# Mini trampoline jumping as an exercise intervention to improve female specific health risk factors and functional fitness in postmenopausal women

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# Abstract

Women have increased risk of functional disability compared to men, including osteoporosis and urinary incontinence. Mini trampoline jumping is a low-impact multi-component exercise that could improve functional fitness and female-specific health risk factors. Therefore, the presented research examined the 1) benefits of a 12-week mini trampoline exercise intervention on female-specific health risk factors and functional fitness; 2) women's perceptions on efficacy of said intervention, and 3) muscle activity and metabolic responses to mini trampoline exercise in postmenopausal women. Thirty-seven postmenopausal healthy women (N=8 control, N=29 intervention; Age: 58.9 y ± 5.8; BMI: 28.64 kg/m$^2$ ± 6.31) participated in the exercise intervention study. The 12-week exercise programme included three 40-min sessions per week. Female-specific health risk factors (i.e., bone health, pelvic floor muscle functioning, urinary incontinence) and functional fitness (i.e., aerobic fitness, walking speed, lower extremity strength, flexibility, balance) were assessed pre- and post-intervention, and at a 3-month follow-up session. Women maintained pelvic floor muscle functioning (1% increase; p=0.31) and improved urinary incontinence symptoms (SUI score: 21% decline; p=0.01) following the intervention, compared to the control group who saw a decline of these measures (PFM functioning: 45% decrease; SUI score: 7% decline). Women significantly improved calcaneal bone mineral density following the intervention (8% increase; p=0.02); however, these improvements declined (4%) again at 3-month follow-up. Resting heart rate (8%; p=0.04) and dynamic balance (14%; p=0.01) significantly improved post-intervention. Aerobic fitness (12% increase; p<0.01), average walking speed (7% increase; p=0.01), flexibility (15% increase; p<0.01), and lower extremity strength (20% increase; p<0.01) also improved following the intervention; these benefits remained after three months. A 13-question open-ended anonymous survey examined participant perceptions after the exercise intervention. Intervention adherence rate was high with participants highlighting the social aspect of group exercise and short durations of exercise sessions. Most women would consider taking part in a mini trampoline exercise programme outside of this study. In a separate cross-sectional study, skeletal muscle activity, cardiovascular and metabolic responses for mini trampoline exercises were compared to more commonly prescribed exercises of walking and home-based strength exercises. Seventeen women (Age = 59.6 y ± 3.92; BMI= 25.5 kg/$m^2$ ± 3.8) performed 5-min of walking, home-based exercises, and trampoline exercises; 10-min rest periods occurred between trials. Metabolic responses were higher for mini trampoline and home-based exercises compared to walking. Mini trampoline elicited higher oxygen consumption (7% gain; $p=0.01$) and RER response (3% gain; $p<0.01$) compared to home-based exercises. In summary, mini trampoline exercises provide a novel and enjoyable form of exercise for postmenopausal women to improve female-specific health, functional fitness, and metabolic health.

# Preface

After completing my Master's degree I approached Dr Sarah Shultz to discuss potential projects to pursue my PhD. Dr Sarah Shultz mentioned a project to examine the mechanical implications of mini trampoline exercises in overweight and obese children, which she had developed with Dr Philip Fink. However, my research interests were more aligned with improving the health of the older population and I was particularly interested in an intervention study. After initial discussion with Dr Sarah Shultz, we agreed that an exercise intervention using mini trampolines in an older population had the potential to be an innovative and successful research project.

After an extensive Review of Literature, it became clear that there was a lack of examination of mini trampoline exercises in a female population, particularly postmenopausal women. Guided by discussions and debates with my supervisory team Dr Sarah Shultz, Dr Philip Fink, Dr. Sally Lark, and Dr Toby Mündel, I developed the eventual study design. The methodology manuscript was written and published in advance (see Appendix H) of experimentation to gain reviewer feedback. However, the chapter was re-written in places to reflect the past tense nature of writing of the thesis and re-ordering of a priori aims to reflect the emphasis on postmenopausal female health issues that were discovered as the study progressed.

With initial contact and help from Dr Sarah Shultz, I was able to present the research proposal as Guest Speaker at the Hutt Rotary, to raise awareness of this research project and help with recruitment. I was fully involved in all aspects of the experimental design, did all the recruitment, the exercise intervention, and data collection. I learned how to use new equipment including the quantitative ultrasound and force-plate. All data management, statistical analysis and interpretation were concluded by myself, with guidance from my supervisory team, particularly Dr Philip Fink, who had also instructed me how to use new software such as MATLAB for processing the balance data and SAS for data analysis. All written interpretation and discussion of results is my own work with guidance from my supervisory team.

This PhD journey certainly presented itself with numerous unexpected challenges. First, there was the closure of the sport and exercise department at Massey University in Wellington, resulting in me losing a room to do any further testing and exercise classes. Secondly, there was COVID-19, which not only brought its own mental challenges for me personally but also resulted in being unable to conduct any further research projects in the foreseeable future. Having no room availability and general uncertainty regarding the future of human research had initially put a stop to my research project. I am glad and relieved that I had a supportive supervisory team helping throughout these times. However, this supervisory team also saw some changes (partially due to the campus closure at Massey University in Wellington) with my primary supervisor changing three times in this process (the role taken on by Professor David Rowlands), and the initial supervisors moving to different universities and different countries and time zones, making for some challenging meeting times.

Nonetheless this research project has so far resulted in 5 publications in scientific journals with 2 more manuscripts currently in review. Therefore, the thesis is set out as a series of individual chapters, each with their own reference list. Furthermore, part of this research was mentioned and highlighted in a recent article in the New York Times titled "Bouncing your way to better health" published on the 11th November 2022, for which Dr. Sarah Shultz and myself took part in separate interviews.

Anja Fricke

# Acknowledgements

There are many acknowledgements that need to be made, as the completion of this thesis would not have been possible without the support of the following people.

I first want to thank all my wonderful participants without whom this research would have been impossible. I had the opportunity to work with an amazing group of women, who were all incredibly dedicated, reliable, and so hard working throughout this intervention. Each of the women committed to this research project, despite what was going on in their own work or personal lives. No exercise session or assessment was ever boring with these fantastic women. We shared so many laughs, sweat and even a tear here and there. My appreciation for these women has no ends!

I also want to acknowledge my amazing team of supervisors: Prof. Sarah Shultz, Dr. Philip Fink, Dr. Sally Lark, Assoc. Prof. Toby Mündel, and Prof. David Rowlands. Despite living in three different time zones particularly during my last year, they have all done a fantastic job helping me get across the finish line through sharing of experience, ongoing guidance, advice, encouragement and patience, as well as providing some fun late night or very early zoom meetings as we lived across in three different time zones. I particularly want to thank my primary supervisors, Sarah, Phil, and David for always making the time when I needed advice and help, particularly when things didn't go according to plan, as well as revising seemingly countless iterations of my work. I want to thank Sarah for helping my professional as well as personal growth from my undergrad degree and throughout my PhD. Sarah has helped me to realise my full potential, she has helped me get through the highs and lows and has been incredibly supportive and helpful throughout this entire journey. Without Sarah, I would most likely not have embarked on this journey. I want to thank Phil and David for their guidance and help throughout this PhD journey. Both have helped get through the scary world of statistics and their extensive knowledge has taught me more than I thought was possible!

I would like to thank Dr. Erica Rauff for the countless zoom meetings and introducing me to the world of qualitative research. Erica helped me guide through the qualitative research manuscript and has taught me the importance of qualitative research. A special mention also goes to Stacey Kung and Mostafa Yaghoubi for helping me with the set-up of equipment and software as well as providing guidance and experience with data processing. I would also like to thank Sam Dickie and Liz Castle from the Hutt City Council who helped organise and provide a free room for the exercise intervention at the Petone library – which enabled 12 more women to participate in this study.

The demands of the PhD life not only test you academically, but also mentally and emotionally, so I want to thank my fellow PhD students for being there to share their struggles and being an amazing support group, both on and off campus. I particularly want to thank Stacey Kung who supported me through all the highs and particularly the lows. Additionally, I would like to thank my family and friends, Tina and Max, Torsten and Ines, and Joana for their support, encouragement, and especially patience. In particular I would like to thank my sister Tina who also provided me with plenty of distraction and entertainment during the endless Covid-19 lockdowns here in the UK. A special mention also goes out to my husband Dean and my friend Kalima who both had to first-hand experience my frustrations and exhaustions at times, and who both helped me get through those times.

Finally, I would like to thank Massey University for awarding me a doctoral scholarship to complete this degree, funding this project, providing me with valuable teaching and mentoring work experience, and for the additional financial support to help attend my first (virtual) international conference.

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# List of abbreviations

| | |
|---|---|
| ANOVA | Analysis of variance |
| BMD | Bone mineral density |
| BMI | Body mass index |
| BP | Blood pressure |
| bpm | Beats per minute |
| cm | Centimetres |
| EMG | Electromyography |
| HR | Heart rate |
| HRmax | Maximum heart rate |
| Hz | Hertz |
| ICC | Intraclass correlation coefficient |
| kg | Kilogram |
| kph | Kilometres per hour |
| m | Meters |
| MVC | Maximal voluntary contraction |
| PAR-Q | Physical activity readiness questionnaire |
| RMS | Root mean square |
| SD | Standard deviation |
| sec | Seconds |
| SUI | Stress urinary incontinence |
| UUI | Urgency urinary incontinence |
| y | Years |

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# Chapter 1

## Why study health in postmenopausal women?

The health status of women is a major public health concern, mainly because the number of older women is increasing all over the world (Bergland & Engedal, 2011). Furthermore, women tend to outlive men and it is not uncommon for older adults to live without their children (Bergland & Engedal, 2011). Functional ability is a key factor for older middle-aged individuals to maintain an independent lifestyle and participate in family and community activities (Christensen, Støvring, Schultz-Larsen, Schroll, & Avlund, 2006). Components of functional ability include being able to rise from a seated to standing position, walk at fast speeds safely enough to cross a road, step onto or avoid raised objects, and maintain an upright posture (Peeters, Dobson, Deeg, & Brown, 2013). These components all require sufficient muscle strength, mass, power, and endurance (Dewhurst, Nelson, Dougall, & Bampouras, 2014) and any deficits can limit mobility and activity, especially for women (Matsouka, Harahousou, Kabitsis, & Trigonis, 2003). Aging increases the prevalence of osteoporosis and decreases in muscle mass, which are most likely to occur during the peri-menopausal and postmenopausal period (approximately 50 years of age) (Shariati-Sarabi, Rezaie, Milani, Rezaie, & Rezaie, 2018). Menopause is known to have the single greatest effect on overall bone mass loss and osteoporosis, a disease marked by low bone mass and deterioration of bone tissue, which affects four times as many women as men (McGarry & Kiel, 2000). Importantly, decreased bone mass significantly increases the risk of fractures, disability, and chronic pain (MacLean et al., 2008).

