gaps where *Active Women over 50* could have better supported their physical activity and suggestions for addressing ways the program could be improved in each of the themes (Table 3). Suggestions centred on program initiation and facilitation of additional opportunities to meet other attendees for physical activity and ideas for additional content and delivery options for program features. The suggestions and implications of the findings together address research question 3.

DISCUSSION

This study explored how participants viewed physical activity in general, the factors that influenced their ability to be active and how these factors intersected with their attraction to and experience of a physical activity information and support program *Active Women over 50*. Our analysis identified four themes: (1) Age and gender matters, (2) Physical activity is social, (3) Strategising for physical activity, and (4) Self-responsibility discourse. Below we contextualise these findings in the broader physical activity promotion literature and draw out the implications for designing appropriate physical activity interventions for women aged 50 and over.

Contextual factors and tensions with personal responsibility

Our participants experienced individual and systemic level constraints to physical activity which was the context shaping their ability to be active. At an individual level, our findings align with National survey workforce and primary carer data where women comprise 69% of primary carers aged 45–64 years and 10% more women work full-time compared to 20 years ago [12]. Also, the 2018 Australian Institute of Health and Welfare report 62% of women aged 45–64 years live with at least one chronic condition and may experience physiological changes such as (peri)menopausal symptoms or higher prevalence of urinary incontinence [22, 35]. This data suggests that middle-aged women who hold family/carer

Table 3 Summary of participant suggestions for improving *Active Women over 50* against themes

Themes / Subthemes	**Participant suggestions for** *Active Women over 50* **program relevant to theme**	**Identified gap and recommendation to improve** *Active Women over 50*
Age and gender matters / Life-stage demands	*"Maybe some information around menopause and how you cope with that…"* (P2) *"…Except, just like related to having time 'cause that's sometimes a big thing. I could go for a 15 minute walk, or I could do something in 15 minutes. Actually, I've got an hour, I can probably go to the gym and it won't be a problem or I've only got a quick 30 minute lunch break and I'd like to do something… I'd like to squeeze in something in the evening between making dinner and the washing up or whatever… And maybe things you can do with your family, that involve your family as well."* (P5)	**Need**: Wider information and solutions for women aged 50+ **Recommend**: Adapt and integrate physical activity information with wider age/gender-related matters. These could include physical activity solutions for people with time constraints or information on broader health topics such as menopause or nutrition.
Age and gender matters / Invisibility and hypervisibility	*[In response to a previous gym experience where staff provided little assistance which was perceived as due to her gender] "I know we had somebody come and talk to us, but it might've been nice if we'd gone there, because I've never been over to the gym. I'd probably feel a bit intimidated about going for the first time" (P14)*	**Need**: Support attendees' reticence to use gyms as a physical activity option. **Recommend**: Program facilitation of attendee group visits to the workplace gym and health facility.
Physical activity is social / Social connection	*"I think being able to talk to the participants after the workshop would have been … Yeah, it [would] have been nice just to see what other people's experience was… Yeah, certainly being able to exchange ideas maybe in a more physical … more sort of face-to-face experience…With the participants and the facilitators, I guess."*(P14)	**Need**: Opportunities for attendees to share physical activity information/ideas. **Recommend**: Program initiation and facilitation of face-to-face meetings with other attendees beyond the information session.
	"And I want you [program facilitator] to be there and say, "come on [names self], let's run around the park today, you've got half an hour break, I want to see you out there. Other women are going to be there." So I would do more of that. I would do more of that…." (P9) *"But it might've been nice to, you know just thinking in a brainstorm kind of a way, maybe to have been invited to come along to do a lunchtime workout together or something like that. Just to connect doing some kind of physical activity together."*(P5) *"Not just give you information but actually maybe provide a class so a lot of people can do it and have a feeling and then maybe they'll start to join."* (P16)	**Need**: Physical activity opportunities for attendees. **Recommend**: Program initiation and facilitation of face-to-face physical activity opportunities with other attendees beyond the information session.
	"I think it would be helpful if you actually went out into the community and sort of found groups and shimmied them along…go to their church group or their social group, their book club, their whatever it might be…so you want to build on that emotional requirement."(P19)	**Need**: Established social connections to provide support for physical activity. **Recommend**: Leverage established social connections for supporting physical activity by implementing program in community groups.
Strategising for physical activity / Accountability	*"And possibly following up with you [program facilitator] and checking your progress instead of an email, a phone call with a bit of a discussion from the person who does have your baseline, to check in how you're going, I would have found it very helpful."* (P6) *"Yeah, that digital thing [pre-intervention accelerometer]. But I never actually found out anything from it. I never actually found out any results from it. So … I guess, I would've had a position to, "Okay, well I need to improve on this." Yeah."* (P19)	**Need**: Accountability to someone for being physically active. **Recommend**: Provide accountability to the program via (e.g.) regular "check-in" with attendees; personalisation of program through tailoring, personalised outcomes-focused feedback, and facilitate individual physical activity planning.
	"Like I said before, if you gave me an exercise physiologist and said okay this exercise physiologist is going to give you a program and then follow you every week or every fortnight or month or whatever, I'd probably be more motivated than I would be, cause I'm scared of it because I now have to live up to his expectation of what I'm meant to be doing. If somebody else is expecting me to do something then I tend more to do it." (P20) *"Well, there's an exercise physiologist who works here at the hospital, but …I don't have any medically limiting conditions, so really, it's just motivation I need. So, I don't need anyone physically … I don't need anyone to, kind of, show me how to do things. I just need someone behind me, pushing me."* (P19)	**Need**: Someone to be accountable to for physical activity **Recommend**: Be accountable to a health professional who can provide physical activity personalisation.
Strategising for physical activity / Monitoring	*"So I think something where you can maybe add in your steps, or add in three types of exercise that you've done during the week…and that builds into a graph or something… You have a weekly goal. You strive to get to your weekly goal, you get Frequent Flyer points. I have worked out that it's probably worth, I don't know, like $30 a year in Frequent Flyer points that you're getting. So it's nothing, you know what I mean?"* (P18)	**Need**: Support motivation by linking physical activity to incentives. **Recommend**: Link activity tracker output to a web-based personalised dashboard with set goals. The dashboard could be linked to an incentive program that rewards the attainment of goals.

Table 3 (continued)

Themes / Subthemes	Participant suggestions for *Active Women over 50* program relevant to theme	Identified gap and recommendation to improve *Active Women over 50*
Strategising for physical activity / *Active Women over 50* as a catalyst and resource	*"And you file it [the email], you categorise it, and then you forget about it…Text? A text might've been better. It might've been more ding, you know like you kind of get a message and you go, "okay."… Yeah, a text might be better."*(P9)	**Need**: Flexibility for receiving messages. **Recommend**: Provide alternate formats other than email to receive motivational messages.
	"I think videos are always a good thing. Short videos." (P5)	**Need**: Engagement with email messages. **Recommend**: Incorporate video content into motivational email messages.

responsibilities have less leisure time, poorer physical health and enjoyment of physical activity [36, 37].

We found cultural attitudes towards older people had a negative impact on physical activity participation. This has been similarly reported by UK Active case reports [38] which identified systemic barriers for physical activity among older age groups at health facilities. These included inaccessible schedules, an atmosphere of exclusivity, or a workforce lacking sufficient knowledge about age-related health conditions. Other studies have reported women with "fat" body shapes experience explicit negativity when exercising in public places or feeling judged as lazy which meant they avoided exercising publicly [22, 39, 40]. Potentially, a cultural bias towards youth and idealised female bodies may mean the age- and gender-specific targeting of the *Active Women over 50* program could act as a discouragement for some women where the entrenched cultural attitude is perpetuated amongst those whom it biases. For our participants, the program's specific targeting seemed to address some of those challenges by catering for women over 50. While cultural and systemic factors may influence physical activity, *Active Women over 50* trial outcomes demonstrate that an individual-level program is acceptable and effective among this population.

The strong discourse of self-responsibility was in tension with these cultural and contextual barriers. Despite feeling responsible for physical activity, the time and effort involved for physical activity was often undermined by women's demanding life circumstances. Waller (2005) explains that despite recognising that these circumstances were often beyond their control, some engaged in self-blame, describing under activity as failure to prioritise or personal inadequacy[41]. Therefore, the personal responsibility discourse motivated women to seek support for physical activity by enrolling in the *Active Women over 50* program but also masked the role of the broader context in following through with being active.

Active Women over 50 was a behavioural program targeted at an individual level which Adams et al. (2016) reports depends on individual agency to sustain behaviour change[42]. Specific to health, agency is the "individuals' ability to achieve health goals they value and act as agents of their own health"[43] influenced by broader external conditions[41] . Social and environmental conditions supporting in low individual agency for physical activity are ideal. Yet, our study describes the negative influence that external cultural and systemic attitudes can have on physical activity and together with *Active Women over 50* trial outcomes demonstrating acceptability and effectiveness, an individual-level program among this population is warranted. Clearly, behaviour change is complex and requires a multi-faceted approach at individual and systemic levels.

The role of social factors

Our findings highlight the role social factors play in motivating physical activity for participants. Holt-Lunstad (2018) defined social connection as connecting with others physically, behaviourally, cognitively, and emotionally and for our participants this conferred a sense of belonging[44]. Participants valued face-to-face opportunities that provided a mechanism for sharing contextualised knowledge about how to be active and for motivation. Participants were also motivated by social factors not requiring interaction but through comparison with others of their age and gender and this reference group was used for self-evaluation [45]. Yet for our participants, the motivation to be active through social comparison was also determined by the extent of identification with the reference group.

Heaney and Israel (2008) describe social support having dimensions of emotional, appraisal, instrumental and informational support which our participants reported were provided by a number of program components[46]. Emotional support was provided through encouragement and reassurance of watching peer video case studies and seeing other "like-minded" women at the workshop; appraisal support via the email messages prompted self-reflection and physical activity planning; instrumental support through loan of the *Fitbit* activity tracker; and lastly, the workshop content provided informational support.

Despite the value of the program components, participants expected and wanted more social opportunities. In particular, participants identified that program-driven face-to-face physical activity sessions and further opportunities to interact with other women of their age would

have been more supportive (Table 3). Previous studies describe the unique role that peers play in promoting health behaviours, including program attendance, and emotional, appraisal and informational support which is often based on experiential knowledge [47, 48]. These are compelling reasons to strengthen social factors in future iterations of the program. However, it is noted this study was conducted prior to the COVID-19 pandemic so preferences for face-to-face physical activity interactions may have diminished since. Having adapted to social restrictions, people may be more willing to consider other options, such as via remotely delivered programs.

Building in a strategy

The *Active Women over 50* program combined a defined program with set components and was designed to give women sufficient flexibly to accommodate their priorities. However, the program was self-driven which disappointed participants who anticipated and wanted some accountability for physical activity – either as a program component or a side-effect of social interaction with peers. 'External accountability' and the motivator of "checking in" with research staff was a similar finding reported by Lindgren et al. (2019)[25]. Accountability refers to motivation that arises from the expectation of giving an account and being held responsible for an intention or goal by another person [49].[25] Previous literature suggests that among middle aged populations accountability is heightened by relationship proximity. Within pre-existing social relationships, accountability increased physical activity in both face-to-face and online contexts [50–52]; however between strangers accountability was less likely to increase physical activity [53, 54]. Our study found accountability to health professionals motivated physical activity through their provision of physical activity information, personalisation of physical activity programs, and follow-up reassessment [55, 56]. So, while accountability is a substantial force in motivating behaviour, to whom one is being held accountable has a strong bearing on physical activity.

Another motivating strategy for being active was monitoring also described as "internal accountability" by Lindgren et al. (2019)[25]. The act of observing and recording physical activity seemed to substantiate efforts and provided participants with self-accountability. However, many wanted their physical activity data to be interpreted, evaluated and contextualised against normative values and a peer group through the personal touch of external feedback [25][57]. Among people aged 55 years and over, feedback is a strategy that has been associated with long-term effectiveness of interventions [58] and is a key consideration for future iterations.

Finally, many participants decided to enact their desire to be active and enrol in *Active Women over 50* because of the organisation leading the program. Ranney et al. (2018[59]) and Avery (2010)[60] describe the credibility of an organisation can be integral to whether people heed or ignore health messages. The public evaluate an organisation's trustworthiness by scrutinising the integrity, competence, motives, public portrayal. Therefore, such trusted organisations need to take advantage of their reach and influence on stimulating and supporting change in health behaviours.

Behaviour change is complex, so to be effective, strategies to tailor an intervention at an individual level need to be addressed. Tailoring an intervention to suit an individual's circumstances and preferences, underpinned by behaviour change theory and frameworks have been found to be cost-effective [61]. Effective health behaviour interventions could therefore be scalable, that is, be potentially "delivered to an increasing number of participants or through an increasing number of settings, while retaining effectiveness" [15] cited in [16], as a solution for the problem of physical inactivity.

Implications

Considerations for designing future physical activity interventions to ensure relevance to women aged 50+are highlighted in this study. First, programs need to adopt an integrative approach to promoting physical activity as a part of overall health and life. By drawing on a range of health and life topics, such as menopause, nutrition and stress management, programs may be able to communicate greater relevance and embed physical activity support strategies within the complex life context described by our participants (Table 3). A broader holistic approach to health may also appeal to a wider variety of people in the target population who may not otherwise consider accessing physical activity support.

Second, the diversity of individual circumstances and motivators for physical activity suggests the need to offer a range of flexible program strategies that appeal to individuals' situations and preferences, and include solutions that account for time constraints, local resources and physical limitations or disabilities (Table 3). A guided group-visit to the workplace gym, or provision of vouchers to trial facilities could support visibility and attendees' hesitancy to access unfamiliar physical activity settings. Also, partnerships between program designers and agencies that provide and influence physical activity options (e.g., health facilities, local councils) could help to address barriers to accessing these options.

Third, the benefits of social relationships for physical activity implies the need to facilitate existing or new physical activity social networks (Table 3). Social networks could be leveraged for face-to-face physical activity opportunities, sharing of information and resources and for accountability. Forging new social networks through

popular online platforms such as *Facebook* could be feasible. Since adults aged 50+tend to use *Facebook* for communication [62], the platform could be used to host private discussion groups and physical activity resources such as walking maps and activity logs. The resources required by a program to facilitate a social network among working women in this age group are unknown. Further research is needed to determine for example, the level of input needed from program staff to impact physical activity and studies of cost-effectiveness [48, 63].

Fourth, programs could build in accountability and feedback for physical activity via free government health services such as a telephone health coaching service (e.g. [64] or health/exercise professionals [65] (Table 3). Future iterations could incorporate audit and feedback throughout the program by communicating baseline and periodic physical activity measurements. Tailored feedback could also be provided by digital platforms. A web-based dashboard with an online physical activity diary could track personal trajectories and send messages of praise or suggestions such as "if you've set some SMART goals, tell someone"[66].

Fifth, contextual factors and the self-responsibility discourse implies program framing is critical. Establishing the program as a way to support women to combat the pressures of life circumstances and systemic barriers might be a way to engage them in a positive journey of taking responsibility that avoids self-blame. The program needs to adopt motivational, empowering language that explicitly counters the self-blame discourse and recognises the powerful cultural attitudes and practices that make it difficult for women over 50 to be active. Support for realistic goal setting needs to be part of this as failure to meet goals can quickly spiral downwards to a sense of being a failure. Program designers can also work in partnership across sectors that influence physical activity options (e.g., health facilities, local councils) to provide the right conditions for women to be active (Table 3).

Finally, providing the right conditions through systemic change is also important for sustainable behaviour change at a population level, especially given the nuanced interplay of individual, social and wider contextual factors. This is beyond the scope of behavioural programs such as *Active Women over 50*, but it is a reminder that public health researchers have a broader responsibility to advocate for changes in damaging cultural attitudes and practices. In relation to women over 50 and physical activity, our analysis highlights changes in working hours, the division of labour in the home and greater cultural acceptance of ageing women with less-than-perfect bodies. Such long-term and significant societal change can only be addressed by sustained supportive policy, governance and resource allocation across a range of sectors to build a supportive context that encourages people to engage in physical activity[38, 42, 67].

Strengths and limitations of study

A strength of this study was the exploration of the broader factors facing women over 50 and how these factors shape experiences of a physical activity program. A better understanding of the wider contextual factors for women aged 50+can guide the design of behavioural interventions to better support this population to be active. A limitation was that while the study drew on a range of participants with differing ages and employment/carer responsibilities as far as the overall sample allowed, study participants were all meeting or exceeding the WHO guidelines for physical activity. Inactive women were not represented in this sample so hearing from those who chose not to participate in the interviews could have provided further perspectives and different views. Another limitation was that one interviewer (GW) had been the study manager of the trial, which may have impacted the willingness of some women to participate, or biased sharing feedback with a trial team member. Other limitations of this study included possible recall bias of the program which was experienced at least 3 months prior and that recruitment occurred during a season where people are typically on summer holidays in Australia (November to January) resulting in a low consent rate.

Conclusion

Women aged 50 and over face challenges that limit their capacity to be physically active. We identify key challenges described by participants in the *Active Women over 50* program which operate at individual, social and systemic levels. We argue that future physical activity promotion programs targeting this population should offer a range of strategies and structural supports that address different circumstances and levels of agency. We make five suggestions, which do not need to be resource intensive, that could be feasible within a scaled program structure.

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Authors' contributions

AT, CS, GW conceived the study. GW, AH, AG contributed to study design, analysis and interpretation of the data. GW and AH contributed to data collection with assistance from AG. GW drafted the manuscript and all authors contributed to revisions and approved the final manuscript.

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Data Availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval was granted by the Ethics Review Committee at the Sydney Local Health District Research Ethics and Governance Office (X17-0316 & LNR/17/RPAH/473). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare they have no competing interests.

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Authorship contribution statement

As primary supervisor and co-author of the paper "Active Women over 50 online information and support to promote physical activity behaviour change: Study protocol for a pilot trial", I confirm that Geraldine Kit-Bing Wallbank is the lead corresponding author and has made the primary contribution to this study in each of the following areas in collaboration with co-authors Sherrington C, Hassett L. Kwasnicka D, Chau JY, Martin F, Phongsavan P, Grunseit A, Canning C, Baird M, Shepherd R, Tiedemann A:

- Conception and design of the research
- Data collection
- Writing of the manuscript and critical appraisal of the content

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank 

20 August 2025

Preamble to Chapter 6

This chapter describes in detail the study protocol for the pilot randomised waitlist-controlled trial reported in Chapter 7, strengthening the rigor of the thesis. Building on the work presented in Chapter 3, Chapter 4 and Chapter 5, this chapter presents an intervention that was iteratively developed with multi-disciplinary collaborators and again guided by the principles of pragmatism, efficiency and scalability. This pilot trial broadened the target group to include community-dwelling women aged 50 years and over who resided across NSW, Australia.

Pilot and Feasibility Studies

STUDY PROTOCOL Open Access

Active Women over 50 online information and support to promote physical activity behaviour change: study protocol for a pilot trial

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Abstract

Background: Physical activity has many physical and mental health benefits and can delay the development of disability in older age. However, uptake of this health behaviour is sub-optimal in women in their middle and older age. This trial aims to establish the acceptability and feasibility of the *Active Women over 50* programme involving online information, telephone health coaching and email or SMS support to promote physical activity behaviour change among women aged 50 years and over.

Methods: Sixty community-dwelling women who are insufficiently active according to national guidelines, will be recruited and randomised to 1) receive the *Active Women over 50* programme or 2) a wait-list control. *Active Women over 50* is a 3-month physical activity programme guided by behaviour change science, providing access to a website, one telephone-delivered health coaching session from a physiotherapist and 8 email or 24 SMS messages. The primary outcome is the proportion of participants at 3 months post-randomisation who would recommend participation in the programme to another person like themselves. Secondary outcomes are feasibility measures: rates of recruitment, retention, completeness of outcome data and uptake of telephone support; and intervention impact measures: accelerometer-assessed average steps/day, proportion of participants meeting national guidelines on moderate to vigorous physical activity; and questionnaire-assessed quality of life, exercise perceptions, mood, physical functioning and self-reported physical activity. Intervention participants will also complete a follow-up survey to assess impressions of the intervention and adoption of strategies for physical activity participation. Data will be analysed descriptively to guide the design of a larger trial. Between-group differences in secondary outcomes will be used to estimate effect sizes for sample size calculations for a fully powered randomised controlled trial.

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(Continued from previous page)
Discussion: This feasibility pilot trial of an efficient eHealth and health coaching intervention guided by user input and behaviour change theory, will inform future interventions to address low physical activity participation among an under-active group at risk of future disability.

Trial registration: ANZCTR, ACTRN12619000490178, registered 26 March 2019

Keywords: Physical activity, Exercise, eHealth, Website, Health coaching, Feasibility, Behaviour change, Study protocol, Pilot trial

Background

Physical inactivity is a significant but modifiable public health problem. Globally, it is associated with 5.3 million deaths [1] and has an economic cost of INT$67.5 billion per year [2]. Physical inactivity is as important a risk factor for developing chronic disease and disability as smoking and obesity [3].

There is compelling evidence of the benefits of physical activity for physical and mental health at all ages [3] and maintenance of independence in older age [4]. Regular physical activity can prevent or help manage some health conditions and has been reported to delay disability by up to 15 years in older women [4]. The national guidelines for physical activity recommend Australian adults to accumulate 150 to 300 min of moderate-intensity or 75 to 150 min of vigorous-intensity physical activity, or an equivalent combination of both moderate and vigorous activities each week, and to do muscle-strengthening activities on at least 2 days each week [5]. Achieving the national guidelines for physical activity in middle age has longevity benefits regardless of baseline physical activity [6].

Physical activity participation is sub-optimal in women in their middle age and very low in older women. Sixty-five per cent of women over the age of 55 years and 80% of women over the age of 75 years do not participate in sufficient regular physical activity to gain health benefits [7]. While some women become more physically active with retirement [8] this may be too late to prevent disability in older age. By 2023, Australian women will be retiring at an older age with access to the senior pension age increasing to 67 years [9]. Commencement of sufficient regular physical activity before retirement therefore needs to be a priority and maintained in the long term to promote independent and healthy ageing.

Barriers to physical activity participation for women are unique. The 2014 national survey showed that women have higher sedentary time and greater carer responsibilities than men [10, 11]. These barriers, coupled with the demands of paid work and low confidence for participating in physical activity in the absence of a previous habit, place women in their middle-age years particularly at risk of being insufficiently physically active to maintain good health. This population would benefit from a targeted and supported evidence-based approach to increase their physical activity in a way which is achievable and sustainable.

Health psychology uses a variety of tools and behaviour change techniques that can be made available to middle-aged women to support them to increase their levels of physical activity and to maintain these levels in the long term. A theoretical basis incorporating the self-determination theory (SDT) [12] and Behaviour Change Wheel and COM-B system model of behaviour [13] shed light on key factors necessary for the initiation and maintenance of physical activity [14]. SDT considers an individual's motivation behind the choices they make by addressing competence, autonomy and psychological relatedness, and the COM-B system model of behaviour considers an individual's capability, opportunity and motivation to achieve behaviour change. Key factors of SDT and COM-B include plentiful resources (psychological and physical), effective self-regulation, maintained motivation to be active, positive habits and positive environmental and social influences. Effective behaviour change interventions often include techniques that tap into these behavioural factors. For instance, resources in the form of health information and programme information provides an individual with physical capability and competence; goal setting, self-monitoring, action and coping planning support self-regulation and opportunities for behaviour change; relatable peer role models stimulate motivation; using habit formation techniques help to develop automaticity forming positive responses to contextual cues; and supporting development of positive habits, i.e. increasing physical activity and reducing sedentary behaviour [15–17].

Behavioural interventions can be delivered digitally, via web and smartphone, in order to increase scalability for population-level impact [18]. eHealth online interventions using web, email and SMS-based platforms have a number of advantages over face-to-face interventions, especially where they can be delivered to mobile phones: they have wide reach, comparatively low cost of implementation and delivery, and flexibility of intervention use at times and location convenient for the user [19, 20]. Mobile phone access to websites, video, email and short message service (SMS) provides a portable,

everyday use context for receiving eHealth messages, promoting higher engagement and adherence [21, 22]. There is emerging evidence supporting the use of SMS to promote health behaviour [23], and including email reminders to prompt participants' health behaviour change [24]. One disadvantage of online interventions is potential disengagement as people prefer the personalised nature of face-to-face interactions. To address this, effective interventions often include phone or video sessions with a health coach who guides the participants, provides social support and tailors behaviour change techniques to participants' abilities and preferences, supporting participants' autonomy, in line with SDT. A review of health coaching has shown a beneficial effect on physical activity [25], so including a skilled health coach with an online intervention is likely to increase engagement and consequently the effectiveness of the intervention. To date, there are limited programmes that flexibly support middle-aged women in becoming more active and staying active for life which can be implemented at scale. Online behavioural interventions augmented by health coaching provide a potential scalable solution to the current problem of inactivity among this age group.

This trial aims to establish the acceptability and feasibility of the *Active Women over 50* programme, a 3-month programme comprising online information, telephone health coaching and follow-up email or SMS support to promote physical activity behaviour change among women aged 50 years and over.

Methods/design

Trial design

We will conduct a feasibility pilot study using a randomised controlled trial (RCT) with wait-list control. The CONsolidated Standards Of Reporting Trials (CONSORT) flow diagram is illustrated in Fig. 1. This trial has been designed according to the CONSORT statement [26] and will be reported according to the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) statement [27], and with reference to the Template for Intervention Description and Replication (TIDieR) checklist [28] in Table 1.

Eligibility criteria

Women are eligible for inclusion in the trial if they are aged 50 years and over, and community-dwelling residents in New South Wales, Australia. Potential participants will be excluded if they have limited English language skills, do not have access to the internet, have a medical condition that precludes participation in regular physical activity or are already sufficiently active in accordance with Australian physical activity guidelines [5].

Recruitment

Participants will be recruited through advertising in newsletters and websites of community organisations, university and local health districts, via the study recruitment website, www.activewomenover50.org.au, word-of-mouth and social media. Participation is cost-free and no incentives are offered for participation. Potential participants will be screened for eligibility via an online survey. Recruitment commenced 3 May 2019, and at the time of submission of this manuscript, 66 participants had been recruited, 56 randomised and 0 participants had completed follow-up measures.

Randomisation

Following confirmation of eligibility and completion of informed written consent and the baseline measures, participants will be randomly allocated by a research assistant to the intervention or control group in equal numbers using computer-generated randomisation. Allocation will be determined using concealed allocation, via a randomisation schedule embedded in a secure web-based software platform, *REDCap* (Research Electronic Data Capture) [35, 36] hosted at The University of Sydney, Australia. A variable block randomisation schedule will be prepared from a computer-generated list of random numbers by a researcher not involved in participant recruitment.

Intervention group

The intervention is described by the TIDiER checklist (in Table 1). Intervention components and choice of behaviour change techniques were informed and underpinned through integration of the Behaviour Change Wheel and COM-B system model of behaviour [13], SDT [12] and user input from a convenience sample of women in the target population. Examples of intervention functions and behaviour change techniques (BCTs) used in the *Active Women over 50* intervention are shown in Table 2. The *Active Women over 50* intervention was developed following our previous trial [38] investigating an information and support intervention with a 3-month follow-up period to enhance physical activity in university and health service-employed women over 50 years of age. The feedback from participants indicated a need for more support (manuscript under preparation). The intervention group will receive access to the *Active Women over 50* website plus one telephone consultation with a research physiotherapist trained in health coaching, plus either 8 email or 24 SMS follow-up motivational messages over a 3 month period.

Intervention participants will receive access to the *Active Women over 50* website (Fig. 2) via a web address and will be asked not to share the website to avoid study contamination. The website will deliver content via three main webpages namely, "Why be Active?", "How to be

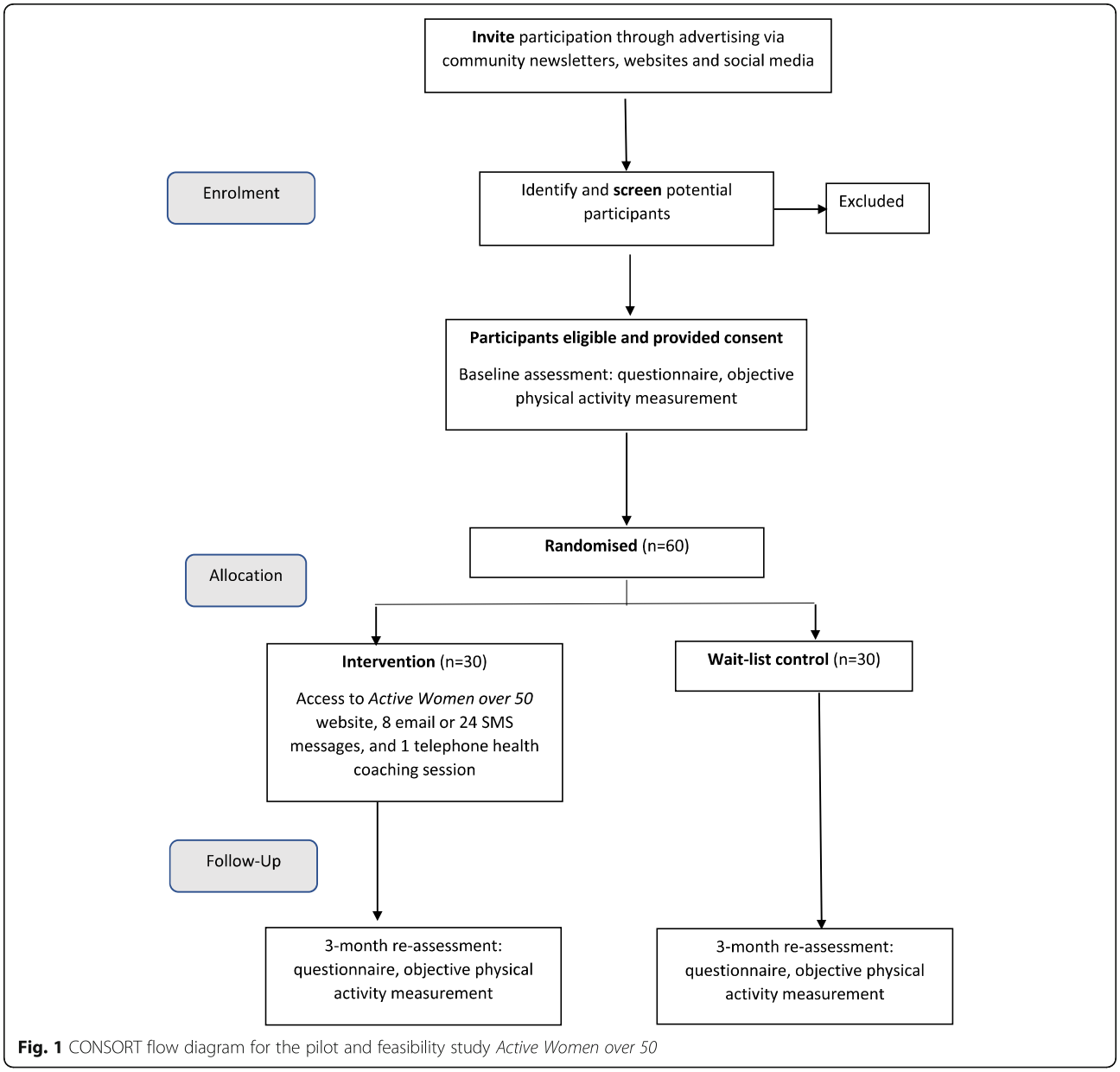

Fig. 1 CONSORT flow diagram for the pilot and feasibility study *Active Women over 50*