Older women are also more likely to develop conditions such as urinary incontinence, which also decrease the ability to perform activities of daily living (Weiss, 1998). Stress urinary incontinence is the most prevalent form of urinary incontinence (Weiss, 1998) and is defined as an involuntary loss of urine that commonly occurs during some form of physical exertion and effort or during sneezing and coughing (Norton & Brubaker, 2006). When bladder pressure exceeds the urethral pressure during the sudden increase of intra-abdominal forces, the pelvic floor musculature is unable to compensate for the increased pressure, resulting in involuntary loss of urine (Norton & Brubaker, 2006). Urinary incontinence can lead to serious medical conditions like urinary tract infections and perineal rash. However, there are also social implications due to embarrassment and subsequently reducing social interactions and physical activity (Bø, 2004a). The pelvic floor musculature commonly weakens with older age due to sarcopenia, childbirth trauma, and menopause, although the full effects of menopause and loss of pelvic floor muscle are not yet clearly understood (Seshan, AlKhasawneh, & Al Hashmi, 2016).

Several studies have shown that sedentary adults are at greater risk of functional decline compared to adults who exercise regularly, and exercise programmes at any age are highly recommended to reduce the effects of functional decline (Christensen et al., 2006; Clark, 1996; Distefano & Goodpaster, 2018; Gianoudis, Bailey, & Daly, 2015; Song et al., 2015). Physical activity is considered to be the most important factor in promoting health and quality of life in the later years of life (Christensen et al., 2006). Regular physical activity can minimize the effects of the physiological decline that occurs during aging and improve overall pelvic floor muscle function, bone health, and physical functioning (Bø, 2004b; Norton & Brubaker, 2006; Seshan et al., 2016). Pelvic floor muscle strength, and urinary incontinence symptoms have been shown to improve through exercise interventions targeting the pelvic floor muscles in older women (Ferreira, Santos, Duarte, & Rodrigues, 2012; Kim, Yoshida, & Suzuki, 2011). Even exercise interventions that did not specifically target the pelvic floor muscles but instead produce co-contractions of pelvic floor muscles were able to improve pelvic floor muscle strength and urinary incontinence symptoms (Bø, 2004b). Bone mineral density in postmenopausal women can be maintained with exercises, although significant improvement of bone mineral density in postmenopausal women is difficult (Marques et al., 2011). Exercises do not need to be of high intensity to maintain bone health in sedentary, elderly women, thus highlighting the importance of exercise to maintain or even improve bone health (McGarry & Kiel, 2000).

Despite the well-known benefits of regular exercise, older adults often have difficulties adhering to exercise programmes (Moore, Holden, Foster, & Jinks, 2020; Tak Erwin, van Uffelen, Mai, van Mechelen, & Hopman-Rock, 2012). About 10-15% of older adults who start a structured exercise programme are known to drop out during the first 6 months, with the majority of relapses occurring during the first 3 months (Tak Erwin et al., 2012). Factors that can determine adherence to an exercise programme in older adults include motivators (which increase adherence) and barriers (which decrease adherence) (Forkan et al., 2006; Tak Erwin et al., 2012). The strongest motivators affecting exercise adherence in older women include enjoyment, duration of physical activity bout, appropriate setting, high level of self-efficacy, and programme tailoring (White, Randsdell, Vener, & Flohr, 2005). In particular, the duration of individual physical activity bouts and appropriate location were deemed critical to increase adherence to exercise programmes (White et al., 2005). Additionally, increased adherence in exercise programmes was found when women participated in multiple short bouts of exercise during the day. Furthermore, home-based and work-based programmes may be more convenient and thus increase the adherence rate in women (White et al., 2005). Adherence to exercise could be decreased by common barriers including insufficient time, lack of social support, lack of a facilities, lack of transportation to exercise, insufficient money, and lack of exercise experience (Forkan et al., 2006; Moore et al., 2020; Tak Erwin et al., 2012). Therefore, exercise programmes targeting older adult women should focus on strategies that allow women to overcome most of the previously mentioned barriers in order to increase their adherence to exercise.

Mini trampoline jumping, also known as rebounding, is a highly beneficial low-impact aerobic exercise capable of improving fitness and health. Rebounding exercises incorporate a multi-component approach, which affects many physical factors including strength, body stability, muscle coordinative responses, joint movement amplitudes and spatial integration (Aragão, Karamanidis, Vaz, & Arampatzis, 2011). Mini trampoline exercises have been shown to improve aerobic fitness, balance, muscle strength, postural control, (Aragão et al., 2011; Kidgell, Horvath, Jackson, & Seymour, 2007; McGlone, Kravitz, & Janot, 2002), as well as female specific health risk factors in young women

(Namboolu, Bunyaratavej, & Kritpet, 2012). No research so far has examined the effects of a mini trampoline exercise intervention on postmenopausal women's health. Specifically, no research so far has examined if mini trampoline exercise could improve pelvic floor muscle functioning and bone health in postmenopausal. Furthermore, the efficacy of a mini trampoline exercise intervention in postmenopausal women is still unknown.

## Aims

The primary aim of this thesis was to examine the potential benefits of a 12-week mini trampoline exercise programme in postmenopausal women on:

1) Female specific health risk factors, which include bone health, pelvic floor muscle functioning, and urinary incontinence.
2) Functional fitness, including physical endurance, walking speed, muscle strength, flexibility, and balance.

Secondary aims of this thesis were:

1) To study the mechanisms (muscle activity and energy expenditure) associated with some of the biomechanical and physiological benefits of mini trampoline jumping and compare these variables to other physical activities more commonly undertaken by postmenopausal women.
2) To examine the efficacy of mini trampoline exercise intervention and if there is interest and potential for similar mini trampoline exercises in the future.
3) Lastly, to investigate the benefits of mini trampoline exercise intervention on complications specific to a postmenopausal female patient with a stroke (case study).

## Structure of the thesis

Following this introductory chapter (**Chapter 1**), **Chapter 2** will provide an extensive literature review. The literature review also includes a summary of the systematic literature review which focused on exercise intervention to improve pelvic floor muscle functioning in older women experiencing urinary incontinence. The systematic literature review resulted in a published manuscript in the *Journal of Women's Health Physical Therapy* (see Appendix H). The following chapters (**Chapter 3-8**) have been prepared as a collection of manuscripts that have been submitted or are already published in refereed journals. **Chapter 4** has been published in the *International Journal of Preventative Medicine*, **Chapter 6 and Chapter 8** have been published in the *Journal of Women's Health Physical Therapy*, and **Chapter 7** has been accepted for publication in the Journal of Sport and Exercise Science. They consist of a methodology paper (**Chapter 4**), three original research articles (**Chapter 5-7**), and a case report (**Chapter 8**). **Chapter 4** lays out the methodology of the research project, the case report in **Chapter 8** addresses the two primary aims of the thesis and applies these to a specific cohort. **Chapter 5** addresses the first primary aim of the thesis (female specific benefits), **Chapter 6** addresses the second primary aim of the thesis (functional fitness), and **Chapter 7** addresses the secondary aim (intervention efficacy). The prepared manuscripts have been reformatted from their original form for consistency of style throughout the thesis, but the content generally remains the same unless otherwise specified in the footnote following the abstract at the beginning of each chapter. Since the chapters have been prepared as manuscripts suitable for publication in peer reviews journals, there may be some repetition throughout the thesis (particularly in the methodology).

**Chapter 2** presents a literature review. The review begins by establishing a rationale for examining and improving health in older women. The next section explains why women are at more risks of functional decline compared to men and the impact of menopause of women's health. Following sections provide information about existing exercise interventions to improve the functional decline of aging, particularly for female specific health risk factors as well as interventions to improve general physical functioning in older women. The final section establishes the rationale of why mini trampoline exercise was chosen as a novel exercise intervention for this research project.

**Chapter 4** presents the overall methodology of this research. The project itself consisted of a 12-week mini trampoline exercise intervention for postmenopausal women between the ages of 50-69 years old and included tests prior and post the intervention and a 3-months follow-up. A total of 37 women were recruited for this project and assigned to a control group (N=8) or an intervention group (N=29). The methodology paper set out the prioritised outcomes as physical fitness and the additional outcomes as female specific health risk factors; the prioritisation of these aims was reversed during the course of this intervention study. This paper addresses the implications of this research programme and illustrates that each decision made in the methodology of this intervention is based on previous research.

**Chapter 4** examined the differences in muscle activity and metabolic rates between mini trampoline exercise compared to home-based exercises and walking in postmenopausal women. **Chapter 5** examines the effects of the 12-week mini trampoline exercise intervention on the female specific health risk factors of bone health and urinary incontinence, while **Chapter 6** examines the effects of the intervention on functional fitness (cardiovascular fitness, aerobic fitness, gait, lower extremity strength, flexibility, and balance). The qualitative research report in **Chapter 7** identifies the overall efficacy of the exercise intervention. The positive outcomes recorded and discussed in the preceding chapters for functional fitness, clearly influenced the reported efficacy results. **Chapter 8** presents an interesting case report. The case report follows a woman who suffered a stroke seven years ago, which left her partially paralysed on the right side of her body. The woman fit all of the inclusion criteria set out for this intervention; however, she could not be included in the overall results due to her disability. Despite the partial paralysis, the participant was able to perform all the exercises and assessments, although sometimes with limitations. The results highlight the potential of mini trampoline exercises as a possible exercise intervention for women who experience partial paralysis.

The final chapter (**Chapter 9**) concludes the thesis and integrates findings from all research chapters, thus providing an overview of the benefits of a mini trampoline exercise intervention in postmenopausal women. In this chapter the limitations are considered, and suggestions for the direction of future research in this area are provided.