Active" and "Be Inspired". The "Why be active?" webpage will emphasise the importance of becoming active from middle age for maintenance of health and physical function and prevention of falls in older age. The *Active Women over 50* website content will include evidence-based information about the impact of even small increases in physical activity on health and longevity. The "How to be active" webpage will include practical suggestions on becoming more active and guidance on the setting of SMART (Specific, Measurable, Achievable, Realistic and Time-related) goals and self-assessment of barriers to physical activity participation and solution generation as key behaviour change techniques. The website will link to external sources of support/information, such as the NSW Ministry of Health-funded *Get Healthy* free health coaching service [39] and the *Active and Healthy* online directory [30] of physical activity opportunities. The website will also provide suggestions of resources and internet applications supporting behaviour change and habit formation, and other links for information about physical activity for different health conditions and services available. The "Be inspired" webpage will include inspirational video case studies of "success stories" of four "real-life" women aged over 50 who have managed to increase their physical activity levels in the face of mobility, health or practical difficulties and the benefits that they have experienced. To stimulate motivation

Table 1 Intervention description using the Template for Intervention Description and Replication (TIDieR) checklist [28] for *Active Women Over 50* study

1. Brief name	*Active Women over 50* online physical activity information and support
2. Why	Physical activity has many physical and mental health benefits, including the delay of developing disability in older age. Yet the uptake of this health behaviour is particularly low in older women and sub-optimal in working women in their middle age. While commencement of regular sufficient physical activity in middle-age years needs to be a priority for healthy ageing, women over 50 years have unique barriers to becoming more active (e.g. higher sedentary time, greater carer responsibilities, work demands). Behavioural interventions delivered remotely and digitally via web, email and SMS platforms offer wide reach and provide flexibility of intervention use at times and location convenient for the user. Telephone health coaching can also be delivered remotely and provides tailoring of the intervention to a person's abilities and preferences. A theoretical basis incorporating the Behaviour Change Wheel and COM-B system model of behaviour, Social Determination Theory has been used to design the intervention and choice of behaviour change techniques. The intervention targets barriers unique to women over 50 and will incorporate the behaviour change techniques including goal setting, problem-solving, action and coping planning, review of behavioural goals, self-monitoring, social support and social comparison, information provision, persuasion about capability and habit formation to facilitate and sustain behavioural change.
3. What materials	Participants will have access to the internet. The website will be accessed by the internet and will provide 1) information for the benefits of physical activity including links specific to women, different health conditions and ages; 2) resources and strategies for how to become physically active including a pre-exercise screening tool and exercise intensity guidelines [29], guide on getting started, internet-based programme resources such as the *Active and Healthy* website [30], *parkrun* website promoting free, weekly community walk/runs [31], links to sporting groups and suggestions of smartphone applications; 3) inspirational stories of people becoming physically active including professionally produced video case study interviews of four real-life female women aged over 50 who have overcome barriers to increase their physical activity; and 4) the opportunity for participants to share their own ideas and inspirational stories via the website. Participants will also receive their choice of either 8 email messages or 24 SMS messages embedded with behaviour change techniques that will link back to and reinforce the website content and provide further motivation to increase their physical activity. Participants will also receive one telephone health coaching session with a trained research physiotherapist trained in physical activity behaviour change techniques.
4. What procedures	Access to the intervention website will be provided to participants upon randomisation to the intervention group. Participants will be asked not to share the website to avoid contamination. Participants will also be given the choice to receive either 8 emails or 24 SMS messages over the 3-month study period, and a mutually agreed time will be made for the health coach to contact the participants within 2 weeks of receiving access to the intervention. The health coach will document behaviour change techniques used in the telephone session. All participants will have email access to the trial manager for any further enquiries.
5. Who provided	The study manager will provide participants with access to the website, regular messages and liaise appointment times with the health coach. Health coaching will be provided by a tertiary-trained physiotherapist employed by the study with research experience delivering telephone-based health coaching. The coach will have completed courses through Wellness Coaching Australia [32], HealthChange Australia [33] and Medicoach [34] in motivational interviewing and behavioural intervention techniques.
6. How	Participants will be notified by email upon randomisation to the intervention group and will gain access to the intervention website via a web address. Frequency of accessing the website will be at the discretion of the participant. The email will also give participants the choice to receive regular messages via email or SMS and will ask for available times when the health coach may contact them. The health coach will be provided with participants' available times, contact, demographic and current physical activity details by the study manager.
7. Where	Participants will access the intervention via the internet and telephone at a location of their convenience.
8. When and how much	After participants are given the intervention website address, they have access to the website at any frequency they choose. The regular email or SMS messages link back to the website to support behaviour change with the reinforcement of information and suggested strategies. The health coaching telephone call will be made within 2 weeks of accessing the intervention. There will be no cost to participate.
9. Tailoring	All participants will receive the same online resource (website and email or SMS messaging content), but the opportunity to talk with a health coach will allow for tailoring to individual's preferences, needs and circumstances so that physical activity can be adopted and maintained. Participants will be advised to seek individual advice from a health professional if they are concerned about commencing physical activity or have an injury.

and provide an interactive element to the website, there will also be the opportunity for participants to share their own ideas and inspirational stories via the website. Frequency of use of the *Active Women over 50* website will be at the discretion of the participant.

Participants will receive one telephone health coaching consultation, which will occur within 2 weeks of randomisation. The consultation session will facilitate goal setting and physical activity behaviour change, using evidence-based theoretically informed behaviour change principles. Health coaching will be provided by a tertiary-trained

Table 2 Examples from the *Active Women over 50* intervention coded within the COM-B domains, intervention functions and behaviour change techniques (BCTs)

COM-B domains	Intervention function	BCTs	Examples
Psychological capability	Education	Information about health consequences (5.1)	**Website:** "Why be Active?" section: "Regular physical activity can make you feel good and improve your self-esteem and confidence creating opportunities to socialise and meet new people"
			SMS/Email: Week 5: "Strength and balance exercises can help to prevent falls. You can do these exercises while watching TV. Look under "Tips" at www.[study website name].com/getting-started"
			Health coaching: Verbal education about physical activity for falls prevention
	Training	Instruction of how to perform a behaviour (4.1)	**Website:** "How to be Active-Getting started-Tips & hints" section: Video links, e.g. falls prevention exercises
			SMS/Email: Week 6: "Is something blocking your activity plans? Think of likely solutions. Perhaps break down goals into easier steps. Or ask an exercise professional for advice."
			Health coaching: Instruction on balance exercises where appropriate
		Graded Tasks (8.7)	**Website:** "How to be Active-Getting started-7 steps to getting started" section: "Start small and gradually build up the amount of time you are active, or the intensity you can be active, or your goals. Use this pre-exercise questionnaire [link], and find out what light, moderate and vigorous exercise intensity is for you."
			SMS/Email: Week 1: "Every bit of exercise counts! Start small and gradually build up."
			Health coaching: Advice about gradual increase in physical activity
	Enablement	Goal setting (behaviour and outcome) (1.1, 1.3)	**Website:** "How to be Active-7 Steps for Getting Started-Step 4" and "How to be Active-Tools to keep going" section: refers participants to scheduling and goal setting resources.
			SMS/Email: Week 2: "Work towards your activity goals! Write down your when-where-how-action plan for the week. Put your plan & goals on your fridge, or where you can see them."
			Health coaching: Advice on setting Specific, Measurable, Achievable, Realistic, Timely (SMART) goals, setting goals with the participant.
		Action planning (1.4)	**Website:** "How to be Active-Tools to keep going" section: provision of physical activity weekly planner and physical activity charting templates
			SMS/Email: Week 1: "How do others keep motivated to be active? Many find making a plan with firm goals helps. Have a look at www.[study website name]/tools-to-keep-going"
			Health coaching: Advice on action planning, referring to the website for physical activity weekly planner and charting templates
		Self-monitoring of behaviour (2.3)	**Website:** "How to be Active-Tools to keep going" section: provision of templates to chart physical activity "How to be Active-Mobile apps" section: suggestions of mobile apps to assist self-monitoring
			SMS/Email: Week 3: "Hi [FirstName], Track your activity on a calendar,

Table 2 Examples from the *Active Women over 50* intervention coded within the COM-B domains, intervention functions and behaviour change techniques (BCTs) *(Continued)*

COM-B domains	Intervention function	BCTs	Examples
			chart or phone app so you can see your progress. See www.[study website name].com/mobile-apps for app suggestions."
			Health coaching: Refer participant to website physical activity planning and charting templates; discussion/suggestions around wearables and phone apps for tracking activity.
		Problem-solving (1.2)	**Website:** "How to be Active-Frequently Asked Questions (FAQ)" section: responds to FAQs about how to be active. E.g. "I've never really been active before. Where do I start?" and "What do I do it I think physical activity is boring?" and "I have longstanding aches and pain. Is physical activity safe?"
			SMS/Email: Week 3: "If lack of time stops you from being active, how can you fit activity into your day? Replace some TV or device time with activity? Or have a walking meeting?"
			Health coaching: Identify motivators and barriers to physical activity, advice on action planning
Reflective motivation	Persuasion	Feedback on behaviour (2.2)	**SMS/Email:** Week 6: "It's 6 weeks since you committed to getting active. Congratulations on your efforts so far!"
		Verbal persuasion about capability (15.1)	**Website:** "How to be Active-Getting started" section: "For you, being more physically active may be simply a matter of spending more time doing the things you already enjoy doing such as taking the dog for a walk or gardening. Or maybe it's doing an activity with someone else. Pick something to do that you enjoy - then you're more likely to stick at it."
			SMS/Email: Week 11: "Things can get in the way of you keeping up your activity. What strategies have you learnt to deal with difficult situations? Do you want to share these? www.[study website name]/contact"
			Health coaching: Motivational interviewing to increase self-efficacy
		Social comparison (6.2)	**Website:** "Be Inspired" section: video case studies produced for the website of real women and their experiences with physical activity – why they do it and what keeps them going; weblinks to articles from social media; opportunity for participants to share their own physical activity story via the website.
			SMS/Email: Week 1: "How do others keep motivated to be active?... Have a look at www.[study website name].com/tools-to-keep-going."
			Health coaching: Provision of examples of what other women 50+ have done to increase physical activity when appropriate
		Credible source (9.1)	**Website:** Investigator institution logos on website "Be Inspired" section: Video case studies from women aged 50+ "How to be Active-Find an activity or sport" section: links to larger reputable organisations, e.g. NSW Health, parkrun Australia
			SMS/Email: Investigator contact details on each email footer, links to website and larger reputable organisations, e.g. NSW Health,

Table 2 Examples from the *Active Women over 50* intervention coded within the COM-B domains, intervention functions and behaviour change techniques (BCTs) *(Continued)*

COM-B domains	Intervention function	BCTs	Examples
			parkrun Australia
			Health coaching: Study health coach will be a Physiotherapist trained in behavioural intervention techniques and health coaching; participants referred to study health coach by study manager
	Modelling	Demonstration of the behaviour (6.1)	**Website:** "Be Inspired" section: Video links, e.g. This Girl Can, Females in Football
			Health coaching: Set goals with the participant; send links to balance exercise videos
Automatic motivation		Habit formation (8.3)	**Website:** "Be Inspired" section: "Penny" video case study talking about importance of routine; "How to be Active-7 steps for Getting started-Step 2" section: "Find out locations, times, costs of the activity or sport." Location and times will then act as cues to action. "How to be Active-Tools to keep going" section: provision of physical activity weekly planner and physical activity charting templates
			SMS/Email: Week 7: "Activities that easily fit into your daily life are much more likely to become a habit. Why not put a note on the fridge, or set a phone reminder to be active?"
			Health coaching: Identify motivators for developing healthy habits
Social opportunity	Enablement	Social support (unspecified) 3.1	**Website:** "Be Inspired-Your story" section: "Share your physical activity story and read others'" to share experiences of physical activity
			SMS/Email: Week 4: "You're more likely to succeed if you tell someone your plans to be active - a relative, friend, or even your GP."
			Health coaching: Identify social supports to support physical activity participation
Physical opportunity	Enablement	Adding objects to the environment (12.5)	**Website:** Links on website for finding physical activity opportunities
			SMS/Email: Week 3: "See www. [study website name]/find-an-activity-or-sport to pick an activity you may enjoy. While being active you could listen to music, a podcast or invite a friend."
	Environmental restructuring	Prompts/cues (7.1)	**Website:** "How to be Active-Tools to keep going" section: provision of goal setting, physical activity planner, physical activity charting templates participants can print out and put up. "Be Inspired-Penny's story" section: recommendations about the routine of putting out clothes at night as prompt to go to gym in the morning
			SMS/Email: Week 7: "Activities that easily fit into your daily life are much more likely to become a habit. Why not put a note on the fridge, or set a phone reminder to be active?"
			Health coaching: Provide suggested prompts/cues to activity, e.g. stick goals/ action plans on fridge

Note: In brackets BCT numbers in line with [37]