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# Chapter 2

## Review of literature

## Aging and physical function

Functional fitness is a key factor for older women to maintain an independent lifestyle and participate in family and community activities (Christensen, Støvring, Schultz-Larsen, Schroll, & Avlund, 2006). Components of functional fitness include being able to rise from a seated to standing position, walk at fast speeds safely enough to cross a road, step onto or avoid raised objects, and maintain an upright posture (Peeters, Dobson, Deeg, & Brown, 2013). Aging is associated with changes to the nervous, cardiovascular, skeletal, and muscular systems resulting in a decline of muscle strength, mass, power, and endurance, as well as cardiovascular fitness. These changes to the body can result in limited mobility and activity by affecting balance, gait, and flexibility and thus increasing the risks of not being able to live independently (Matsouka, Harahousou, Kabitsis, & Trigonis, 2003; Rice & Keogh, 2009). As women age, functions of the cardiovascular system tend to deteriorate with a reduced maximal cardiac output, reduced systolic volume, and reduced arteriovenous oxygen difference, which all contribute to early onset of fatigue and difficulty performing daily activities (Rodrigues-Krause et al., 2018). Cardiorespiratory fitness is a strong predictor of morbidity and mortality among older middle-aged adults (Dogra, Clarke, & Copeland, 2017). Muscular strength is also an important component to maintain quality of life in older age; however muscular strength is known to decline in aging women. Low muscle strength is considered to be a functional impairment and can have a mediating role in the pathway from disease to disability (Rantanen, Era, & Heikkinen, 1994). As age increases, the ability to produce force decreases (Bruce, Newton, & Woledge, 1989; Thompson et al., 2014). A decrease in muscle strength as commonly seen in older people is due to a loss of muscle mass rather than function (Frontera, Hughes, Lutz, & Evans, 1991; Larsson et al., 2019). Muscular weakness in the lower limbs of older adults can often lead to gait patterns that are associated with postural instability, which increases the risks of falls and a decreased quality of life (Correa, Cunha, Marques, Oliveira-Reischak, & Pinto, 2016). Flexibility also often decreases with age due to the changes in collagen quantity and integrity, decreased physical activity, and dietary deficits (Kulkarni & Fernandes, 2017). Loss of flexibility is commonly associated with difficulty of walking, difficulty to accomplish tasks in daily activities, lower back pain, postural deviations, gait limitations, and poor balance and mobility in older people (Klein, Stone, Phillips, Gangi, & Hartman, 2002). Loss of muscular strength and flexibility in older women can also lead to further loss of dynamic balance (Correa et al., 2016). Dynamic balance is equally important in maintaining quality of life in the elderly, as it is required during walking in order to maintain body movement. Poor dynamic balance can increase the risks of falls and reduce overall quality of life in older people (Balasubramanian, 2015).

## Female specific health risks

### Effects of Menopause

Menopause is defined as the permanent cessation of menstruation due to loss of ovarian follicular function (Greendale, Lee, & Arriola, 1999; Sherman, 2005). Menopause is characterised by hormonal changes, particularly by a decrease of oestrogen (Messier et al., 2011). The hormonal status in women, particularly the decline of oestrogen, can have several detrimental effects on women’s health (Messier et al., 2011). Postmenopausal women have been reported to experience severely lower quality of life than women of the same age who are still menstruating (Blumel et al., 2000; Ganapathy, T., & Al Furaikh, 2018). The decline of oestrogen during menopause has been linked to several symptoms and syndromes including hot flashes, urinary incontinence, reduced sexual function, depression, coronary heart disease, and osteoporosis (Greendale et al., 1999). Thus, menopause can cause both physical as well as psychological disorders (Blumel et al., 2000; Ganapathy, T., & Al Furaikh, 2018).

Age and menopause are considered the two main risk factors of developing primary osteoporosis. During the onset of perimenopause oestrogen concentrations decline rapidly, which shifts the balance of bone resorption and bone formation. As oestrogen concentrations decline, both bone resorption and formation increase, with resorption eventually exceeding formation and causing an acceleration of bone mineral loss (Drake, Clarke, & Lewiecki, 2015). Osteoclasts (responsible for bone resorption) have a longer lifespan than osteoblasts (responsible for bone formation). Bone mineral density is also lost as newly formed bone is less dense than old bone. Moreover, the loss of oestrogen causes osteoclasts to erode deeper in the bone, thereby removing some of the cancellous elements entirely. The longer lifespan of osteoclasts and the related deeper erosion of the bone, has been explained by a delay of osteoclasts apoptosis with decreased oestrogen levels (Drake et al., 2015).

The effects of menopause on urinary incontinence are still controversial, however. Some studies have reported associations between menopause and increased incidence of urinary incontinence, while other studies have not (Milsom, Ekelund, Molander, Arvidsson, & Areskoug, 1993; Rekers, Drogendijk, Valkenburg, & Riphagen, 1992; Milsom & Gyhagen, 2019). It is believed that menopause is responsible for atrophy of the bladder trigone and thinning of the urethral mucosa, which could contribute to urinary incontinence symptoms (Greendale et al., 1999; Hillard, 2010). Older studies examining the effects of hormonal replacement therapy of oestrogen found mixed results in the treatment of urinary incontinence. Some studies have reported a reduction of up to 50% in stress urinary incontinence with hormonal treatments (Hilton, Tweddell, & Mayne, 1990; Walter, Wolf, Barlebo, & Jensen, 1978); however, a different study showed no symptomatic benefit of oestrogen replacement for stress urinary incontinence (Fantl et al., 1996). Newer studies, including a systematic review, however indicate that hormone replacement therapy actually increases the risk of developing stress urinary incontinence (Quinn & Domoney, 2009; Steinauer et al., 2005).

Menopause-related conditions such as osteoporosis and urinary incontinence can have major impacts on overall well-being and quality of life. Patients who live with osteoporosis or urinary incontinence are more likely to have depression, reduced employment and work productivity, limited social and sexual function and may be dependent on caregivers (Khandelwal & Kistler, 2013; Nygaard, Turvey, Burns, Crischilles, & Wallace, 2003; Riemsma, Hagen, Kirschner-Hermanns, Norton, Wijk, Andersson, Chapple, Spinks, Wagg, & Hutt, 2017). Furthermore, osteoporosis and urinary incontinence are considered to be important factors for the elderly in the likelihood for admission to long term care and the associated loss of independence and poorer quality of life (Kim, Suzuki, Yoshida, & Yoshida, 2007). Thus, prevention in the early stages of osteoporosis and urinary incontinence becomes increasingly important.

## Osteoporosis

Osteoporosis has been recognised as a major public health concern facing particularly postmenopausal women (Felson et al., 1993; McGarry & Kiel, 2000). As the aging population is increasing, so does the incidence of osteoporosis (Reginster & Burlet, 2006). It is estimated that around 200 million people worldwide are affected by osteoporosis and around 9 million fractures are a result of osteoporosis (Akkawi & Zmerly, 2018). The clinical complications of osteoporosis can have significant impact on quality of life and can lead to a loss of independence. Women diagnosed with osteoporosis are at higher risk of suffering fractures, disability, and chronic pain. Over half of women aged 50 years and older will have an osteoporotic fracture during their lifetime. Women are also four times more likely to be affected by osteoporosis than men, as the age-related decline in bone density is larger in women (De Laet, van Hout, Burger, Hofman, & Pols, 1997; McGarry & Kiel, 2000; Pietschmann, Rauner, Sipos & Kerschan-Schindl, 2009). Osteoporosis is commonly defined by a low bone mass (2.5 standard deviations below the mean for young healthy women) (Marshall, Johnell, & Wedel, 1996) and micro architectural deterioration of bone tissue, which can often lead to non-traumatic bone fractures especially at the spine (McGarry & Kiel, 2000; Riggs & Melton, 1995).

## Urinary incontinence

Urinary incontinence is defined by the International Continence Society (ICS) as a complaint of any involuntary urinary leakage (Norton & Brubaker, 2006). The World Health Organization (WHO) acknowledges incontinence as a set of diseases and the International Classification of Functionality recognizes the associated extreme disablement (Riemsma et al., 2017). The pelvic floor muscles are the main anatomical structures that control urinary incontinence. During contraction the levator ani muscle of the pelvic floor muscle structure pulls the vagina forward towards the pubic symphysis, thus creating a backstop for the urinary tract. A stable backdrop compresses the two walls of the urethra, preventing the leakage of urine (Ferreira, Santos, Duarte, & Rodrigues, 2012; Norton & Brubaker, 2006). Global demographic trends suggest that the incidence of urinary incontinence will rise in the coming years, adding a significant health and social burden as well as increased economic costs for patients and health service providers (Norton & Brubaker, 2006). It is estimated that more than 200 million people worldwide live with urinary incontinence, and women are more commonly affected than men (Khandelwal & Kistler, 2013; Norton & Brubaker, 2006). The yearly direct costs of urinary incontinence in the USA alone are US $16.3 billion, of which 75% are directed towards women living with this condition (Norton & Brubaker, 2006). The health issue is considered to be severe; yet half the people living with urinary incontinence do not discuss their problems with a health care professional or even family members or friends out of embarrassment (Dugan, Lavender, Hebert-Beirne, & Brubaker, 2013).

Stress urinary incontinence is considered to be the most common type of urinary incontinence in young as well as older women (Khandelwal & Kistler, 2013). Stress urinary incontinence is defined as an involuntary loss of urine during activities that increase the intra-abdominal pressure such as sneezing or coughing (Donahoe-Fillmore et al., 2011; Ferreira et al., 2012; Norton & Brubaker, 2006). If the pelvic floor is damaged, the muscles are unable to support the bladder neck during physical stress, resulting in leakage (Norton & Brubaker, 2006). It is thought that women undergo anatomical and neuromuscular changes and injury during childbirth, which causes a loss of pelvic floor musculature. However, some women may not experience incontinence until a small percentage of muscle strength at the pelvic floor muscle is lost due to the normal aging process and other injuries (Norton & Brubaker, 2006). The World Health Organization and ICS recommend pelvic floor muscle training to treat stress urinary incontinence in women. It is said that women undergoing pelvic floor muscle training are seven times more likely to be cured of stress urinary incontinence than those with no treatment (Norton & Brubaker, 2006).

## Improving health in middle-aged and older women

Regular physical activity and can minimise the physiological decline that occurs during aging and can improve overall pelvic floor muscle function, bone health, and functional fitness (Bø, 2004; Ciolac, 2013; Norton & Brubaker, 2006). Sedentary adults are known to be at larger risk of functional decline compared to adults who exercise regularly and exercise programmes at any age are highly recommended to reduce the effects of functional decline (Christensen, Støvring, Schultz-Larsen, Schroll, & Avlund, 2006; Clark, 1996; Distefano & Goodpaster, 2018; Gianoudis, Bailey, & Daly, 2015; Song et al., 2015). Physical activity is considered to be the most important factor in promoting health and quality of life in the later years of life (Christensen et al., 2006).

### Exercise interventions to improve functional fitness

Research to improve physical function in older women is extensive. While some research examined the effects of exercise interventions in older women for overall physical functioning, other studies focused specifically only on one functional fitness component such as aerobic fitness, strength, balance, or flexibility. It is important to target the components of functional fitness in exercise interventions, as all these components are highly associated with functional ability and independent living (Dewhurst, Nelson, Dougall, & Bampouras, 2014).

#### *Aerobic Fitness*

Aerobic fitness as well as resistance exercise programmes can improve cardiovascular function in older women. Water-based resistance training, as well as high intensity deep water running, have both improved aerobic fitness in older women (Broman, Quintana, Lindberg, Jansson, & Kaijser, 2006; Reichert et al., 2018). An 8-week high intensity deep water running training improved submaximal as well as maximal aerobic power in elderly women (Broman et al., 2006). Reichert et al. (2018) examined the effects of different training volumes in water resistance exercises and results showed both low-volume and high-volume exercises improved muscular endurance as well as aerobic fitness. Therefore, low impact exercises with low training volume might be ideal for the frailer population to improve cardiorespiratory fitness.

High impact exercises like Scottish dancing, step aerobics or paddle tennis have also shown improvements in aerobic fitness in older women (Courel-Ibáñez et al., 2018; Dewhurst et al., 2014; Hallage et al., 2010). A study by Dewhurst et al. (2014) compared aerobic fitness levels of female Scottish country dancers (mean age 68 years) with women who participate in a variety of different physical activities. Results indicated that Scottish dancers aged between 60-70 years had similar aerobic fitness as the physically active non-dancers of similar age. Older dancers between 70-80 years, however, did not differ in their aerobic performance compared to the younger dancers, while the non-dancers showed lower aerobic fitness when compared to their younger counterpart. Thus, it can be concluded that Scottish dancing might be more effective in maintaining aerobic fitness into an older age compared to regular exercise. Improved aerobic fitness was also found in regular paddle tennis players (mean age 41 years) compared to sedentary women with similar age. Paddle tennis is a sport using similar tennis rules and scoring system, but it is played inside a small synthetic glass and metal court, resulting in a faster game and increased frequency of actions (Courel-Ibáñez et al., 2018). Therefore, it was recommended that paddle tennis could improve aerobic fitness in middle-aged women (Courel-Ibáñez et al., 2018). Furthermore, the 12-week step aerobics exercise programme by Hallage et al. (2010) showed significant improvements in the 6-minute walk test in older women with a mean age of 64 years. The programme used a lower impact version of step aerobics, whereby one foot remains in contact with the floor or bench at all times. It is important to consider however, that all the three previous mentioned exercises were still of high impact and might not be suitable for some older women, particularly women who are diagnosed with osteoporosis and have an increased risk of injuries and falls.

### *Muscular strength*

An increase in physical activity is correlated with greater muscle strength and several exercise interventions have shown significant improvements in muscle strength in older women (Rantanen et al., 1994). Water-based exercises as well as home-based strength training which are of low impact and more suitable for older people have shown significant improvements in strength (Reichert et al., 2018;

Saeterbakken, Bårdstu, Brudeseth, & Andersen, 2018; Silva et al., 2018). Water-based resistance training programmes combining aerobic fitness and strength straining also found significant improvements in lower limb strength measures and quality of life in older women (Silva et al., 2018). Thus, exercises to improve muscular strength in older women do not need to include high impact exercises and can be of low volume to still elicit positive effects. However, research has highlighted the importance of continuing an exercise intervention. Women with a mean age of 65 years who participated in a 12-week strength training programme saw significant improvements in strength immediately after the intervention; however, strength levels returned to baseline values within a year of detraining (Correa et al., 2016). Thus, it is important to not only use effective exercise interventions, but also interventions that are fun and interesting to increase adherence to exercise even after the intervention is completed (Picorelli, Pereira, Pereira, Felício, & Sherrington, 2014).

### *Balance*

Various exercise interventions including paddle tennis, resistance training, and aerobic training have shown increased dynamic balance and improved postural sway, thus reducing the rate of falling in older women (Balasubramanian, 2015; Judge, Lindsey, Underwood, & Winsemius, 1993; Lord, Ward, Williams, & Strudwick, 1995). Exercise programmes that emphasised postural control, moderate resistance training, and walking improved dynamic balance more significantly than non-focused exercise intervention (Judge et al., 1993). It is therefore important that interventions to improve balance in older women should include balance-specific exercises to yield the best improvements in stability.

### *Flexibility*

Exercise interventions can improve or at least maintain flexibility in older women, and do not need to include specific flexibility exercises to see improvements. For example, 12 weeks of resistance training was sufficient to increase or at least maintain flexibility in older women. Muscles and fascia are responsible for at least 40% of a joint's resistance to movement, which suggests that a resistance training mediated reduction in passive tension and stiffness of these tissues translates into greater range of motion (Carneiro et al., 2015).

## Exercise interventions to improve female specific health risk factors

Hormone therapy is commonly prescribed to women going through menopause, although the precise treatment plan is dependent on the symptoms of each patient. While a treatment plan to reduce symptoms like hot flashes may be short term, a treatment plan to reduce the effects of osteoporosis is long term (Greendale et al., 1999). Although hormone replacement therapy has been effective in treating a variety of conditions associated with menopause, it does have contraindications and complications. Contraindications include undiagnosed vaginal bleeding, breast cancer, and active deep vein thrombosis. Complications of hormone therapy replacement can include endometrial hyperplasia, which is an important risk factor for the development of endometrial cancer (Greendale et al., 1999). Exercise interventions are known to improve urinary incontinence and associated symptoms as well as bone health and osteoporosis, without the negative side effects of hormone replacement therapies.

### *Bone health*

Research has shown that bone density in the spine can be increased by participating in weight bearing activities (Bassey & Ramsdale, 1994). Any tension, compression, and torsion at the tendon and bone complex creates mechanical signals that stimulate bone metabolism and possibly inhibit bone reabsorption (Moreira et al., 2014). For example, a 24-week whole body vibration programme in women (mean age: 65 years) has shown increased bone mineral density in the hip. Bone mineral density can also be maintained through muscle contraction due to the muscle tendon and bone interaction during exercises. Even low-intensity exercise may maintain or even improve bone mineral density in sedentary, elderly women, thus highlighting the importance of exercise to improve bone health (McGarry & Kiel, 2000).

Recent recommendations encourage older adults who are at risk of developing osteoporosis to engage in a multicomponent exercise programme that includes resistance training combined with balance training (Stanghelle, Bentzen, Giangregorio, Pripp, & Bergland, 2018). A loss of muscle mass is directly related to a loss of bone mass and a strength training programme could potentially increase bone mineral density of older women by around 1-3% per year (Stojanović, Drid, Madić, & Ostojić, 2017). The impact of an exercise intervention is considered to be greater if performed with higher mechanical loads and longer duration (Stojanović et al., 2017). Even though load bearing exercises do improve bone mineral density, these exercises might not be safe to perform for older people, thus the search for alternative strategies that decrease injury risk are still being examined (Verschueren et al., 2004). Walking is known to improve femoral bone mineral density in postmenopausal women; however, walking does not improve spinal bone mineral density (Moreira et al., 2014).

It is believed that bones are mechanically loaded through reflexive muscle contractions (Verschueren et al., 2004). Ville et al. (2016) found that a 16-week resistance training programme with elderly women showed significant increases in total hip bone mineral density. However, total hip bone mineral density decreased back to baseline levels after one year following discontinuation of the exercise programme (Ville et al., 2016). These results strongly suggest that continuous supervised resistance training for the prevention of osteoporotic fractures can be highly beneficial. Marques et al. (2011) examined the effects of a resistance exercise programme and an aerobic fitness programme on bone mineral density in older women. Significant improvements in bone mineral density at the trochanter and total hip were found for the resistance training group following the intervention, although no significant changes were found for the aerobic exercise programme group (Marques et al., 2011). This study suggests that higher workloads for an aerobic exercise training programme might be necessary to increase bone mass (Marques et al., 2011). Other intervention studies concluded that an exercise intervention, regardless of duration, does not increase bone mineral density in postmenopausal women but can maintain it and thus, is still beneficial to the health of postmenopausal women (Bocalini, Serra, & Dos Santos, 2010; Kemmler et al., 2004). To date, the exact mode of exercise, dosage, and effects on different outcomes are not yet well established, and further research needs to examine the effects on specific exercise and bone health.

*Pelvic floor muscle exercise and urinary incontinence*

A systematic review was conducted to investigate the benefits of exercise on urinary incontinence (Fricke, Lark, Fink, Mündel, & Shultz 2021) (see Appendix H for the full published manuscript). Pelvic floor muscle training exercises can improve the pelvic floor muscle functioning and consequently reduce symptoms of stress urinary incontinence. Aslan, Beji, & Yalcin (2008) examined the effects of a short 6 to 8 week home-based Kegel exercise programme and showed significant improvements on quality of life, severity of urinary incontinence and pelvic floor muscle strength in elderly women. Thus, even a short exercise programme with little supervision that specifically targets the pelvic floor muscles could improve urinary incontinence (Aslan et al., 2008). Ferreira et al. (2012) compared the effects of two home-based pelvic floor muscle strengthening programmes; one group also received supervised sessions. The interventions saw significant improvements in both groups in pelvic floor muscle strength, urinary incontinence, and perception of improvement; however, improvements in pelvic floor muscle strength and perception of improvement were significantly larger for the group that included supervised sessions (Ferreira et al., 2012). Those results are in agreement with Kim Yoshida, & Suzuki (2011) and Kim et al. (2007) that exercise programmes that included supervision reported better improvements. Kim et al. (2007) and Kim et al. (2011) taught pelvic floor muscle exercises in a regular group setting and found significant decreases in urinary frequency and leakage scores for the intervention group, while the control group (which performed exercises alone at home) did not report any significant changes. In contrast, Tsai & Liu (2009) included a home-based pelvic floor muscle training intervention and found significant improvements for all their outcome measures including severity of incontinence, quality of life, and general functional fitness. Tsai & Liu (2009) further examined the difference between two intervention groups, whereby one intervention group was provided with digital palpation to aid the recognition of the pelvic floor muscles. No significant differences of improvement between these two groups however were found, suggesting that pelvic floor muscle strength training could be effective in improving urinary incontinence, and invasive measures such as digital palpation and biofeedback devices to aid the recognition of this muscle group might not necessarily be required. Ong et al. (2015) included a home-based pelvic floor muscle exercise programme with additional monthly individually supervised sessions. Furthermore, one group also used an additional biofeedback device to help with the recognition and correct contraction of the pelvic floor muscle. Both groups saw significant improvements in pelvic floor muscle strength, and urinary incontinence symptoms, with no significant differences between the groups. In contrast, however, Tak, van Hespen, van Dommelen, & Hopman-Rock (2012) used a physical group exercise programme (including exercises to improve mobility of upper extremities, hand function, walking, standing up and sitting down) with additional unsupervised home-based exercises and behavioural instructions for good toilet behaviour to improve micturition and did not find any significant improvements in urinary incontinence symptoms: only compliant study participants saw a reduction of urinary incontinence symptoms (Tak et al., 2012). Tak et al. (2012) further indicate that in order to improve pelvic floor muscle functioning and urinary incontinence symptoms, pelvic floor muscle exercises that include direct activation of the pelvic floor muscle might be required. The frequency and duration of the interventions varied greatly in the previously mentioned studies; however, all frequencies experienced at least 20% improvement in severity of urinary incontinence and at least 30% improvement in pelvic floor muscle strength. Similarly, the duration of the exercise interventions also seemed to have little decisive impact on results. Even short exercise interventions were able to elicit 52% (Martinho et al., 2016) improvement in pelvic floor muscle strength. Urinary leakage improvements for exercise interventions of 12 weeks duration (Kim et al., 2007; Kim et al., 2011; Tsai & Liu, 2009) were also comparable to those of 6 months duration (Ferreira et al., 2012; Tak et al., 2012). These results indicate that exercise interventions do not necessarily need to be of high frequency or long duration to elicit positive effects on urinary incontinence.