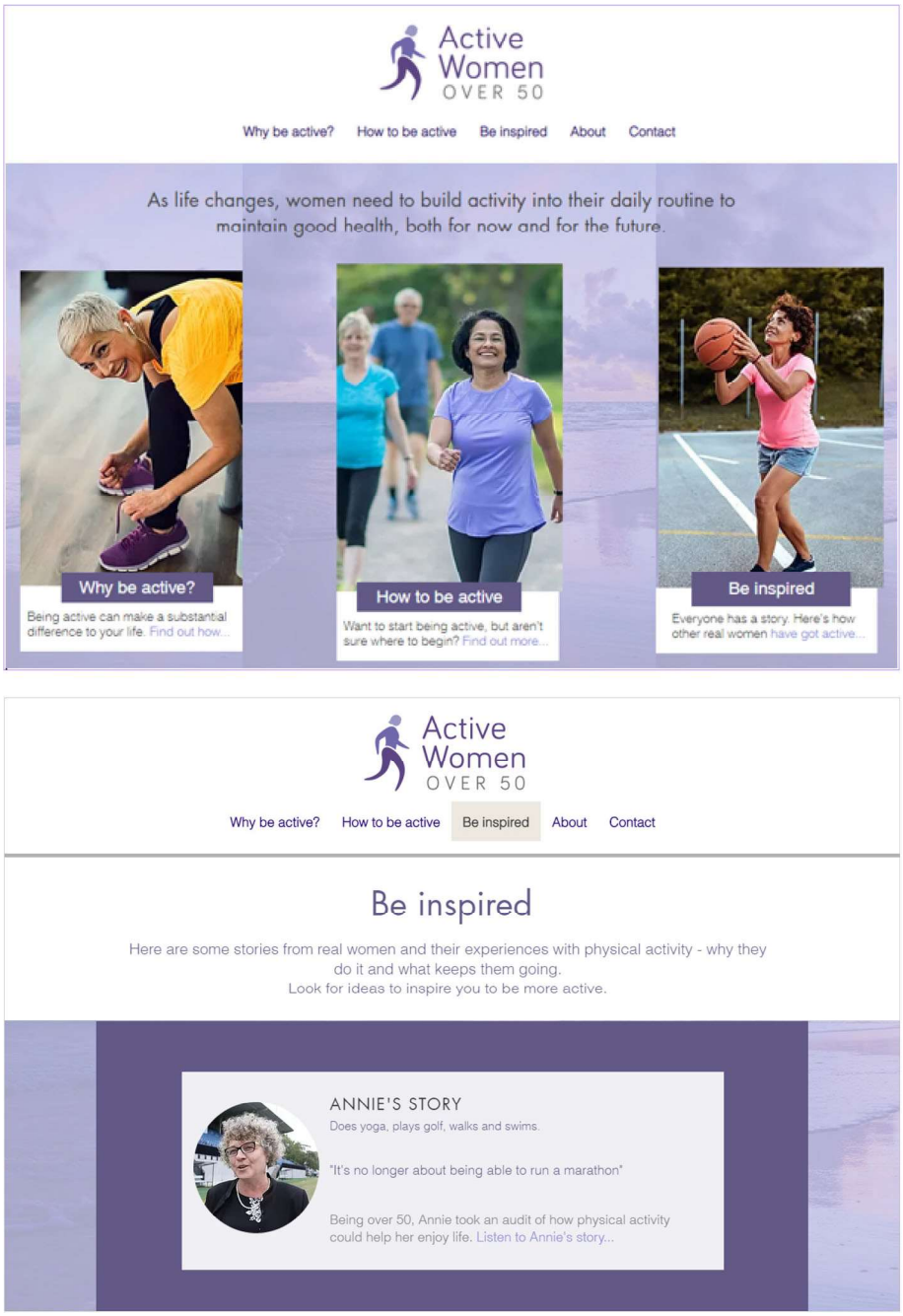

Fig. 2 Intervention screenshot examples—main subpages. Note: main subpages of the website intervention include (a) *Why be Active*, capability and motivation; (b) *How to be Active*, opportunities and skills; (c) *Be inspired*, coping role models; (d) information about the programme; and (e) contact details for enquiries

physiotherapist with additional training in motivational interviewing and behavioural intervention techniques, and experience in delivering telephone-based health coaching in the context of research studies.

Participants will receive either 8 email messages or 24 SMS messages depending on their preference. The messages will be similar in content and aim to support physical activity using behaviour change techniques, informed by the COM-B system model of behaviour [13] and SDT [12]. Behaviour change techniques will include providing practical tips, addressing barriers, providing motivation by social modelling and reminders of the benefits of physical activity, assisting with action planning, problem-solving and time management. These messages

will also contain a link back to the *Active Women over 50* website.

Control group

Participants randomised to the control group will be waitlisted to receive access to the *Active Women over 50* full programme after the 3-month follow-up data collection period.

Outcomes

Primary outcomes

The primary outcome will be participant acceptability of the intervention and study methods. A global measure will assess whether participants would recommend participation in the study to someone else like themselves. Participants will be asked to select "yes" or "no/unsure" to the question "Would you recommend the *Active Women over 50* study to another person such as yourself?" at 3 months post-randomisation.

Secondary outcomes

Secondary outcomes will measure the feasibility of the study methods and intervention and the impact of the intervention. Feasibility will be evaluated with process indicators at 3 months post-randomisation using study records to measure the 1) rates of recruitment assessed by the proportion of people screened who met the inclusion criteria and proportion of eligible people who agreed to participate in the study; 2) representation of sociodemographic characteristics of participants screened and consenting to participate in the study; 3) retention of participants assessed by the number of participants who withdraw consent or participation; 4) mode by which people heard about the study; 5) completeness of outcome data assessed by accelerometer and survey questionnaire outcome data; 6) uptake of telephone health coaching consultation with the research physiotherapist, assessed by the proportion of intervention participants who make an appointment with the research physiotherapist health coach; 7) uptake of the *Active Women over 50* website resource, assessed by the proportion of intervention participants who used the website, the website content that was accessed and the intensity of website usage, measured by Google Analytics; and 8) engagement with the email messages, assessed by the proportion of intervention participants who open the automated email messages sent by secure email marketing website *Vision6* [40]. Records will be kept when different aspects of the intervention are offered, delivered and received by each participant.

Intervention impact will be measured via a questionnaire and *Actigraph GT3X+* accelerometer, as detailed below, at 3 months post-randomisation assessing 1) the average number of steps taken per day (accelerometer measured), 2) the proportion of participants taking part in at least 150 min of moderate-intensity physical activity per week or at least 75 min of vigorous-intensity physical activity per week (as recommended by the Australian Physical Activity Guidelines) [5] (accelerometer measured), 3) exercise perceptions as measured by the *Exercise Benefits and Barriers Scale* [41], 4) mood as measured with the positive and negative subscales of the *Positive and Negative Affect Schedule* [42], 5) self-reported physical activity as measured by the *International Physical Activity Questionnaire* [43], 6) physical functioning as measured by the function component of the *Late Life Function and Disability Instrument* [44], and 7) health-related quality of life as measured by the *EQ-5D-5 L* survey [45].

Data collection procedure

Both the questionnaire-based measures and accelerometer-measured physical activity will be completed at baseline and repeated at 3 months post-randomisation. Data will be assessed or extracted by a research assistant blinded to group allocation. Questionnaires will take approximately 30 min to complete and will be accessed via an online survey link (*REDCap* [36]) or sent in hardcopy by post, as preferred by the participant.

The intervention group will complete an additional questionnaire at 3 months post-randomisation to assess their impressions of the intervention, perceived benefits and barriers, adverse events, usage of goal setting and their physical activity plans following the intervention. The questionnaire will ask both open- and closed-ended questions, for example "Did you set yourself a physical activity-based goal during the study?" and "What, if anything, helped you to achieve your goals?" An email or phone call will be sent to any participants with incomplete outcome measures to improve data completeness and participant retention.

Objectively measured physical activity

Actigraph GT3X+ is able to accurately estimate how physically active a person is throughout the day by measuring 3D body accelerations and is a valid instrument that has been extensively researched in the physical activity and public health field [46]. Participants will wear the *Actigraph (GT3X+)* for 7 consecutive days during waking hours (except during water-based activities or bathing). The accelerometer will be posted to participants with instructions for usage, along with an activity calendar to complete over the 7-day period and a prepaid envelope for returning the device to the research team. Activity counts will be collected at a sampling frequency of 30 Hz and reintegrated to 60-s epochs for data analysis. Accelerometer data will be manually checked against participant activity calendars to verify wear time, and erroneous data will be excluded prior to analysis.

Data management

To ensure participant confidentiality, the final dataset will contain re-identifiable information only. All study data will be entered onto a password-protected database and maintained on a firewall-protected local network server at The University of Sydney. Paper files will be stored in a locked filing cabinet in the Chief Investigator's office. The database and paper files will only be accessed by study staff. All publications associated with the results of the study will involve de-identified data, so participant confidentiality will be maintained.

Analysis of outcomes

Feasibility outcomes will be analysed descriptively to guide the design of a larger trial. Accelerometer data will be analysed using *ActiLife 6* software with time spent in different activity intensity levels calculated using the Troiano 2008 cut-points [47]. Acceptable wear time will be defined as at least 4 days with 10 h or more per day of valid wear time. Periods of 90 min or more of consecutive zeros (indicating non-use) will be considered as non-wear time.

Odds ratios will be calculated to assess the acceptability and feasibility of the study on the dichotomously scored primary outcome (the likelihood a participant would recommend participation in the study to someone else such as themselves) to assess the effect of group allocation on the dichotomously scored secondary outcome (proportion of people achieving physical activity in accordance with national guidelines) [5], adjusting for baseline scores. The study methods will be considered feasible if at least 80% of all participants complete follow-up measurements, or 80% of intervention participants access the intervention website or participate in the telephone health coaching session. Intervention versus control group differences in secondary outcomes, analysed with general linear models adjusting for baseline scores, will estimate effect sizes for sample size calculations for a larger trial and will provide an indication of likely intervention effect. This will be the progression criteria for proceeding to a fully powered randomised controlled trial.

A p value of < 0.05 will be considered statistically significant. Analyses will be pre-planned, conducted while masked to group allocation and will use an intention-to-treat approach. Analyses will be conducted using the *Stata 14* software package.

Sample size justification

There will be 60 community-dwelling females aged 50 years and over recruited for the pilot trial [48], allocated in equal numbers to the intervention and control groups. This sample size will provide feasibility data and estimates for sample size calculations for planning a future fully powered trial [49].

Ethics and dissemination

The trial protocol has been approved by the Human Research Ethics Committee at The University of Sydney, Australia (approval number 2019/075). The trial was prospectively registered (ACTRN12619000490178, 26 March 2019). Results will be disseminated via peer-reviewed journal articles and international conferences, and a lay summary will be made available to all participants at the completion of the study.

Discussion

Active ageing is at the core of this highly innovative project that targets women aged 50 years and older. To our knowledge, there currently exists no other programme that specifically targets physical activity information, resources and support in a way that is relevant to the needs of women aged 50 years and over who are insufficiently physically active.

This innovative programme takes a tailored and supported approach to the provision of physical activity information and follow-up support through health coaching and email or SMS messaging and has the potential to substantially increase physical activity participation in women people aged 50 years and over. End user input has been used to design the website to provide relevance and familiarity to the target audience in the delivery of information, resources, inspirational stories and suggestions. Participants are regularly referred to the website via email or SMS messaging and provided with health coaching to further tailor and support their uptake of regular physical activity.

The *Active Women over 50* programme also allows for the targeting of key messages to a broad range of women aged 50 years and over from different geographical areas and sociodemographic backgrounds. If found to be feasible and acceptable in this pilot RCT and effective in a future planned, rigorously conducted RCT, the *Active Women over 50* programme has the potential to be easily scalable and implemented widely to significantly impact the lives of many people.

Abbreviations

BCT: Behaviour change technique; CONSORT: CONsolidated Standards Of Reporting Trials; RCT: Randomised controlled trial; REDCap: Research Electronic Data Capture; SDT: Self-determination theory; SMS: Short message service, text messaging; SPIRIT: Standard Protocol Items: Recommendations for Interventional Trials; TIDieR: Template for Intervention Description and Replication

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Not applicable

Authors' contributions
AT, CS, GW, and LH conceived of the study. GW, AT, and CS initiated the study design and implementation methods. GW will be the study manager. GW, AT, and CS will conduct the primary analyses. All authors contributed to the refinement of the study protocol and approved the final manuscript.

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Availability of data and materials
Available on request from the corresponding author

Ethics approval and consent to participate
The trial protocol has been approved by the Human Research Ethics Committee at The University of Sydney, Australia (approval number 2019/075, 8 March 2019). Written informed consent will be obtained from study participants.

Consent for publication
Not applicable

Competing interests
The authors declare they have no competing interests.

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CHAPTER 7. Acceptability and feasibility of an online physical activity program for women over 50: a pilot trial.

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Authorship contribution statement

As primary supervisor and co-author of the paper "Acceptability and feasibility of an online physical activity program for women over 50: a pilot trial", I confirm that Geraldine Kit-Bing Wallbank is the lead corresponding author and has made the primary contribution to this study in each of the following areas in collaboration with co-authors Sherrington C, Hassett L. Kwasnicka D, Chau JY, Martin F, Phongsavan P, Grunseit A, Canning C, Baird M, Shepherd R, Tiedemann A:

- Conception and design of the research
- Data collection
- Data analysis and interpretation of findings
- Writing of the manuscript and critical appraisal of the content

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank

20 August 2025

Preamble to Chapter 7

This chapter describes the results of the prospectively registered pilot randomised waitlist-controlled trial protocol described in Chapter 6. This trial tested the acceptability and feasibility of a remotely delivered behaviour change physical activity support program among community-dwelling women aged 50 years and over across NSW, Australia.

TBM

ORIGINAL RESEARCH

Acceptability and feasibility of an online physical activity program for women over 50: a pilot trial

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Abstract

Regular physical activity benefits health across the lifespan. Women in middle-age often juggle carer and work responsibilities, are often inactive, and may benefit from tailored support to increase physical activity. Establish the acceptability, feasibility, and impact on physical activity of a scalable program for women 50+ years.

This pilot trial randomized participants to immediate program access, or to a wait-list control. *Active Women over 50 Online* program included: (1) study-specific website, (2) 8 emails or 24 SMS motivation-based messages, (3) one telephone health-coaching session. Outcomes, at 3 months, were acceptability (recommend study participation, intervention uptake), feasibility (recruitment, reach, completion), intervention impact (physical activity), intervention impressions. At baseline, 62 participants of mean (SD) age 59 (±7) years took 7459 (±2424) steps/day and most (92%) reported ≥2 medical conditions. At 3 months, acceptability and impact data were available for 52 (84%) and 57 (92%) participants, respectively. Study participation was recommended by 83% of participants. Participants mostly agreed to receive health coaching (81%) and messages (87%: email = 56%, SMS = 44%), opened 82% of emails and accessed the website 4.8 times on average. Respondents reported the intervention supported their physical activity. Intervention participants were more likely to increase steps from baseline by 2000+/day (OR: 6.31, 95% CI: 1.22 to 32.70, $p = .028$) than controls, and trended toward more light-intensity ($p = .075$) and moderate-vigorous intensity physical activity ($p = .11$). The *Active Women over 50 Online* program demonstrated acceptability and feasibility among the target population, and effectiveness in some domains in the short term. Results warrant further testing in a full-scale RCT.

Keywords

Physical activity, Digital intervention, Health coaching, Health promotion, Middle-age women

Implications

Practice: An online, tailored physical activity program using low-cost technology to ensure equity of access is acceptable and feasible to deliver to community-dwelling women aged 50 years and over to support physical activity.

Policy: If the intervention is found to be effective in a definitive trial, current nationwide disease prevention strategies implemented in the middle age years could include the provision of an online program using low-cost technology to promote healthy aging through physical activity participation.

Research: High acceptability and feasibility of this intervention warrants further testing in a fully powered trial, but further work is needed to understand the motivators of those who are insufficiently physically active, culturally and linguistically diverse populations, and those with fewer resources to better reach and support them in the uptake of this health behavior.