All previously mentioned exercise interventions showed significant improvement in their outcome measures, however larger improvements were seen in interventions that were supervised. Exercise interventions that were supervised produced nearly 20% higher improvements in urinary leakage compared to exercise interventions that were not supervised. Similar results were seen for improvements in pelvic floor muscle strength, whereby strength improvements were nearly doubled in supervised interventions compared to not supervised.

Similarly, the recent review by Cacciari, Dumoulin, & Hay-Smith (2019) also found that pelvic floor muscle training was effective in improving urinary incontinence compared to no treatment. Previous studies have shown that over 30% of women are unable to contract the pelvic floor muscle in isolation even after an initial consultation with a medical or health professional (Bo et al., 1988; Hesse, Schussler, Frimberger, Obernitz, & Senn, 1990). Most commonly, women tended to contract hip adductors, abdominal and gluteal muscles instead of the pelvic floor muscle. These muscles do not act as a structural support to the pelvic organs and are subsequently unable to help prevent or manage urinary incontinence (Bø, 2004). However, contracting the extrinsic musculature does cause a co-contraction of the pelvic floor muscles in healthy women, which explains why improvements were still seen even with unsupervised home-based exercise interventions that required isolated pelvic floor muscle contractions (Bø, 2004). A review by Fu, Nelson, & McGowan (2019) further highlights the importance of supervised and detailed education of correct pelvic floor muscle activation in order to see pelvic floor muscle strength improvements. Studies in the recent review by Fu et al. (2019) showed that pelvic floor muscle exercises improved women's urine leakage but did not necessarily significantly improve pelvic floor muscle strength. It is believed that women were unable to correctly perform or adhere to pelvic floor muscle exercises. It was therefore recommended to provide detailed education and frequent appointments during the training programme (Fu et al., 2019).

To help participants contract pelvic floor muscles in isolation, studies used biofeedback devices or digital palpation. Using digital palpation or a biofeedback device showed a more definitive impact on pelvic floor muscle strength. Larger improvements of pelvic floor muscle strength were seen in studies using digital palpation (52%) (Martinho et al., 2016) compared to studies not using digital palpation or supervision (32.7%) (Ferreira et al., 2012). Similarly, Ong et al. (2015) showed a 50% larger improvement of pelvic floor muscle strength in the group using a biofeedback device compared to the group not using a biofeedback device. A biofeedback device helps to enhance the correct pelvic floor muscle training by providing feedback about accuracy of muscle contraction including the speed and type of contraction (Ong et al., 2015). Using a biofeedback device for a pelvic floor muscle exercise intervention does, however, have its drawbacks. Some studies have reported high dropout rates as a biofeedback device including vaginal cones can have a poor device tolerance, in some cases even causing pain, vaginitis and bleeding (Ong et al., 2015).

The Best Practice Advocacy Centre of New Zealand (BPAC) uses the UK's National Institute for Health and Care Excellence (NICE) guidelines as evidence-based advice to improve health and social care. Supervised pelvic floor muscle training for at least 3 months duration is recommended as the first line of treatment for women with stress or urinary incontinence. Some studies have shown that shorter durations could also show improvement in the outcome measures. While the use of perineometry or pelvic floor electromyography as biofeedback devices for routine training is not recommended, if pelvic floor muscle training is beneficial then a continued exercise programme utilising biofeedback is recommended. It is important to note that all these recommendations were last updated in 2006. The European Association of Urology (EAU) guidelines on incontinence were last updated in 2009; however, they agree with the NICE guidelines. Interestingly, the EAU guidelines note that the addition of a biofeedback device for pelvic floor muscle training does not appear to be of benefit (Thüroff et al., 2011). Since the EAU 2009 guidelines a study by Ong et al. (2015) published in 2015 showed that pelvic floor muscle training that included a biofeedback device produced larger and faster improvements. Further studies are therefore needed to examine the effects of latest biofeedback devices in pelvic floor muscle training.

Exercise interventions targeting the pelvic floor muscles may be effective in improving pelvic floor muscle strength, urinary incontinence symptoms and even quality of life measures. Additionally, follow-up assessments were indicative that exercise interventions could be effective for long-term improvements. Exercise interventions that were supervised, included some type of biofeedback device, or used digital palpation showed greater and faster improvements than interventions without additional assistance, particularly for pelvic floor muscle strength. Pelvic strengthening was effective in the broader context of exercise, but interventions that ensured correct pelvic floor muscle activation (via supervision, biofeedback, digital palpation) resulted in greater benefits.

## Adherence to exercise

Despite the well-known benefits of regular exercise, women tend to have lower physical activity levels than men and only 27% of women over the age of 65 years meet their daily recommended activity goals (Findorff, Wyman, & Gross, 2009). It is a continuous challenge for health professionals to initiate physical activity in sedentary individuals as well as maintaining it once initiated (Cox, Burke, Gorely, Beilin, & Puddey, 2003). Once women initially engage in physical activity, approximately 50% will drop out of the exercise programme within 6 months (Caserta & Gillett, 1998). Drop out and low adherence rates to exercise programmes are particularly high for older women as they have more co-morbidity, less social support, and more disability and depression than the general population (Picorelli et al., 2014). Another reason for the low adherence rates in older women is that exercise programmes are often prescribed without considering the specific characteristics of the cohort. Approaches that involve individualised exercise programmes are often impractical as they are time demanding and expensive (White, Randsdell, Vener, & Flohr, 2005). It is important to understand the barriers (which decrease adherence) and motivators (which increase adherence) to physical activity (Forkan et al., 2006; Tak, van Uffelen, Paw, van Mechelen, & Hopman-Rock, 2012) in order to increase adherence rates to an exercise programme. Insufficient time, the lack of social support and supervision, no place or transportation to exercise, insufficient money, and lack of exercise experience, are some of the common barriers for older women to participate in regular exercise (Forkan et al., 2006; Moore, Holden, Foster, & Jinks, 2020; Tak, van Uffelen, et al., 2012).

Motivators to exercise include enjoyment, short duration of exercises, good location of exercise classes, low-medium intensities, high self-efficacy, and supervised exercises with social support (Cox et al., 2003; Findorff et al., 2009; White et al., 2005). It is easy to understand that when individuals enjoy what they are doing, they are more likely to continue doing it (White et al., 2005). However, enjoyment is influenced by many other external factors such as mode of exercise and group or individual setting of exercise sessions (White et al., 2005). Increased exercise adherence to programmes was found when women participated in multiple short bouts of exercise during the day. Multiple short bouts of exercises might be more feasible than one long bout of physical activity for middle-aged and older women with career and family responsibilities (White et al., 2005). Similarly, home-based and work-based programmes may be more convenient and thus increase the adherence rate in women (Caserta & Gillett, 1998; White et al., 2005). Although exercises with longer durations and higher intensities may produce greater health benefits than low-intensity activities, sedentary individuals are less likely to adhere to high-intensity exercise programmes (Perri et al., 2002). Previous research concluded that individuals might feel a greater sense of self-efficacy with low-medium intensity exercise compared to high-intensity exercise. Furthermore, injury rates and risks are higher in high-intensity exercise compared to low-medium intensity exercise – particularly for middle-aged, older, and sedentary individuals (Perri et al., 2002). Research has shown that exercise interventions that involve socialisation, support, and a sense of group cohesion promote adherence to the programme (Caserta & Gillett, 1998). Similarities that can be shared between participants enhance the opportunities for participants to bond and feel more confident about participating in an exercise programme (White et al., 2005). Furthermore, supervised exercise has been shown to improve adherence compared to unsupervised exercise and middle-aged and older women prefer to follow supervised exercise programmes (Jordan, Holden, Mason, & Foster, 2010). Adherence to exercise programmes for older women can be improved when exercise classes include a knowledgeable instructor, who can provide feedback and can be seen as a peer with the women who participate (Caserta & Gillett, 1998).

Future exercise programmes targeting older adult women should focus on strategies that allow women to overcome most of the previously mentioned barriers in order to increase their adherence to exercise. To increase adherence for an exercise programme tailored to older middle-aged women, a mixture of supervised scheduled sessions and home-based sessions might be ideal, as it includes some structure but still offers flexibility by exercising at home anytime as well.