Lay summary

Regular physical activity benefits health at all ages. Women in middle-age years often juggle carer and work responsibilities. We investigated the acceptability, feasibility, and effect of a scalable physical activity program targeting this group. Participants were randomly assigned to immediate access to the *Active Women over 50 Online* program or after a 3-month wait. *Active Women over 50 Online* program included: (1) study-specific website with information, case studies and links to physical activity opportunities, (2) email or SMS motivation-based messages, (3) telephone health-coaching session. We recruited 62 participants, who were on average aged 59 years, active, and had at least two medical conditions. At the 3-month follow-up, 83% of participants would recommend study participation. Participants who received the program immediately agreed to receive health coaching (81%) and messages (87%). They accessed an average of five web sessions each in a 3-month period and reported the program supported their physical activity. These participants were also more likely to take an average of 2000+ daily steps more than at baseline, and increased their physical activity at light, moderate, and vigorous intensities more than those who had not received the program. The high uptake, engagement, positive recommendation, and promising impact on physical activity warrants further program testing in a larger trial.

BACKGROUND

Regular physical activity benefits health at all ages and people with varying health states. Functionally, physical activity directly improves independent living, reduces frailty and risk of fracture [1], and delays disability by up to 15 years in older women [2]. If commenced in the middle-age years (40–65 years), physical activity can reduce the all-cause risk for mortality irrespective of past physical activity levels [3] or the intensity of physical activity [4]. The

World Health Organization (WHO) has set clear guidance on the amount of regular physical activity that is needed for health benefits across the lifespan and for different health conditions, specifying the duration, intensity, frequency, and different types of physical activity required [5]. Yet, globally, one in four adults do not meet these guidelines [6] and the prevalence of physical inactivity is higher in women, where one in three women globally do not meet the guidelines for physical activity. This increases to two in five women for the regions of Latin America and the Caribbean, south Asia, and high-income Western countries [6], and one in two aged over 80 years old [7].

There are unique challenges to being physically active for women in their middle-age years. In Australia, women comprise 47% of the Australian labor force [8] and compared to men, they juggle employment with higher primary carer responsibilities: 69% of carers aged 45–64 years are women [9]. Moreover, 62% of women in this age group live with at least one chronic condition [10]. As a result, there are fewer opportunities for women in this age group to be physically active, particularly for those in regional and remote areas [11]. The competing demands and specific barriers to exercise that women experience in middle age years necessitate targeted support to ensure that they adopt and maintaining physical activity for healthy aging.

Health promotion interventions that aim to change lifestyle behaviors, which are delivered by digital technologies offer an efficient, effective, and scalable solution for preventing noncommunicable diseases [12] and addressing physical inactivity. A remote health intervention informed by theories of behavior change could provide the basis for addressing behavioral factors through the design of such interventions. Appropriate behavior change techniques [13] such as goal setting and planning, feedback and monitoring, social support, shaping knowledge, and comparison of behavior can therefore be integrated as active components of health promotion interventions. The inclusion of health coaching in digital behavioral interventions can also address the lack of personalization inherent in technology delivered programs. A health coach can tailor behavior change techniques and improve physical activity outcomes [14]. Health professionals acting as health coaches can improve adherence and health outcomes potentially through building a strong therapeutic alliance with their clients [15,16].

A simple intervention that uses low-cost technology to allow equity of access [17], is scalable for reach, and offers flexibility for women who manage many responsibilities, may be an effective way to support community-dwelling but physically inactive women aged over 50 years to increase their physical activity. To the best of our knowledge, there are no interventions that specifically target community-dwelling women aged 50 years and over across socio-geographic boundaries, that combine remotely delivered, digital technology with tailored health coaching to support physical activity. The aim of this pilot study was therefore to establish the acceptability, feasibility, and likely impact of the *Active Women over 50 Online* program, an innovative digital 3-month behavior change program to promote physical activity among women aged 50 years and over.

METHODS

The trial was designed according to the CONsolidated Standards Of Reporting Trials statement (CONSORT) for a pilot and feasibility trial [18] with reference to the Template for Intervention Description and Replication (TIDieR) checklist [19]. Figure 1 shows the CONSORT flow diagram. The TIDieR checklist and trial protocol have been previously described [20] and are reported here in brief.

Participants

We recruited participants between May and August 2019 in Sydney, Australia via advertising in newsletters and websites of community organizations, the University, local health districts, the study recruitment website, word of mouth, and social media. People registered their interest by completing an online screen, and those eligible were contacted by research staff to obtain informed written consent. Eligibility criteria were female, aged 50 years or over, and living in NSW, Australia. Exclusion criteria were: limited English language skills, no access to an internet-connected device, a health condition that precluded participation in regular physical activity, or already meeting the lower limit of the WHO guidelines for moderate to vigorous physical activity of 150 min per week [5]. Physical activity was assessed by two screening questions that considered physical activity in 30-minute bouts, one question asking about moderate-intensity physical activity and the other about vigorous-intensity physical activity. For example: “How many times a week do you usually do 30 min or more of moderate-intensity physical activity, or walking that increases your heart rate, or makes you breathe harder than normal? (eg, carrying light loads, bicycling at a regular pace)”. Participants were eligible if total weekly physical activity was less than the lower limit of the WHO guidelines for moderate to vigorous physical activity of 150 min per week.

Trial design

We conducted a pilot randomized wait-list controlled trial with follow-up three months postrandomization. Consenting participants were individually randomized at a 1:1 allocation ratio to the intervention or control group after completing baseline measurements. The recruiting investigator (GW) carried out the randomization using web-based randomization to achieve concealed allocation with a

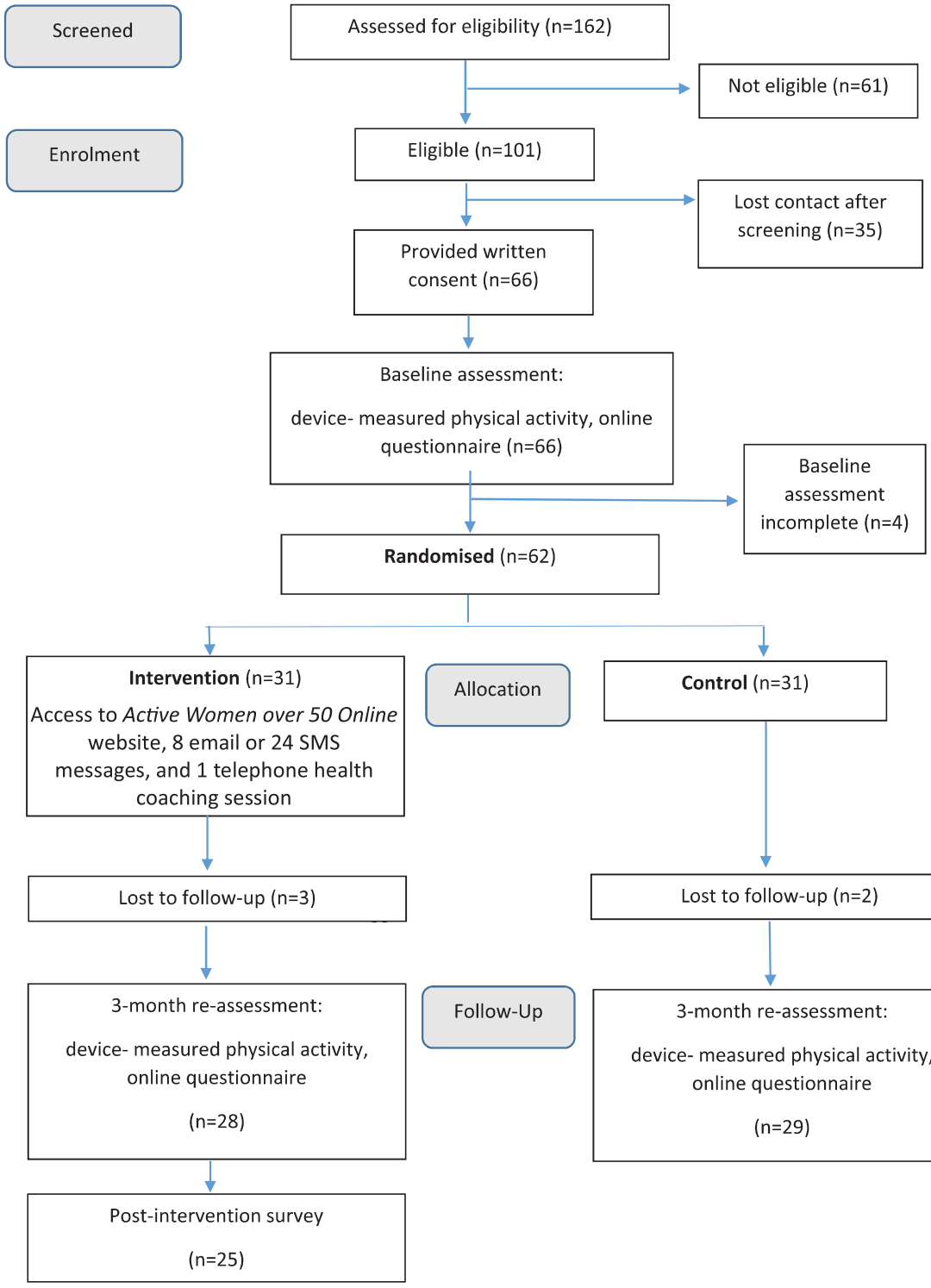

Fig. 1 | CONSORT diagram of participant flow.

computer-generated randomization schedule embedded in a secure online database (REDCap) [21]. The schedule was prepared by an investigator not involved in recruitment (LH) using randomly permuted block sizes of two to six and stratification by metropolitan or regional NSW residential postcode as defined by the Australian Government Department of Home Affairs.

Intervention

The *Active Women over 50 Online* program was developed following our previous trial testing an information and support intervention amongst female university and health service employees aged 50 and over [22]. The intervention was designed with efficiency, use of low-cost resources, and scalability as guiding principles. Intervention components,

including behavior change techniques, were informed and underpinned by the Self-Determination Theory [23], COM-B model and Behaviour Change Wheel [24] with user input from a convenience sample from the target population [20]. The intervention period was 3 months.

The *Active Women over 50 Online* website contained program content on three main pages: "Why be active?", "How to be active", and "Be inspired". The "Why be active?" page included evidence-based information about the effect of physical activity in middle-age to maintain health, longevity, and prevent disability in older age. The "How to be active" page included practical suggestions for becoming more active using behavior change techniques such as SMART goal setting, self-assessment of barriers to physical activity and solution-generation and included links to resources supporting habit formation and behavior change, and information for different health conditions and services. The "Be inspired" page included role modeling content to inspire participant motivation to be physically active through video case studies of "real life" women over 50, external podcasts, blog posts, and the opportunity to share their own ideas and inspirational stories via the website. This was a relatively static information website, publicly available but not easily searchable as the URL did not contain terms related to the study name. Participants accessed the website at their own discretion.

Over the 3-month period, participants received either eight unidirectional email messages or 24 SMS messages, as preferred, which delivered similar content informed by behavior change theories. The messages aimed to build capability, opportunity, and motivation to support physical activity using behavior change techniques. They included reminders of the benefits of physical activity, social modeling, ways to address barriers to activity, and help with action planning. Secure marketing websites were used to send the email messages (*Vision6* [25]) and SMS messages (*BurstSMS* [26]). Intervention participants received a one-off telephone health coaching session within 2 weeks of randomization, delivered by a tertiary-qualified physiotherapist trained in motivational interviewing with experience delivering telephone-based health coaching [27]. The health coach used behavior change elements of health coaching, tailored to individuals to facilitate physical activity behavior change, including motivational interviewing and behavioral intervention techniques, and had completed courses through Wellness Coaching Australia [28], Health Change Australia [29] and Medicoach [30]. At least two attempts were made to contact participants who did not reply to the invitation to receive the intervention.

At randomization, intervention participants were given access to the *Active Women over 50 Online* website and asked to select their preference for receiving the *Active Women over 50 Online* motivational messages (SMS or email), and to nominate available times for a telephone health coaching session. No incentives were offered or provided to participants.

Control participants were waitlisted to receive the *Active Women over 50 Online* program after completing all follow-up measures.

Study measures

Study measures assessed the acceptability, feasibility, and likely impact of the *Active Women over 50 Online* program.

Primary outcome

The primary outcome was a global measure of participant acceptability of the study, assessed by whether participants would recommend study participation to another person. At 3 months postrandomization, participants were asked to select "yes" or "no/unsure" to the survey question "Would you recommend the *Active Women over 50 Online* study to another person such as yourself?".

Secondary outcomes

Secondary outcomes measured process evaluation indicators namely, feasibility of implementation, uptake of the intervention—a proxy measure of acceptability, and impact of the intervention. During the recruitment period, study records were used to measure the: (1) rate of recruitment, assessed by proportion of eligible people who consented to participation; (2) reach, assessed by the representation of sociodemographic characteristics of people screened and who consented, and (3) the mode by which people heard about the study. At 3-month follow-up, study records were used to measure the: (4) retention of participants, assessed by number of participants who withdrew consent or participation; (5) completeness of accelerometer and survey questionnaire outcome data; (6) uptake of telephone health coaching consultation, assessed by proportion of intervention participants making an appointment with the research health coach; (7) uptake of the *Active Women over 50 Online* website resource, assessed by number of website entries, content accessed, and time spent on the website in the first 3 months of the study, measured by Google Analytics; and (8) engagement with the email messages, assessed by proportion of email messages opened.

Intervention impact was measured at baseline and 3 months postrandomization, assessing the: (1) average number of daily steps, measured by *ActiGraph GT3X+* accelerometer [31]; (2) proportion of participants at least meeting the lower limits of the WHO physical activity guidelines, 150 min/week of moderate-intensity physical activity or 75 min/week of vigorous-intensity physical activity or an equivalent combination of both [5], measured by *ActiGraph GT3X+* accelerometer; (3) exercise perceptions, measured by the *Exercise Benefits and Barriers Scale (EBBS)* [32]; (4) mood, measured with the positive

and negative subscales of the *Positive and Negative Affect Schedule (PANAS)* [33]; (5) self-reported physical activity, measured by the *International Physical Activity Questionnaire (IPAQ)* [34]; (6) physical function, measured by the function component of the *Late Life Function and Disability Instrument* (LLFDI) [35]; and (7) health-related quality of life, measured by the *EuroQuol EQ-5D-5L* survey [36].

At follow-up intervention participants completed an additional survey asking open- and closed-ended questions to evaluate their impressions of the intervention, perceived barriers, adverse events, usage of goal setting, and physical activity plans. Participants' responses were summarized. There was no further follow-up for the control group after completing the 3-month follow-up measures.

Retention

Emails, phone calls, and letters were sent to participants with incomplete outcome measures to maximize data completion and retention.