## Mini trampoline exercise and associated benefits

Mini trampoline jumping is a form of aerobic exercise that emerged nearly 50 years ago and has recently gained popularity (Höchsmann, Rossmeissl, Baumann, Infanger, & Schmidt-Trucksäss, 2018; McGlone, Kravitz, & Janot, 2002). Mini trampolines are relatively inexpensive, small, portable, and offer all the benefits of a low impact exercise, while being able to be performed in small confined spaces, including at home (Weston, 2001). Exercises are often performed in group settings and incorporate arm and leg movements, all while exercising to music (Höchsmann et al., 2018). Exercises on mini trampolines focus more on a downward push of the legs rather than just bouncing and jumping movements. Focusing on the downward push of the legs limits the upward propulsion and increases the amount of physical work performed by the lower extremities (Höchsmann et al., 2018). Although mini trampoline jumping places high demands on the muscles of the lower extremities, it is a multi-component exercise approach that is considered to affect many physical factors including muscle strength, aerobic fitness, body stability, muscle coordinative responses, joint movement amplitudes and spatial integration (Aragão, Karamanidis, Vaz, & Arampatzis, 2011). Exercises on a mini trampoline are able to produce intensities that are suitable for improving cardiorespiratory fitness in different target groups. Mini trampoline exercises can reach a large range of exercise intensities by changing foot strike frequency, height of the leg lift, additionally holding hand weights and holding or not holding onto handrails (Weston, 2001). Individuals taking part in a mini trampoline exercise programme are still able to self- adjust the exercise intensities, thus it allows for an effective workout for users of different fitness levels and capabilities (Aragão et al., 2011). A main advantage of a mini trampoline exercise is that it is low impact and joint friendly, thus suitable for older people or people who have suffered injuries (Aragão et al., 2011). Furthermore, research has indicated that compliance rates with mini trampoline exercise interventions are generally high as the exercises did not necessarily required supervision and the bouncing effect is often considered to be enjoyable as it requires a lower physical effort compared to bouncing on hard surfaces (Maharaj & Nuhu, 2016).

Although mini trampoline exercises have been around for nearly 50 years, research on mini trampoline interventions and its effects is limited. A few studies have examined the effects of a mini trampoline exercise intervention and the management of type 2 diabetes (Cunha et al., 2016; Maharaj & Nuhu, 2016). A mini trampoline exercise programme that includes intermittent periods of moderate and high intensity exercises can decrease blood glucose levels and is considered to be a useful approach in the management of cardiovascular risks in diabetes (Cunha et al., 2016). Interventions on a mini trampoline can be beneficial as an adjunct treatment with hypoglycaemic medication to potentially reduce the cost and associated adverse effects of long-term use diabetic medication (Maharaj & Nuhu, 2016). Furthermore, exercises involve the entire body and not just the lower limbs. Improvements of cardiovascular fitness are believed to be due to the cyclical jumping on the elastic surface that facilitates musculoskeletal function of the entire body and with that an increased heart rate and respiratory rate. Together, these functions facilitate an improvement in vascular function of the entire body (Maharaj & Nuhu, 2016).

Overall, functional capacity has shown improvements following a mini trampoline exercise intervention. A short 3 week rehabilitation intervention that focused on daily mini trampoline exercises significantly reduced the pain in the lumbar region of the spine and improved functional capacity including flexibility, endurance, and lower extremity muscle strength in patients suffering from spinal pain (Raczyńska, Żurek, Barej, Pelzer, & Lehrl, 2015). Another study involving an 8 week long mini trampoline jumping intervention in young healthy adults showed improvements in lower extremity strength (Witassek et al. 2018). This study included movements which focused on upwards movements of the knees towards the sternum and it is believed that this increased loading of the trunk flexors contributed to the increased lower extremity strength following the intervention (Witassek et al. 2018).

Cardiovascular function has also shown to improve following an 8 week long mini trampoline exercise intervention in young healthy adults (Sahin et al. 2016). Sahin et al. (2016) included movements involving knee bending, running and jumping and it was believed that these movements on the elastic base of a mini trampoline caused a higher energy expenditure compared to the just cyclical motions during running.

One of the largest known beneficial effects of mini trampoline exercise are improvements in balance. Exercises on unstable surfaces are commonly prescribed to improve balance, as they are highly integrative and place higher demands on the neuromuscular system (Kidgell, Horvath, Jackson, & Seymour, 2007). So far only two studies have examined the effects of a mini trampoline exercise intervention on balance in an older population. Hanachi & Kaviani (2010) found that a 6-week long mini trampoline exercise intervention was sufficient to show significant improvements on dynamic balance abilities in all directions in older women. Aragão et al (2011) examined the effects of a mini trampoline exercise intervention on balance and fall prevention in an elderly population. The 14-week exercise intervention showed significant improvements in dynamic stability and also significant increases of maximal isometric voluntary contraction moment of the ankle plantarflexors (Aragão et al., 2011). The ankle plantarflexors are important muscles during the recovery reaction right before a fall, as they allow for stability for adequate step positioning of the recovery limb (Aragão et al., 2011).

Research that has shown to be effective in improving aerobic fitness (Sahin et al., 2016), balance (Aragão et al., 2011; Hanachi & Kaviani, 2010; Kidgell et al., 2007), flexibility (Raczyńska et al. 2015) and lower extremity strength (Witassek et al., 2008) following a mini trampoline exercise intervention were of 8-12 weeks of duration and exercises were performed 2-3 times a week for 30-60 minutes each. Mini trampoline exercise interventions generally started simple and progressed in their complexion by including more complex movements and involving arm motions (Raczyńska et al., 2015). For example movements included hopping in place which progressed to hopping in place adding rotations and hopping in place adducting and abducting legs, front and back jumps with both feet joined and adding rotations for progression,  and one foot jumps in place progressing to one foot jumps forward and back (Aragão et al., 2011).

There is limited research on how mini trampoline exercise can improve female specific health risk factors in postmenopausal women such as urinary incontinence and bone health. Research has shown that mini trampolining can significantly stimulate the pelvic floor muscles in healthy young adults (Saeuberli, Schraknepper, Eichelberger, Luginbuehl, & Radlinger, 2018); but it is not known if the increased activity of pelvic floor musculurature during mini trampoline jumping can result in improved PFM functioning and decreased urinary incontinence. Pelvic floor muscle functioning can be improved by targeted PFM exercise (Ferreira, Santos, Duarte, & Rodrigues, 2012; Kim, Yoshida, & Suzuki, 2011); however it is known that contracting the PFM in isolation is generally difficult without supervision or biofeedback devices. Exercises that cause a co-contraction of PFM by contracting the hip adductors and abdominals have shown to increase PFM functioning and decrease stress urinary incontinence symptoms (Bø, 2004a). Therefore it is possible that mini trampoline exercises that include movements whereby the pelvic floor muscle is co-contracted could improve PFM functioning and decrease the incidence of stress urinary incontinence.

Similarly, there is limited research on the effects of mini trampoline jumping on bone health. One study found that even though mini trampoline exercise is considered to be of low impact, several bone health markers improved following the exercise programmes (Namboolu, Bunyaratavej, & Kritpet, 2012). However, research was only conducted on healthy young women without documented benefits in older cohorts.

Although research on mini trampoline exercise intervention is still limited, it can be assumed that mini trampoline exercise is a fun alternative aerobic exercise that could improve overall physical health and can be performed by people suffering from overuse injuries or combating exercise boredom.

## Conclusion

As the aging population of this world is increasing, it becomes more important to ensure good health for the elderly population. General health and functional capacities such as cardiovascular fitness, balance, strength, and flexibility decline with increasing age. Functional ability is a key factor for elderly individuals to both maintain independent living and participate in family and community services. Women are at higher risks of functional disabilities compared to men due to developing conditions such as osteoporosis and urinary incontinence. During menopause hormonal changes, and in particular, the sudden decrease of oestrogen is strongly related to loss of bone mineral density and with that an increased risk of osteoporosis. Although the effects of menopause on stress urinary incontinence have not yet been well established, it is clear that older women are more likely going to suffer from urinary incontinence due to loss of pelvic floor muscle function, commonly a result of childbirth trauma and sarcopenia with aging. Regular physical activity and/or an exercise programme can minimise the physiological alterations that occur during aging and can improve overall physical fitness including aerobic fitness, strength, balance, and flexibility as well as improving or maintaining bone health and pelvic floor muscle function. Mini trampoline exercises are highly beneficial and of low impact. Additionally, it incorporates a multi-component approach, which affects many physical factors including strength, body stability, muscle coordinative responses, joint movement amplitudes and spatial integration. Several physical abilities contribute to the ability to remain functionally independent and exercise interventions should therefore not rely on a single measure to improve general function. No research so far has examined the effects of a mini trampoline exercise intervention on older women’s health. Furthermore, no clear exercise intervention has been identified to improve bone health or urinary incontinence symptoms in older women. Research indicates that a mini trampoline exercise intervention might have the potential to improve physical fitness, bone health, and pelvic floor muscle function in older women, thus increasing overall quality of life.

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# Chapter 3

## Mini trampoline vs home-based and walking exercise on skeletal muscle activity and energy expenditure

### Abstract

Women tend to be at higher risk of developing diseases like osteoporosis, hypertension, diabetes and urinary incontinence compared to men. Mini trampoline exercises can improve urinary incontinence, bone health, and cardiovascular fitness in women; however, it is unknown how these physiological changes compare to more commonly prescribed exercise modalities such as home-based strength exercises or walking. This research article aims to examine differences in muscle activity and metabolic rates between mini trampoline exercise compared to home-based aerobic exercise and walking in postmenopausal women. Seventeen postmenopausal women (Age: 59.6 y ±3.9 ; Weight: 68.8 kg ±13.6; Height: 1.64 m ±.07; BMI: 25.5 ± 3.8 kg/m$^2$) participated in this study. Participants performed walking, home-based strength exercises, and trampoline exercises in bouts of 5 minutes, with a 10-minute rest period between each exercise. Oxygen consumption, energy expenditure, muscle activity, and heart rate were measured continuously throughout each exercise trial. The results showed significant differences in physiological responses between trampoline exercises, walking, and home-based exercises. The trampoline exercise was associated with higher HR ($p<0.01$), METs ($p=0.002$), energy expenditure ($p=0.01$), and oxygen consumption ($p=0.03$) compared to walking. There was a lack of significant differences for muscle activity patterns between the 3 exercise modalities exercises; however, mini trampoline and home-based exercises are both more effective exercises modalities as they elicit higher HR (13.9% increase, $p<0.01$ and 11.2% increase, $p=0.01$ respectively), RER (14% increase, $p<0.01$, and 11% increase, $p<0.01$ respectively), and oxygen expiration (9% increase, $p=0.03$ and 11% increase, $p=0.01$ respectively) compared to walking. Although, there was a lack of significant differences for muscle activity patterns between these exercises, mini trampoline and home-based

exercises are both more effective exercises modalities to improve cardiovascular fitness compared to walking. Further research is needed to confirm the findings and to explore the potential implications for exercise programming.

Statement of contribution: Methodology design: Fricke A., Fink, P. W., Shultz, S. P, Rowlands, D.S.; Data collection: Shultz, S.P.; Data processing: Fricke A., Data analysis: Fricke A., Rowlands D.S.; Write-up: Fricke A., Fink, P. W., Shultz, S. P., Rowlands D.S.