Data collection and management

Data were collected via study records for recruitment (screening for eligibility, consent, randomization) and when intervention components were offered, delivered, and received; via Google Analytics for the website usage; and via *Vision6* [25] for email message activity. Intervention impact data were collected via questionnaire and *ActiGraph GT3X+* accelerometer [31]. All questionnaires were accessed by an online survey link via REDCap [21] or sent to the participant in hardcopy by post if preferred. Data were assessed or extracted by a research assistant blinded to group allocation. The accelerometer was posted to participants with instructions for usage and an activity log to complete over the 7-day wear period. Participants wore the accelerometer on their right hip for seven consecutive days during waking hours, except during water-based activities or bathing. Activity counts were collected at a sampling frequency of 30 Hz and reintegrated in 60-s epochs for data analysis [37,38]. A research assistant blinded to group allocation manually checked data against participant activity calendars to verify wear time and erroneous data were excluded prior to analysis. All study data were entered onto a password-protected database and maintained on firewall-protected local network server at the University, accessible only by study staff. The final dataset contained de-identifiable information to ensure participant confidentiality.

Data analysis

Odds ratios were calculated to assess the acceptability of study participation on the dichotomously scored primary outcome, and the effect of group allocation on dichotomously scored secondary outcomes using baseline scores as the covariate. Feasibility outcomes were analyzed descriptively. Criteria for study feasibility was set at 80% a priori for the completion of follow-up measurements. Criteria for study acceptability was set at 80% a priori for the following acceptability outcomes: participants recommending study participation, participants electing to receive either SMS or email messages, participants making an appintment with the health coach. Accelerometer data were analyzed using *ActiLife 6* software and Troiano 2008 cut-points for time spent in different activity intensity levels [38]. Acceptable wear time was defined as ≥4 days with ≥10 hr/day of valid wear time. Periods of ≥60 min of consecutive zeros indicating non-use were considered nonwear time [38]. General linear models using baseline scores as the covariate estimated effect sizes for group differences for continuously scored secondary outcomes to provide an indication of likely intervention impact and the progression criteria for proceeding to a fully powered randomized controlled trial. A p value of <.05 was considered statistically significant. Analyses were pre-planned, conducted while masked to group allocation and used an intention-to-treat approach. Analyses were conducted using *Stata 14* software. A sample size of 60 participants was recruited [39] to provide feasibility and acceptability data and estimates for sample size calculations for a future fully powered trial [40].

RESULTS

Sixty-two participants took part in the study with an average age of 59 years old (SD 7, range 50–77 years). There were 31 participants in each group. Sociodemographic and baseline characteristics were similar for both intervention and control groups (Table 1).

Acceptability

Global measure of acceptability

Overall, participation in the study was acceptable regardless of whether the intervention was received immediately or after 3 months. Of the 52 respondents, 43 (83%) participants (intervention: 22/25; control: 21/27) indicated they would recommend participation to another person at 3 months postrandomization with no between-group differences detected (χ^2 [1] = 2.95, p = .229).

Intervention acceptability

There was a median 3(IQR = 5.5) days from the date of randomization to Intervention participants responding by email with their preferred choice of intervention delivery.

Active Women over 50 Online Website usage

Website usage was recorded for a 3-month period, from when the first participant was randomized to when the first waitlist control participant gained access to the intervention, to prevent

Table 1 | Participant characteristics at baseline presented as *n* (%) (*N* = 62)

Baseline Characteristics	Control, *n* = 31	Intervention, *n* = 31
Age in years, mean(SD)	58.5 (6.9)	60.0 (7.4)
Living in metropolitan areas	26 (84)	26 (84)
Language other than English spoken at home	3 (10)	5 (16)
2 or more medical conditions	26 (84)	31 (100)
Carer responsibilities	19 (61)	24 (77)
Currently working[a]	24 (77)	23 (74)
Working[a] hours/week, mean(SD)	30 (12.7)	30 (12.8)
Participated in structured PA[b] when younger[c]	19 (61)	25 (81)
Accelerometer: number of steps/day	7658 (2531.1)	7261 (2337.2)
Accelerometer: MVPA mins/week, mean(SD)	219 (133.8)	210 (138.0)
Accelerometer: LPA hours/week	33 (8.7)	31 (7.1)
Accelerometer: sedentary hours/week, mean(SD)	56 (9.2)	56 (9.9)

Note: recruitment period 14.5 weeks
[a]Working = paid or unpaid work.
[b]Structured PA = structured physical activity; community-based exercise, sport or physical recreation program including but not limited to fitness or community centre exercise programs, dance, tai chi, aqua aerobics, soccer, bush walking, school sport/PE, wheelchair basketball etc. These activities are done with other people (participants or instructors).
[c]younger = prior to current age.
MVPA, moderate to vigorous intensity physical activity; LPA, light-intensity physical activity.

cross-contamination of results. During this period, 28 intervention participants used 86 different internet-connected devices (41% desktop computer, 33% mobile smartphone, and 26% tablet device) to access the website over 135 sessions (Table 2) Participants accessing the website engaged in, on average, 4.8 sessions each, and during every session they spent 6 min viewing an average of 5 webpages. Interaction with the website was reasonably high. On an average, 80% of visits to the website continued with further website interaction. This was measured by a 20% "bounce rate", where 20% of visitors arrived at the website and left without interacting with the content. The most viewed webpages were the home page, "How to be active", and "Getting started" pages, and visitors tended to exit the website via webpages providing information for action planning or finding an activity or strategy to keep active (Table 2).

Active Women over 50 Online motivational messages

Twenty-seven intervention participants (87%) chose to receive motivational messages. A slightly higher proportion chose email messages rather than SMS (15/27, 56%; SMS: 12/27, 44%) including one participant who unsubscribed after the fourth email. Participants opened 79% (95/120) of email messages sent and clicked on 31% of the embedded links that directed them to the *Active Women over 50 Online* website.

Telephone health coaching

Twenty-six intervention participants (84%) accepted the offer to receive the health coaching session. Four participants were either unavailable for their session or did not reply to make an alternate time. Twenty-two participants (71%) received a session lasting a median of 41 (IQR15) min.

Postintervention follow-up survey

Twenty-five (81%) intervention participants provided feedback on adverse events, their physical activity, and impressions of the intervention via a survey with open and closed questions. Adverse events resulting from being more physically active were reported by five participants: one serious (broken wrist), five musculoskeletal injuries (flare up of chronic hip bursitis, forearm muscle and hamstring injury, sacroiliitis, plantar fasciitis) and one migraine. Four participants required medical attention.

General comments

Overall, participants were positive about the intervention and being physically active, commenting that the intervention increased their awareness and encouraged them to be physically active, and could benefit other women in their age group. Yet, the intervention did not suit all participants, for example one participant wanted subsidized personal trainer services, and another was seeking a program offering social interaction.

Physical activity levels and strategies used

Eleven (44%) participants rated their physical activity higher, 9 (36%) the same, and 5 (20%) lower following the intervention. These responses are consistent with follow-up accelerometer measures for the proportion who met or exceeded their baseline number of daily steps (16/28, 57%), time spent in moderate-vigorous intensity physical activity (14/28, 50%), and time spent in light-intensity physical activity (17/28, 61%). Participants used a range of physical activity strategies. Almost all participants accessed

Table 2 | *Active Women over 50 Online* website usage and pages viewed over 3-month period by intervention group ($n = 28$)[a]

Website Usage		Total	New Users	Returning Users
Participants, *n*		28	–	–
Users, *n*		86	86	25
Users per participant, *n*		3.07	–	–
Sessions, *n*		135	86 (63.7%)	49 (36.3%)
Sessions per user, *n*		1.57	1	1.96
Average session duration (min:s)[b]		5:54	5:56	5:51
Bounce rate, %		20.0%	19.77%	20.41%
Pages viewed, *n*		669	445	224
Pages viewed per session, *n*		4.96	5.17	4.57
Pages Viewed	**Page Views**	**Average Page Time (min)[b]**	**Bounce Rate**	**% Exit**
Home page[c]	148	1:16	8%	9%
How to be active[c]	99	1:28	10%	23%
Be inspired[c]	74	1:40	0%	4%
Why be active? [c]	76	3:34	0%	27%
Getting started[d]	81	2:34	11%	21%
Find an activity or sport[d]	54	12:54	54%	34%
Tools to keep going[d]	45	3:12	67%	41%
Mobile apps[d]	34	3:45	50%	21%
Tips and hints for getting started[d]	27	2:58	7%	7%

Notes:
[a] Website activity for first 3 months of study period before first waitlist control participant gained access to the intervention, recorded by Google Analytics.
[b] average values calculated by Google Analytics. Individual session information unavailable.
[c] Main webpage.
[d] Subpage under a main webpage, or link within subpage.
User = a desktop, mobile, or tablet device used to visit the website; New users = first-time the desktop, mobile, tablet device was used to visit the website; Returning users = a previously used device visiting the website; Session = period time a user is actively engaged with the website; Bounce rate = percentage of visitors who enter then leave the page without interacting with the page. Higher percentage indicates higher number of visitors leaving the page without interaction. Entry to the page could be through an embedded link in email/SMS messages or a bookmarked page. % Exit = percentage of users exiting from the website after viewing the page

structured physical activity options through local fitness centers and programs (96%), followed by using the *Active Women over 50 Online* website (80%), goal setting (80%), exercising with others (72%), receiving the *Active Women over 50 Online* motivational SMS or email messages (64%), and using an activity tracker (48%). Of those who set physical activity goals, 14 (70%) indicated these were achieved with the assistance of an activity tracker or the telephone health coaching session or due to a sense of accountability to the research team. The most common barriers to achieving physical activity goals were lack of time ($n = 10$ participants, 40%), sickness or injury ($n = 6$, 24%), lack of energy ($n = 5$, 20%), lack of willpower ($n = 5$, 20%), fear of injury ($n = 2$, 8%), and lack of resources ($n = 2$, 8%).

Impressions of intervention components

(a) Website: Most participants indicated the website was easy to access and navigate and commented that it was a useful resource ($n = 23$, 92%); (b) *Telephone health coaching*: Almost all participants indicated the telephone health coaching session supported their PA ($n = 22$, 88%) and noted the initial discussion was an encouragement, a prompt, and a good point of contact with the research team; (c) *Messages*: Almost two-thirds of participants indicated they used the messages to support their physical activity ($n = 16$, 64%), and while some said the SMS messages prompted them to get active, for one participant the inconvenient timing of the SMS coming when activity was not possible, was not helpful. The lack of personalization of the intervention was mentioned as another shortfall. Some participants had wanted personalized feedback, individual barrier analysis, and human interaction to support their physical activity.

Physical activity plans

All but one respondent reported they had plans to continue being physically active over the next 6 months. Of the 19 respondents who provided details of their plans, nine planned to continue with their current physical activity arrangements, six planned to schedule more individual physical activity into their time, and four planned to start a structured physical activity.

Feasibility

Recruitment and retention

Participant flow through the study is shown in Fig. 1. One-hundred and sixty-two women contacted the research team to participate, hearing about the study via advertisements seen on email (48%), word of mouth (21%), social media (20%), advertisements at workplace or health facility (11%). Potential

participants were screened for eligibility including 27 (17%) who lived in regional NSW. Of 101 eligible, 66 consented to participate, 62 (61%) completed all baseline measures and were randomized. Nine (15%) participants lived in regional NSW, and 10 (16%) spoke a language in addition to English at home. Reasons for ineligibility were already physically active (n = 56, 92%), living outside NSW (n = 4, 7%), or under 50 years old (n = 1, 2%). Retention was 96%: 3(4%) participants did not complete either the survey or device follow-up measurements. No participants withdrew their consent during the study period.

Completion of outcome data

At 3 months postrandomization, primary outcome measures were collected from 52 of 62 participants (85%, control = 27, intervention = 25), accelerometer outcomes from 57 participants (92%, control = 29, intervention = 28), survey outcomes from 56 participants (90%, control = 29, intervention = 27), and intervention feedback from 25/31 intervention participants (81%). Reasons for incomplete data were family matters (n = 1) and no reasons given for other incomplete data.

Intervention delivery

Intervention participants received access to the website at randomization, messages on the date they replied to the intervention offer email, and health coaching session a median of 6(IQR = 6.0) days after replying to the intervention offer. All telephone health coaching sessions primarily used motivational interviewing techniques and discussion of motivators for physical activity. Other health coaching approaches used during the session included a discussion of barriers to physical activity, goal setting/evaluation, falls prevention/education, experiential learning, modifications to program and building social supports. The health coach made on average 16 physical activity program recommendations and set an average 3.8(SD1.6) physical activity goals with each participant.

Impact of *Active Women over 50 Online* program

Device- and survey-measured outcomes are shown in Table 3. At baseline, participants took an average 7459(SD 2424) daily steps, spent 214(SD 135) min/week in moderate-vigorous intensity physical activity, and 32(SD 8) hr/week in light-intensity physical activity. Self-reported total physical activity (IPAQ) was on average 570(SD 688) min/week, and participants had high baseline physical function (LLFDI), perceptions of exercise benefits/barriers (EBBS), positive mood (PANAS), and quality of life (EQ5D5L) (Table 3).

At 3 months postrandomization, device-measured physical activity showed a significant between-group difference in the proportion of participants taking 2000 or more daily steps than at baseline that favored the intervention group (OR: 6.31 95%CI: 1.22 to 32.70, p = .028, Table 3). There was also a tendency for the intervention group to spend more time in light-intensity physical activity (p = .075) and be more likely to increase moderate-vigorous intensity physical activity by at least 120 min/week compared to controls (p = .11). There were no significant between-group differences for the secondary outcome measures (Table 3).

DISCUSSION

This three-month online physical activity information and support program using low-cost technology was acceptable and feasible among community-dwelling women aged 50 years and over and showed some promising results for the impact on physical activity. The criterion for acceptability was exceeded for study participation, irrespective of whether the intervention was offered immediately or with a 3-month delay supports testing of the intervention in a fully powered trial. Acceptability criteria for the uptake of motivational messages and telephone health coaching were exceeded for intervention participants (>80%). The intervention group's high uptake of the intervention, level of engagement with the website, messages, and positive feedback about the telephone health coaching session supports further intervention testing. Control participants were given access to the intervention after all follow-up measures were completed.

This study demonstrated feasibility across three dimensions: the implementation process, intervention delivery, and outcome measurement completeness. Criteria for feasibility exceeded 80% for the completion of primary outcome measures, accelerometer and survey outcomes, and the intervention feedback survey. The recruitment and retention rate of participants were high. All but three participants (96%) completed at least one aspect of the final assessment. There was a variation in the response rates for different outcome variables, which was out of the study's control. We have noted the individual sample sizes in Table 3.

A key finding from this pilot trial was that despite intending to recruit a physically inactive sample, baseline physical activity measurements revealed participants were already active. This may reflect an unintended consequence of the online screening process which asked for bouts of physical activity and not the time spent in physical activity. It likely meant that participants underestimated their total physical activity and appeared less active at screening than reality.

This finding has implications for the method of screening and recruitment to reach those who are physically inactive in a fully powered trial. Other brief physical activity assessment tools have similar limitations using bouts of physical activity [41].

Table 3 | Secondary outcomes by group at baseline and follow-up (mean (SD) or *n*(%)) and between-group effects (mean difference between groups, RR, or OR (95%CI), *p*-value) (*N* = 62).