## Introduction

As overall life expectancy continues to increase, the number of non-communicable diseases have been increasing world-wide (Bergland & Engedal, 2011; Palacios, Borrego, & Forteza, 2005). Women tend to outlive men and are at higher risk of developing diseases like osteoporosis, hypertension, diabetes and urinary incontinence, which can reduce overall quality of life and independence (Bergland & Engedal, 2011; Palacios et al., 2005). Physical inactivity can further increase menopausal health problems including urinary incontinence and bone health (Mendoza et al., 2016). Regular exercise and physical activity is particularly recommended for older women, as they are known to have lower physical activity levels than men; just 27% of women over the age of 65 years meet daily recommended activity goals (Broman et al., 2006; Findorff, Wyman, & Gross, 2009; Mendoza et al., 2016). There are a number of commonly observed facilitators (i.e. motivators) to exercise in older women such as enjoyment, length of exercise bout, appropriate setting, level of self-efficacy, and programme tailoring (White, Randsdell, Vener, & Flohr, 2005). Common barriers that could decrease adherence to exercise in older women include insufficient time, the lack of social support, lack of location or transportation to exercise, insufficient money, and lack of exercise experience (Forkan et al., 2006; Moore et al., 2020; Tak Erwin et al., 2012). In order to increase adherence to exercise, it is important that future exercise interventions try to overcome these barriers (Rodrigues, Armstrong, Adachi, & MacDermid, 2017).

The majority (79.1-86.6%) of older adults engage in home-based physical activity (Moschny et al., 2011; Stalling et al., 2020). Walking and home-based strength anaerobic training are particularly prescribed for postmenopausal women as these exercises can improve overall physical functioning and fitness in this cohort (Mendoza et al., 2016). Several studies have shown that regular walking at moderate to vigorous intensities as well as strength exercises can both improve cardiovascular functioning, bone health, flexibility and muscle strength in postmenopausal women (Di Blasio et al., 2018; Gába et al., 2016; Guessogo et al., 2016; Lin & Lee, 2018; Nikkhah, Abedi, & Najjar, 2015; Nunes et al., 2016; Siwapituk & Kitisomprayoonkul, 2016; Watson, Weeks, Weis, Horan, & Beck, 2015). However, postmenopausal women often have difficulty adhering to exercise programmes such as strength exercises and walking (Moore, Holden, Foster, & Jinks, 2020; Tak Erwin, van Hespen, van Dommelen, & Hopman-Rock, 2012).

Mini trampolines offer all the benefits of a low impact exercise; they are also small, portable, comparatively inexpensive, and can be performed in small confined spaces, including at home (Weston, 2001). Mini trampoline exercises are capable of improving aerobic fitness, balance, muscle strength and coordination, and postural control in younger and older adults (Aragão, Karamanidis, Vaz, & Arampatzis, 2011; Cunha et al., 2016; Giagazoglou et al., 2013; Maharaj & Nuhu, 2016; Miklitsch, Krewer, Freivogel, & Steube, 2013; Nuhu & Maharaj, 2017). Recent research also showed that postmenopausal women who participated in a 12-week mini trampoline exercise programme exhibited improvements in female-specific risk factors, such as bone mineral density scores and stress urinary incontinence scores (Fricke et al., 2023).

Muscular activity and strength as well as cardiovascular fitness are particularly important factors in maintaining physical activity and independence (Tikkanen et al., 2016). Dimensions of physical fitness such as strength and aerobic endurance have been strongly linked to leisure activities such as hiking, gym training, and aerobics in older adults (Albrecht et al., 2023). Muscle activity in older adults during walking is different compared to young adults; specifically older adults show greater co-activation of muscles around the ankle and knee at similar walking speeds (Chandran et al., 2019; Schmitz et al., 2009). This co-contraction is believed to be used as a way to stiffen the joints and thus enhance stability (Schmitz et al., 2009). Walking exercises using ankle weights in older adults have shown to improve muscular activity during walking, specifically at the rectus femoris (Narouei et al., 2021). Home-based strength training can impact neural activation in older adults (Hirono et al., 2023). Hirono et al., (2023) examined the effects of a bodyweight squat exercises on neuromuscular adaptations and found that although there were no changes for strength gains or morphologic adaptions, there were changes for neurological adaptations helping to stabilize funtionality. Similarly, home-based resistance training had less impact on cardiac autonomic control than endurance and multimodal training (Graessler et al., 2021). Multi-component exercise has shown important gains in muscle strength, neuromuscular performance and aerobic function (Lin et al., 2023). Mini trampoline exercise could be considered a multi-component exercise; however, no study to date has compared the effectiveness of mini trampoline exercise to home based strength exercises or walking in healthy postmenopausal women. Therefore, the aim of this research is to examine mechanisms associated with these variables (i.e. muscle activity and energy expenditure) during mini trampoline jumping, compared to activities (walking and home-based aerobic exercise) more commonly undertaken by postmenopausal women.

## Methods

### Study Design

This study was a cross-sectional, within-subject design. Ethics approval was attained via the Institutional Review Board at Seattle University (FY2022-022). Participants were recruited in the community via word of mouth, email, and through the use of flyers. Participants were included if they were female aged 50-69 years, able to walk independently without any aid, and completed the Physical Activity Readiness Questionnaire (PAR-Q+) to determine physical activity readiness. Participants were excluded if they failed to pass the PAR-Q+ or had a health history of any neuromuscular conditions (e.g. multiple sclerosis), lower extremity bone fractures or knee and hip replacements within the last 12 months, uncontrolled hypertension and cardiovascular diseases, as well as severe lower extremity arthritis and orthopaedic diseases that would prevent physical functioning.

### Data collection

#### *Baseline recordings*

Participants' height and weight were recorded, using standard scales. A heart rate monitor was secured just under the bra line. Dominant limb was determined as the foot used to kick a ball (van

Melick, Meddeler, Hoogeboom, Nijhuis-van der Sanden, & van Cingel, 2017). Surface electromyography electrodes (EMG; Delsys Trigno, Natick, MA) were placed on the medial gastrocnemius, gluteus maximus, biceps femoris, and tibialis anterior of the participant's dominant limb according to SENIAM guidelines (Hermens et al., 1999). The gracilis was located on the medial aspect of the thigh at 60% of the thigh length (measured from greater trochanter to lateral epicondyle) (Elsais, Preece, Jones, & Herrington, 2020). Placement was confirmed using ultrasound (Watanabe & Akima, 2009). All electrode placement areas were shaved and thoroughly cleaned using alcoholic wipes.

### *Exercises*

Participants performed three different types of exercises in bouts of 5 minutes with a minimal 10-minute rest periods in between each exercise; the next trial commenced when heart rate returned to within 10% of the recorded resting rate. Exercises were randomized in order. Oxygen consumption, energy expenditure, METs, oxygen expiration, RER, and HR were collected continuously throughout each exercise trial via the COSMED (K4 b2, Cosmed, Rome, Italy). Muscle activity was also collected throughout the entire trial via electromyography. Participants performed all home based and mini trampolining exercises according to pre-recorded videos to ensure a fixed tempo and exercise intensity.

#### *Mini trampoline*

Participants performed exercise on the mini trampoline for 5 minutes. Exercises performed on the trampoline included: jogging on the spot (1 min), alternating knee raises (30 sec), alternating heel raises (30 sec), jumping jacks (30 sec), scissor jumps (30 sec), left leg bounce (30 sec), right leg bounce (30 sec), and jumping with both feet while squeezing the ball between their knees (1min). These exercises are similar to those used by older women in previous exercise intervention (Fricke, Fink, Lark, Mundel, & Shultz, 2021).

*Walking exercises*

Participants walked between two cones that were positioned 15-m apart. The exercise mimicked the set-up used in the 6-min walk test with older populations (Rikli & Jones, 1998). Participants walked at a progressive pace that requires some effort to maintain but participants were still able to hold a conversation.

*Home based strength exercises*

Participants performed a variety of bodyweight exercises designed to strengthen the lower extremity. Exercises included: side steps (30 sec), jogging on the spot (1 min), alternating knee raises (30 sec), heel raises alternating legs (30 sec), jumping jacks (30 sec), calf raises (30 sec), adducting hips with ball between legs (30 sec), sit to stand exercises from chair (30 sec), and glute-bridges (30 sec).

## Data analysis

Mean (SD) for breath-by-breath external respiration data were calculated for the entire trials. The EMG data were analysed using modified version of the burst analysis (Theou et al., 2013). To avoid any transients from switching between tasks, only the middle 10 sec of each task were analysed. The data was first analysed using Delsys EMGworks Analysis software 4.7.3.0 (Delsys Inc, Boston, MA, USA), which filtered the data at 0.125 and a 0.0625 msec moving RMS was used to create a linear envelope. The data were then imported into Matlab for the burst analysis. Unlike previous research (Theou et al., 2013), the EMG envelope was not down-sampled to 10 Hz, as the data would lose too much temporal precision. A threshold of 20% of maximal EMG was used to identify bursts. The onset of a burst was identified as the first point where the EMG exceeded the threshold, with a minimum of ten data points between onsets of a burst (to avoid identification of multiple bursts if the signal was around the threshold). A burst was considered to end when the signal dropped below the threshold. For each activity, the number of bursts and the percentage of time each muscle was active during the 10 second window were calculated.

Estimates of the effect of exercise location and modality on outcomes were analysed using a mixed liner model analysis of variance. The fixed effect was location-modality and the random effect was participant. The random coefficients model included the default variance components. Outcomes were presented as least-squares means estimates and 95% confidence interval. Statistical significance was set at the conventional 5% rejection threshold. All analyses were conducted in SAS (version 9.3; SAS Institute Inc., Cary, NC).

## Results

Overall, 17 postmenopausal women participated in this study (Age: 59.6y ± 3.9; Weight: 68.8kg±13.6; Height: 1.64m ±0.07; BMI=25.5 kg/m$^2$ ±3.8). The effect of exercise location and modality on external respiratory data is shown in Table 3.1. There were significant increases in HR (p<.0001), METs (p=0.002), energy expenditure (p=0.01), RER (p<.0001), oxygen expiration (p=0.03) and oxygen consumptions (p=0.01) in the trampoline compared to the walking exercise. Significant increases in HR (p=0.01), oxygen expenditure (p=0.01), oxygen consumption (p=0.01) and RER (p<.0001) were also found in the home-based compared to the walking exercises. RER (<0.001) and oxygen consumption (p=0.03) were the only metabolic variables to be significantly higher during the trampoline exercises compared to the home-based exercises.