Outcome	Baseline Control (*n* = 31)	Baseline Intervention(*n* = 31)	3-month Follow-up Control(*n* = 29)	3-month Follow-up Intervention(*n* = 28)	Between-Group Difference, Adjusted for Baseline
Accelerometer: Number of steps/day [a,c]	7658 (2531.1)	7261 (2337.2)	7931 (232.6)	7933 (2953.2)	412.4 (95%CI: −607.4 to 1432.3), *p* = .421
Accelerometer: proportion increasing daily steps ≥2000 from baseline, *n* (%)[a,d]	–	–	2 (7)	9 (32)	OR: 6.31 (95%CI: 1.22 to 32.70), *p* = .028
Accelerometer: MVPA min/week [a,c]	219 (133.8)	210 (138.0)	233 (143.7)	269 (238.3)	5.15 (95%CI: −56.5 to 66.8), *p* = .868
Accelerometer: proportion exceeding lower MVPA guidelines, 150 min/week, *n*(%)[a,d]	23 (74%)	20 (64%)	19 (66%)	19 (68%)	OR: 1.06 (95%CI: 0.35 to 3.23), *p* = .917
Accelerometer: proportion exceeding upper MVPA guidelines, 300 min/week, *n*(%)[a,d]	5 (16%)	7 (23%)	7 (24%)	9 (32%)	OR: 1.59 (95%CI: 0.48 to 5.18), *p* = .445
Accelerometer: proportion increasing MVPA ≥120 min/week, *n*(%)[a,d]	–	–	4 (14)	9 (32)	OR: 2.938 (95%CI: 0.783 to 11.025), *p* = .110
Accelerometer: LPA hours/week [a,c]	33 (8.7)	31 (7.1)	34 (9.2)	35 (10.6)	3.62 (95%CI: −0.37 to 7.61), *p* = .075
Accelerometer: sedentary hours/week [a,c]	56 (9.2)	56 (9.9)	57 (10.0)	57 (12.9)	0.13 (95%CI: −4.76 to 5.02), *p* = .957
IPAQ: total physical activity, mins/week [a,c,g]	522 (500.3)	618 (841.1)	723 (720.9)	639 (635.3) [e]	−133 (95%CI: −487.48 to 221.40), *p* = .455
IPAQ: walking, mins/week [a,c]	264 (278.8)	334 (509.5)	329 (425.8)	234 (388.4) [e]	−115.4 (95%CI: −332.04 to 101.21), *p* = .290
IPAQ: moderate-intensity, mins/week [a,c]	237 (339.7)	269 (354.2)	356 (463.3)	372 (460.6) [e]	−10.32 (95%CI: −242.40 to 221.76), 0.929
IPAQ vigorous-intensity, mins/week [a,c]	22 (62)	15 (45.8)	38 (88.9)	33 (72.6) [e]	−3.73 (95%CI: −46.09 to 38.62), *p* = .861
IPAQ MVPA, mins/week [a,c]	258 (355.9)	284 (392.7)	394 (471.8)	405 (487.9) [e]	1.31 (95%CI: −241.97 to 244.60), *p* = .991
LLFDI scale (25–125) [a,c]	116 (6.2)	110 (16.5)	116 (6.6)	113 (13.5) [f]	−0.39 (95%CI: −4.11 to 3.33), *p* = .835
EBBS scale (43–172)[a,c]	127 (13.2)	134(14)	130 (11.4)	137 (14.3) [e]	3.47 (95%CI: −1.29 to 8.23), *p* = .149
PANAS: positive subscale (10–50) [a,c]	30 (8.7)	34 (7.3)	30 (7.8)	33 (8.8)	1.09 (95%CI: −2.60 to 4.79), *p* = .556
PANAS: negative subscale (10–50) [b,c]	16 (5.1)	16 (5)	15 (5)	14 (4.3)	−1.51 (95%CI: −3.60 to 0.58), 0.154
EQ-5D-5L [a,c]	0.851 (0.102)	0.779 (0.167) [e]	0.855 (0.1)	0.801 (0.184) [e]	0.02 (95%CI: −0.047 to 0.084), *p* = .574

Notes: MVPA, moderate to vigorous intensity physical activity; LPA, light-intensity physical activity; IPAQ, International Physical Activity Questionnaire; LLFDI, Late Life Function and Disability Instrument; lower limb function component score; EBBS, Exercise Benefits and Barriers Scale; PANAS, Positive and Negative Affect Schedule. EQ-5D-5L = health utility score.

[a] Higher score reflects better performance;

[b] Lower score reflects better performance;

[c] Between-group differences from linear regression models;

[d] Between-group differences from logistic regression models;

[e] 1 missing value;

[f] 2 missing values;

[g] Total IPAQ time for walking, moderate, vigorous physical activity.

A screening tool that contained more descriptive information about physical activity levels at work and leisure such as the Stanford Brief Activity Survey [42] could be a possible solution.

This study recruited via the research team's established channels which may have inadvertently limited the "reach" to the intended target group. The recruitment method reached women living regionally, but they were only nominally represented in this study (16%) compared to higher proportions (25%) in the NSW population in 2011 [43]. In future trials, we recommend recruitment through organizations that are not associated with university or health services but have broad reach across the state. These may include the "Country Women's Association", female-specific organizations, community groups, or parent groups connected with high schools. Future work is also needed to better understand how to reach women aged 50+ who are physically inactive, who have fewer resources, and who are least aware about the benefits of physical activity, to better inform the design of a behavior change intervention that reaches and supports those most in need.

This study's recruitment of an active sample does reflect however, the desire of women who are already physically active, to become more active, and who seek support from an online intervention to enact this. The rationale to deliver an intervention to already active people is the evidence that additional health benefits can be gained with exceeding the upper limits of the WHO physical activity recommendations [5], particularly one that uses minimal resources such as this.

Social strategies to support physical activity in this cohort were highlighted through feedback from intervention participants, many of whom chose to be physically active by exercising with others. There is evidence that interacting within a social network provides benefits and support for physical activity [44], so future interventions of this type for women over 50 years need to consider social components in their design. Further study is required to determine how this can be applied to a remotely delivered intervention and the type and mode of social interaction which would be acceptable and effective for our target group [45].

Study-related adverse events included one serious injury. While physical activity has a protective effect against injurious falls [46], being more physically active also exposes one to greater risk [47], and requires individuals to balance the benefits with the risks as was shown in the results. Adverse events were not measured in the control group but should be in a fully powered RCT.

The impact of the intervention was demonstrated by increased daily steps of 2,000 or more from baseline. This was an interesting finding as this magnitude of change has been reported to be sufficient to produce a health benefit [48]. This measure may also be a more sensitive, meaningful reflection of the uptake of physical activity than measuring the proportions of those who meet or exceed WHO recommendations. The trend to increase light-intensity physical activity in this study was also an encouraging finding, and may reflect increased time spent in other aspects of physical activity such as balance or strengthening, or reflect the WHO recommendation for physical activity capacity building "starting small and building up" [5]. At the other end of the spectrum, the tendency for moderate-vigorous intensity physical activity to increase by 2 hr or more than baseline was also seen.

Unsurprisingly, this pilot study did not detect an intervention impact in other outcomes for physical activity, function, attitudes, and perceptions, but it was not powered to do so. However, the high baseline physical activity of the sample is a consideration for a fully powered trial. Interestingly, the follow-up *IPAQ* survey-measured physical activity recorded control participants reporting more physical activity than intervention participants. While self-reported physical activity tends to overestimate physical activity compared to device-measured physical activity [49], this finding may reflect a cohort of participants who were motivated to increase their physical activity as the upshot of enrolling in a physical activity intervention study as has been reported in other studies [50].

Strengths

A strength of this study was the flexibility of the intervention that allowed convenient access to each intervention component, reflected in high acceptability and feasibility, and has positive implications for testing the intervention in a larger trial in this target population. Another strength of this study was the intervention was designed with efficiency, equity of access, and scalability. If found effective in a larger trial, only minimal low-cost resources would be required to implement this intervention at a population level to support physical activity regardless of baseline physical activity levels. At a time when face-to-face delivery of health promotion strategies are restricted due to the COVID-19 pandemic and when there is a greater interest in physical activity [51] such a remotely delivered intervention is particularly relevant. Moreover, the pilot testing of this online intervention was completed before the COVID-19 pandemic, so testing in a fully powered trial is timely.

Limitations

There were limitations to this study. First, while attempting to exclude potential participants meeting the lower end of the WHO physical activity guidelines, baseline measurements recorded already active participants who were inadvertently included via the screen, which may limit the generalizability of the findings. This is a common problem in physical activity research where people who are interested in an intervention are those who are likely to be recruited to participate in research, resulting in a physically active sample at baseline.

Second, the 3-month study period is a relatively short duration for follow-up and is unable to assess maintenance of physical activity, so a larger trial should include a longer follow-up period to assess this. Third, these results are not transferrable to people excluded from the study such as those without English or access to the internet. Further work is needed to better understand how to reach these groups. Another limitation of this study was the omission of fidelity checks on the content of health coaching. Finally, this study did not consider adherence to the balance and strengthening recommendations in the WHO physical activity guidelines. Measurement of these is needed in future work to better understand the impact of interventions on all aspects of physical activity.

CONCLUSION

This behavior change intervention supported women over 50 who were active to be more active. High acceptability and feasibility of the *Active Women over 50 Online* program was demonstrated, and the impact on increasing daily steps warrant further testing in a larger trial. Further work is needed to better understand the motivators for people who are physically inactive to better reach and support them for healthy aging.

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Compliance with Ethical Standards

Primary Data: The analysis plan was not formally pre-registered. De-identified data, materials used to conduct the study, and the analytic code used to conduct the analyses are not available in a public archive. They may be available by emailing the corresponding author.

Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors. The trial received ethical and governance approvals from The University of Sydney Human Research Ethics Committee (2019/075), Sydney, Australia.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Trial registration:

The trial was prospectively registered with the Australian and New Zealand Clinical Trials Registry (Number ACTRN12619000490178, registered 26 March 2019).

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CHAPTER 8. Discussion and Conclusion.

8.1 Authorship contribution statement

As primary supervisor, I confirm that Geraldine Kit-Bing Wallbank authored Chapter 8, Discussion. Critical feedback was provided from supervisors Professor Anne Tiedemann, Professor Cathie Sherrington and Associate Professor Anne Grunseit.

Professor Anne Tiedemann

20 August 2025

Geraldine Wallbank

20 August 2025

8.2. Overview

The overall aim of this thesis was to investigate strategies for improving physical activity participation among mid-aged women for promoting health, wellbeing and independence in older age. This thesis used research methodology to:

1. Examine the current evidence for remotely delivered interventions to support choice-based physical activity (**Chapter Two**),
2. Design and evaluate the effect on physical activity of a 'low dose' physical activity support intervention among employed women aged 50 years and over (**Chapters Three and Four**),
3. Evaluate the perspectives of women aged 50 years and over in designing a physical activity intervention (**Chapter Five**),
4. Design and evaluate the effect on physical activity participation of a remotely delivered intervention to support choice-based physical activity among community-dwelling women aged 50 years and over across New South Wales (NSW), Australia (**Chapters Six and Seven**).

8.3. Principal findings

Given the scale of the problems of physical inactivity (1) and chronic disease (2, 3) in an ageing population (4), it is essential that strategies for addressing these challenges are delivered in a sustainable way (5, 6). Remotely delivered strategies offer simplicity and efficiency, but the applicability to mid-aged women was unknown. A review of the literature presented in **Chapter Two** investigated the features and effectiveness of remotely delivered physical activity interventions for supporting choice-based physical activity. The review found a moderate volume of fair to low quality evidence for interventions of this type, and it highlighted the scarcity of evidence specifically targeting

women in their mid-age years in this field. Of the identified studies, interventions typically included multiple delivery platforms or strategies, with content provided either in a scheduled format (e.g., email messages) or made available for participants to access 'on-demand'. On-demand strategies which included 'real-time' interaction (e.g. pedometer, online groups) trended to improve physical activity. No other trends regarding intervention content, study design, participant characteristics were identified. The review found a need for more evidence about the impact of multi-strategy choice-based physical activity interventions that specifically targeted community-dwelling women aged 50 years and over and where low baseline physical activity was an eligibility criterion.

To address the problems of physical inactivity and chronic disease in an ageing population, rigorously tested interventions are essential (7). **Chapter Three** presented the study protocol for a prospectively registered randomised waitlist-controlled trial of a 'low dose' *Active Women over 50* physical activity support intervention. The study documented the methodology for testing the intervention and included the template for intervention description and replication (TIDieR) checklist (8). The population was employed women aged 50 years and over who were insufficiently physically inactive. The workplace setting was chosen due to the high amount of time spent at work in sedentary time (9, 10), the possible time trade-off between working and physical activity (11), the possible benefits that being physically active may have on worker wellbeing (11, 12) and the need to incorporate physical activity into multiple settings including the work environment (1).

The intervention was underpinned by behaviour change science and included a range of discrete strategies which could be delivered using readily available resources with minimal technology. The strategies were presented together as a package from which

participants could select their preferred support strategies. The intervention included 1) an information session held near the workplace; 2) a handbook of physical activity resources; 3) motivational video case study stories of women aged 50 years and over who had overcome challenges to become physically active; 4) fortnightly motivational messages delivered by email over 3 months; 5) an online 'Yammer' participant discussion group for sharing physical activity information and inspiration, 6) loan of a Fitbit activity tracker to monitor daily step count. The comparator was a waitlist control group who received the intervention after 3 months. Primary outcome was proportion of women achieving ≥10,000 daily steps, device-measured at 3-month follow-up. Secondary outcomes were the proportion of people achieving national guideline-recommended physical activity levels, self-reported hours of weekly physical activity, perceived benefits of and barriers to exercise participation, physical functioning, and mood. The intervention group gave program feedback at follow-up.

The results of this 'proof-of-concept' randomised wait list-controlled trial testing the effect of the low-dose *Active Women over 50* physical activity support intervention on physical activity participation were presented in **Chapter Four**. One hundred and twenty-six physically inactive employed women in Sydney, Australia participated in the trial. The PEDro Score assessing risk of bias in this randomised controlled trial, downloaded from the PEDro database (https://www.pedro.org.au/), was 7 out of 10. This score represents 'good' methodological quality (13), losing 1-point for 20% participant attrition, from a maximum score of 8/10 for a physical activity trial due to two ineligible items that assess participant and therapist blinding.

This randomised wait list-controlled trial showed a trend of increased daily steps following this well-received, simple, low-intensity intervention. At follow-up, all intervention participants had investigated or adopted one or more of the suggested intervention strategies and had made physical activity plans for the next 6 months. Thirty-one intervention participants (58%) adopted technology to support their physical activity (e.g. activity trackers, website resources, mobile phone applications, study email messages to support their physical activity), 39 (74%) set physical activity goals, of which 35 people (90%) partially or fully achieved them. Intervention participants took 510 more steps/day (95% CI -69.9 to 1090, p = 0.08). No statistically significant between-group differences at follow-up on primary and secondary outcomes were detected. It was concluded that a more intensive intervention perhaps using technology with greater follow-up support was likely needed to impact physical activity and health outcomes in this population.

Understanding the target population for which an intervention is intended is crucial to ensure its relevance and effectiveness (14). The qualitative study presented in **Chapter Five** aimed to understand the perspectives of women aged 50 years and over in relation to physical activity in general, their experiences of the *Active Women over 50* physical activity program and their recommendations for future programs. The study found that an interplay of several factors shaped participants' capacity to be active. Physical activity and program participation was affected by personal, life-stage, cultural factors and the tension between those factors and a self-responsibility discourse. Social support and finding a suitable strategy for generating and sustaining motivation were deemed integral to being active. The study concluded that future programs could facilitate social networks, accountability, an integrative approach and positive framing to support women's agency in being active.

Chapter Three, Chapter Four and the qualitative evaluation in Chapter Five were the foundation for further refining a remotely delivered behaviour change intervention. This intervention incorporated tailored input and supported choice-based physical activity and was framed to empower women aged 50 years and over. **Chapter Six** presented the study protocol for a prospectively registered pilot randomised controlled study and included the template for intervention description and replication (TIDieR) checklist (8). The aim was to test the acceptability and feasibility of the online *Active Women over 50* intervention to support choice-based physical activity. The population was broadened from the preceding trial to community-dwelling physically inactive women aged 50 years and over across NSW, Australia. The online intervention required access to a telephone and an internet-connected device and included 1) telephone health coaching; 2) website with information, resources and stories from peers as sources of inspiration; 3) choice of receiving motivational messages via email or SMS messages. Self-determination theory(15) and the Behaviour Change Wheel and COM-B system model of behaviour (16) were used to understand factors related to initiating and maintaining physical activity. These factors were operationalised using behaviour change techniques that were embedded in the content of each of the intervention strategies (17). Input from end-users ensured the content was relevant and appropriate. The comparator was a waitlist control group who received the intervention after 6 months. The primary outcome was a global measure of acceptability, the proportion of participants at 3 months post-randomisation who would recommend participation in the program to another person like themselves. Secondary outcomes were 1) feasibility measures (rates of recruitment, retention, completeness of outcome data and uptake of telephone support); 2) intervention impact measures (accelerometer-assessed average steps/day, proportion of participants meeting national guidelines on moderate to vigorous physical activity; and questionnaire-assessed quality of

life, exercise perceptions, mood, physical functioning and self-reported physical activity); and 3) intervention participant impressions of the intervention and adoption of strategies for physical activity participation.

The *Active Women over 50* online intervention was tested in a pilot randomised waitlist-controlled trial, with results presented in **Chapter Seven**. The PEDro Score assessing risk of bias in this randomised controlled trial, downloaded from the PEDro database (https://www.pedro.org.au/), was 8 out of 10, from a maximum score of 8/10 for a physical activity trial due to two ineligible items that assess participant and therapist blinding, representing 'high' methodological quality (13). Sixty-two participants were on average 59 (±7.1) years old, metropolitan-living (84%), had two or more medical conditions (92%), and took 7459 (±2424) daily steps at baseline.

Global acceptability was high, with 83% of participants reporting that they would recommend study participation to others. Intervention acceptability was met, with over 80% uptake of each intervention strategy achieved. The relatively fast recruitment and high retention rates (14.5 weeks for 62 participants, and 96% respectively), as well as the high uptake of each intervention strategy reflected a sample of participants who were motivated to receive support for physical activity.

Study processes and intervention delivery were found to be feasible. The telephone health coaching session was delivered a median of 6 days from the invitation for a median duration of 41 minutes. The trial found a potential impact on physical activity for the proportion of intervention participants increasing daily steps by 2,000 or more relative to

baseline compared with control (OR: 6.31, 95% CI 1.22 to 32.70, p = 0.028). Intervention participants also tended to do more light-intensity physical activity (p = 0.075) and weekly moderate-vigorous physical activity by at least 120 minutes (p = 0.11) compared to the control following the intervention.

The study highlighted that a remotely delivered intervention was acceptable to mid-aged women across NSW, Australia, was feasible to deliver, and that mid-aged women in NSW, Australia, were receptive to receiving support for becoming more physically active. The findings warranted further testing in a fully powered trial.

8.4. Implications for practice

8.4.1 Prioritise interventions that make it easier for mid-aged women to choose a physically active lifestyle.

8.4.1.1 Accessibility enhances autonomy.

Given the complexities of their life stage responsibilities, mid-aged women need accessible supports that help them engage with and maintain physical activity amid their often-changing circumstances. Interventions that are remotely delivered enable midlife-aged women to choose when they access the support, and from where they access the support for physical activity. Accessible support aligns with the principle of offering women choice which enhances autonomy. As emphasised by Self-Determination Theory (15), this fosters intrinsic motivation, empowerment and a stronger sense of agency.

8.4.1.2 Resource-efficiency and inclusivity.

Accessibility and sustainability are important practical considerations in program planning. Support can be delivered without requiring high-cost or high-dose resources. Resources with minimal, readily available technology requirements ensure access for all population groups. When inherent costs for participation are minimised, more people, including those from low socio-economic backgrounds, may be more willing to consider, and to participate, and to remain in a program. Minimising participant expense broadens the program's reach, enhances inclusion of diverse population groups, and increases overall population impact. Additionally, programs with low inherent costs may be positively regard by the public as authentically concerned with promoting health, rather with any alternative motives (18).

8.4.1.3 Flexibility is central.

Flexibility allows people to adapt choices to suit their needs, preferences and circumstances. This can enhance autonomy and control, overcome barriers and improve engagement. Programs can offer women flexible options for receiving physical activity support by providing a range of strategies to choose from. These may include scheduled elements (e.g., email messages), on-demand resources (e.g., a website), 'real-time' interactions (e.g., an online group), and personalised support such as health coaching – each appealing to different preferences and needs.

Programs can also provide women with the flexibility to choose their preferred type of physical activity rather than a prescribed one that may not suit different abilities or schedules or interests. Emphasising choice and enjoyment in physical activity increases motivation, participation, the likelihood of habit formation, and long-term adherence. A

variety of physical activity options such as structured activities (e.g., sports, exercise classes), unstructured activities (e.g., cycling, walking) and suggestions for low-cost and free options can be presented to women to enable them to choose the activities that best suit their circumstances.

8.4.2 Include the three key features that support physical activity among mid-aged women.

This thesis identified three key intervention features for supporting mid-aged women to be more physically active: flexibility, accountability, and social support. Flexibility of an intervention as described above, supports autonomy and motivation by enabling women to align the support they receive and activities they engage in with their situation.

Accountability for physical activity refers to the sense of responsibility to be active when one is answerable to another person or supported by a structured system. Programmatically, this could be a health coach, strategies for accountability to a significant other, or self-accountability through tracking physical activity using a chart or wearable activity tracker.

Social support plays an important role in being physically active and staying physically active. Enjoyment and satisfaction is greater when being physically active with friends (19) and exercising in group settings (20), and this connection with others provides social support, motivation and may influence exercise adherence. Strategies for harnessing one's own existing social networks to support being physically active and facilitated online platforms have the potential to socially connect women who have a shared purpose of being more physically active.

8.4.3 Empower mid-aged women to be physically active through program framing.

This thesis highlights that being physically active can be complex for mid-aged women as there is an interplay of factors that can influence their capacity to regularly participate. Women may view contextual challenges such as health conditions (21, 22), lack of time (23), carer responsibilities (24, 25), attitudes towards older people (26) or different body shapes (27, 28) as personal shortcomings, even though these factors can often be outside their control. These can lead to a sense of personal failure for not being sufficiently active and can result in a cycle of physical inactivity (29, 30). Interventions that adopt positive program framing which emphasises responsibility and avoids self-blame is essential for supporting women to be more active. By emphasising the health benefits of being physically active and providing support to set realistic goals, women may have opportunities to experience success, be empowered and motivated to increase their physical activity and be supported to form long-term physical activity habits.

8.4.4 Consider the role of health professionals in promoting physical activity.

This thesis highlights that women in midlife represent an untapped group eager to maintain health as they age, and a group who is willing to receive support to be more physically active. Health professionals such as general practitioners, physiotherapists, exercise physiologists are the first point of contact for individuals seeking healthcare and are well-placed to support people in adopting healthier lifestyles to reduce the risk of chronic disease.

However, health professionals report that constraints on their clinical time and a lack of access to quality resources (31) makes it difficult to promote physical activity in addition to treating health conditions. If found effective in a fully powered trial, the *Active Women over 50* program could be a resource that health professionals can recommend for empowering women in midlife to be more active, and in the longer-term helping to reduce the burden on health services.

8.4.5 Widen the appeal for support through an integrative approach to physical activity.

Life complexities described by participants in Chapter Five could be in part addressed through physical activity interventions taking an integrative approach. By incorporating various health topics in an intervention, physical activity could be recognised as more relevant, and women may be more willing to embed physical activity into their lives. Taking an integrative approach could also appeal to a wider range of women who might not typically seek support for physical activity.

8.5. Implications for future practice, research and policy

This thesis has implications for the WHO Global Action Plan on Physical Activity objective 'creating active people' (32). Specific implications include shaping future practice, research and policy aimed at promoting physical activity participation among mid-aged women.

8.5.1 Build partnerships that advocate for mid-aged women.

Programs could advocate for mid-aged women to help address barriers and improve access to physical activity opportunities. By partnering across sectors that influence physical activity (e.g. health facilities and local councils), resource-efficient suggestions

could be incorporated into a scaled program. Examples are organising a group visit to a local health facility, or the provision of vouchers to trial physical activity opportunities.

8.5.2 Identify research and policy priorities.

The 2025 initiative by the Australian Government to invest $573m in a women's health package, which includes funding for menopause health assessments and contraception, is a promising step towards prioritising accessible healthcare for women (33). This thesis emphasises the importance of building on such preventive care initiatives by advocating for policies that prioritise practical, targeted solutions to address physical inactivity among women in midlife. The ultimate goal of future policies would be to prevent future health conditions and minimise the demands on healthcare services.

Engagement with stakeholders must convey that solutions for promoting physical activity in mid-aged women need not be resource-intensive, but they do need to be tested for effectiveness and implemented at a population level. Physical activity support strategies, programs and resources need to be developed and widely implemented to engage individuals, health professionals and communities.

8.5.3 Deliver physical activity support where it's needed most.

The World Health Organization emphasises universal and equitable health care in its commitment to Universal Health Coverage (UHC), ensuring everyone receives necessary health services without suffering financial hardship (34). Australia performs well with UHC at a primary health level (35), providing low-cost services to all citizens and permanent residents.

However, some populations in Australia still face challenges to accessing health services. For example, people from culturally and linguistically diverse backgrounds, indigenous populations, living in rural and remote areas, and those with socioeconomic disadvantage (36). Multiple complex reasons contribute to the disparities experienced by each group in seeking, reaching and receiving healthcare (37). These reasons include low health literacy, language barriers, sociocultural factors, provider's behaviours and communication, health workforce management, models of care, and evidence use in planning and monitoring (36).

It was beyond the scope of this thesis to explore strategies for all population groups, therefore future research is needed to address the needs and preferences of specific population groups. Physical activity interventions must be designed with a clear understanding of the needs and preferences of these populations, which requires consultation with both program users and those involved in delivery to ensure its relevance and impact (37-40).

8.5.4 Demonstrate cost effectiveness of remotely delivered physical activity interventions.

Physical activity has been described as the 'best buy in public health' due to its wide-ranging benefits (41). Although public health interventions can save costs (42), allocating health budgets to both prevention and the treatment of illness remains a persistent challenge (43). There is limited evidence on the cost-effectiveness of physical activity programs (44), and even less evidence for promotion-focused programs, particularly those targeting adults in midlife (45, 46).

It is crucial to collect economic evidence on effective remotely delivered physical activity promotion interventions, including their impact on health service usage and the costs of program delivery (44). This evidence is essential to inform policies that support the investment in these interventions (43, 47) and to help ensure that limited resources are targeted towards those who would benefit most.

8.5.5 Consider implementation and scale-up.

This thesis has examined evidence-based strategies for promoting physical activity participation in midlife women. However, formative evaluation and effectiveness testing is one of many steps toward improving health at a population level (48). Future work is needed to identify strategies to promote the uptake and integration of effective programs into real-world settings (49, 50), and to expand their reach into broader practice and policies to achieve population-level impact (51). Implementation requires the involvement of multiple stakeholders such as community groups, funding bodies, policy makers, and professionals who are responsible for delivering the program and ongoing support, so that programs can be sustained. Stakeholder groups have their own constraints and priorities, so a consultation process is crucial to enable them to partner alongside the research system to embed programs into real-world settings (52).

8.6 Methodological strengths and limitations

8.6.1 Strengths

The overall strength of this research was the rigorous methodology used to test the interventions. By employing the 'gold standard' prospectively randomised controlled trial study design and incorporating a waitlist control group, the studies aimed to minimise bias and strengthen the internal validity of the findings so that differences between groups

could be confidently attributed to the intervention. Additionally, device-measured physical activity outcomes were used to minimise measurement biases and the trials presented in Chapter Four and Chapter Seven achieved a PEDro score (https://www.pedro.org.au/) of 7/10 and 8/10 indicating high methodological quality (13).

Another strength of the research was the rigorous yet pragmatic design of the interventions. Behaviour change theory and frameworks underpinned the intervention content which was delivered with an emphasis on efficiency and scalability. The intervention also drew on widely available resources with low technology requirements that could be easily adapted to a range of settings and would potentially expedite future implementation. Additionally, interventions in this research were designed with qualitative views and experiences of midlife women (Chapter 5) which enhanced the relevance and potential uptake within the intended population.

8.6.2 Limitations

There were some general limitations of this research. Firstly, it was difficult to reach participants with low physical activity levels, those most in need of physical activity support, which is a limitation common to many studies in this field. Self-reported low physical activity was a pragmatic decision due to limited resources for the inclusion criterion, yet baseline device-measured physical activity often revealed physical activity levels that met the physical activity guidelines. In future, additional resources would need to be allocated to ensure the intended population is included, such as through individual interview procedures that verified eligibility or by implementing a recruitment strategy that targeted sedentary or low physical activity settings (e.g., craft groups, book clubs).

Secondly, the intervention required participants to have internet access and proficiency in English to engage with the program, which excluded those who could benefit from the intervention but did not have regular internet access or who had culturally and linguistically diverse backgrounds. However, physical activity research among the midlife women is formative and this limitation raises the opportunity to adapt or co-design the intervention in future work.

Another limitation of the research was the short duration of the interventions tested. Whilst there were encouraging results, the impact on the maintenance of physical activity and other health-related outcomes is unknown. Future studies could include a follow-up physical activity measurement timepoint for maintenance.

Finally, although the use of device-measured physical activity outcomes helps address self-report bias, this approach also has limitations and may not provide a fully accurate picture of physical activity. Participants may increase their physical activity simply because they are aware of being monitored (the Hawthorne effect), and the Actigraph devices that were used are limited to detecting land-based physical activity, thereby potentially underestimating total physical activity.

8.7 Conclusion

Physical inactivity and an ageing population contribute to rising chronic disease and disability worldwide, highlighting the need for scalable solutions to increase physical activity before reaching older age. The mid-aged years represent a critical window for

promoting and supporting physical activity behaviour change especially among women, and for addressing this broader public health challenge.

New and rigorously tested formative work presented in this thesis contributes to establishing efficient solutions for the problem of physical inactivity among midlife women. The strategies outlined were theory-informed, designed with user-input, inclusive, and had flexibility at their core. The intervention that was developed, established that a remotely delivered, choice-based physical activity intervention was acceptable and feasible among mid-aged women across NSW Australia. This thesis offers clear recommendations for future research, inter-sectoral partnerships, policy development, and applicability to underserved populations.

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