The effect of exercise location and modality on muscle activity is shown in table 3.2 for number of bursts and table 3.3 for percentage of activation. The number of bursts only showed a significant increase for the gastrocnemius medialis (p=0.01) during trampoline exercises compared to walking. The percentage of muscle activation was significantly increased within the gluteus maximus (p=0.04) during the trampoline exercise compared to walking. A significant increase of percentage activation was found for the tibialis anterior during walking when compared to home exercises (p=0.04) and trampoline exercises (p=0.05).

Table 3.1. Effects of 5 min home-based, trampoline and walking exercise on HR, energy expenditure, METS, Oxygen expiration, RER, and VO2

| | | Post Treatment LSmean Group Scores (95% Confidence Limits) | | | | Group (Int-Con) Mean Differences (95% Confidence Limits) | | | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | | **Estimate** | **Lower** | **Upper** | **Contrast** | **Estimate** | **Lower** | **Upper** | |
| **HR** (bpm) | HOME | 125 | 117 | 132 | HOME-TRAMP | -5 | -12 | 2 | 0.19 |
| | TRAMP | 129 | 122 | 137 | HOME-WALK | 13 | 6 | 20 | **0.01** |
| | WALK | 111 | 104 | 119 | TRAMP-WALK | 18 | 11 | 25 | **<.0001** |
| **EE** (kcal/min) | HOME | 6.31 | 5.75 | 6.87 | HOME-TRAMP | -0.4 | -1.0 | 0.1 | 0.13 |
| | TRAMP | 6.74 | 6.18 | 7.30 | HOME-WALK | 0.5 | -0.1 | 1.1 | 0.08 |
| | WALK | 5.80 | 5.25 | 6.37 | TRAMP-WALK | 0.9 | 0.4 | 1.5 | **0.01** |
| **METs** (kcal/kg/hour) | HOME | 5.34 | 4.93 | 5.75 | HOME-TRAMP | -0.40 | -0.84 | 0.05 | 0.08 |
| | TRAMP | 5.73 | 5.33 | 6.14 | HOME-WALK | 0.31 | -0.12 | 0.75 | 0.17 |
| | WALK | 5.03 | 4.62 | 5.43 | TRAMP-WALK | 0.70 | 0.26 | 1.14 | **0.002** |
| **Oxygen expiration** (ml/min) | HOME | 235 | 214 | 256 | HOME-TRAMP | 3 | -14 | 21 | 0.73 |
| | TRAMP | 232 | 211 | 253 | HOME-WALK | 24 | 6 | 42 | **0.01** |
| | WALK | 211 | 190 | 232 | TRAMP-WALK | 21 | 3 | 39 | **0.03** |
| **RER** ($VCO_2$ produced/$VO_2$consumed) | HOME | 0.94 | 0.91 | 0.97 | HOME-TRAMP | 0.03 | 0.01 | 0.06 | **0.04** |
| | TRAMP | 0.91 | 0.88 | 0.95 | HOME-WALK | 0.13 | 0.10 | 0.16 | **<.0001** |
| | WALK | 0.81 | 0.77 | 0.83 | TRAMP-WALK | 0.10 | 0.08 | 0.13 | **<.0001** |
| **$VO_2$** (ml/min) | HOME | 1274 | 1160 | 1388 | HOME-TRAMP | -95 | -207 | 17 | **0.01** |
| | TRAMP | 1369 | 1255 | 1483 | HOME-WALK | 58 | -53 | 171 | 0.30 |
| | WALK | 1215 | 1101 | 1329 | TRAMP-WALK | 154 | 41 | 266 | **0.01** |

Data are least-squares mean (LSmean) estimates and 95% confidence limits. Abbreviations: HOME: home-based exercise; TRAMP: trampoline exercise; HR: Heart rate; EE: Energy expenditure; METs: Metabolic Equivalents; RER: Respiratory Exchange Ratio; $VO_2$: Oxygen consumption

Table 3.2. Effects of 5 min home-based, trampoline and walking exercise on lower limb muscle activity (number of bursts)

| | | Post Treatment LSmean Group Scores (95% Confidence Limits) | | | | Group (Int-Con) Mean Differences (95% Confidence Limits) | | | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | | **Estimate** | **Lower** | **Upper** | **Contrast** | **Estimate** | **Lower** | **Upper** | |
| **Adductor longus** | HOME | 14.2 | 10.2 | 18.2 | HOME-TRAMP | 1.0 | -3.7 | 5.9 | 0.66 |
| | TRAMP | 13.1 | 9.1 | 17.1 | HOME-WALK | 0.6 | -4.1 | 5.4 | 0.77 |
| | WALK | 13.5 | 9.6 | 17.4 | TRAMP-WALK | -0.4 | -5.2 | 4.3 | 0.86 |
| **Biceps femoris** | HOME | 25.7 | 20.1 | 31.3 | HOME-TRAMP | -2.9 | -11.5 | 5.7 | 0.49 |
| | TRAMP | 28.6 | 22.9 | 34.2 | HOME-WALK | -1.2 | -9.8 | 7.3 | 0.77 |
| | WALK | 26.9 | 21.3 | 32.5 | TRAMP-WALK | 1.6 | -6.9 | 10.2 | 0.69 |
| **Gastrocnemius medialis** | HOME | 13.2 | 11.0 | 15.5 | HOME-TRAMP | -2.1 | -5.1 | 0.8 | 0.14 |
| | TRAMP | 15.4 | 13.2 | 17.6 | HOME-WALK | 1.5 | -1.4 | 4.6 | 0.28 |
| | WALK | 11.6 | 9.4 | 13.9 | TRAMP-WALK | 3.7 | 0.7 | 6.7 | **0.01** |
| **Gluteus maximus** | HOME | 15.2 | 13.6 | 16.8 | HOME-TRAMP | 0.6 | -1.7 | 3.0 | 0.59 |
| | TRAMP | 14.6 | 12.9 | 16.2 | HOME-WALK | -1.4 | -3.8 | 0.9 | 0.22 |
| | WALK | 16.6 | 15.0 | 18.2 | TRAMP-WALK | -2.0 | -4.5 | 0.3 | 0.09 |
| **Tibialis Anterior** | HOME | 14.4 | 12.7 | 16.1 | HOME-TRAMP | -0.6 | -3.1 | 1.8 | 0.59 |
| | TRAMP | 15.1 | 13.4 | 16.7 | HOME-WALK | -2.4 | -4.9 | 0.0 | 0.06 |
| | WALK | 16.9 | 15.2 | 18.6 | TRAMP-WALK | -1.8 | -4.3 | 0.6 | 0.14 |

Data are least-squares mean (LSmean) estimates and 95% confidence limits. Abbreviations: HOME: home-based exercise; TRAMP: trampoline exercise

Table 3.3. Effects of 5 min home-based, trampoline and walking exercise on lower limb muscle activity (percentage on)

| | | **Post Treatment LSmean Group Scores (95% Confidence Limits)** | | | | **Group (Int-Con) Mean Differences (95% Confidence Limits)** | | | **p-value** |
|---|---|---|---|---|---|---|---|---|---|
| | | **Estimate** | **Lower** | **Upper** | **Contrast** | **Estimate** | **Lower** | **Upper** | |
| **Adductor longus** | HOME | 0.52 | 0.43 | 0.59 | HOME-TRAMP | 0.01 | -0.09 | 0.11 | 0.84 |
| | TRAMP | 0.50 | 0.42 | 0.58 | HOME-WALK | -0.02 | -0.12 | 0.08 | 0.65 |
| | WALK | 0.53 | 0.45 | 0.62 | TRAMP-WALK | -0.03 | -0.13 | 0.07 | 0.52 |
| **Biceps femoris** | HOME | 0.50 | 0.43 | 0.57 | HOME-TRAMP | 0.00 | -0.08 | 0.08 | 0.99 |
| | TRAMP | 0.50 | 0.43 | 0.57 | HOME-WALK | 0.03 | -0.04 | 0.12 | 0.35 |
| | WALK | 0.46 | 0.40 | 0.53 | TRAMP-WALK | 0.03 | -0.04 | 0.12 | 0.36 |
| **Gastrocnemius medialis** | HOME | 0.53 | 0.45 | 0.62 | HOME-TRAMP | -0.02 | -0.14 | 0.09 | 0.65 |
| | TRAMP | 0.56 | 0.48 | 0.64 | HOME-WALK | 0.01 | -0.11 | 0.13 | 0.85 |
| | WALK | 0.52 | 0.44 | 0.61 | TRAMP-WALK | 0.03 | -0.08 | 0.15 | 0.53 |
| **Gluteus maximus** | HOME | 0.53 | 0.48 | 0.59 | HOME-TRAMP | 0.06 | -0.01 | 0.13 | 0.11 |
| | TRAMP | 0.47 | 0.41 | 0.53 | HOME-WALK | -0.01 | -0.09 | 0.06 | 0.65 |
| | WALK | 0.55 | 0.49 | 0.61 | TRAMP-WALK | -0.07 | -0.15 | -0.01 | **0.04** |
| **Tibialis Anterior** | HOME | 0.58 | 0.54 | 0.62 | HOME-TRAMP | -0.01 | -0.05 | 0.05 | 0.89 |
| | TRAMP | 0.58 | 0.54 | 0.62 | HOME-WALK | -0.05 | -0.11 | -0.01 | **0.04** |
| | WALK | 0.64 | 0.6 | 0.68 | TRAMP-WALK | -0.05 | -0.10 | -0.01 | **0.05** |

Data are least-squares mean (LSmean) estimates and 95% confidence limits. Abbreviations: HOME: home-based exercise; TRAMP: trampoline exercise

## Discussion

The aim of the present study was to investigate mechanisms associated with muscle activity and energy expenditure during mini trampoline jumping, compared to more commonly studied and performed activities in postmenopausal women. Results showed that there were significant differences in the physiological responses to trampoline compared with walking exercise. Specifically, the trampoline exercise was associated with higher HR, METs, energy expenditure and oxygen consumption. Muscle activity only showed significantly increased number of bursts for the gastrocnemius medialis during trampoline jumping compared to walking. Significant differences for the percentage of muscle activation were also found for the gluteus maximus, which was higher during trampoline exercise compared to walking, and tibialis anterior which was higher during walking compared to home or trampoline exercises.

Differences of physiological responses during trampoline exercises and walking were supported by previous research demonstrating that trampoline exercises can elicit a greater cardiovascular and metabolic response compared to other forms of exercise such as walking (Draper, Clement, & Alexander, 2020). Mini trampoline exercises showed no significant differences in HR, oxygen consumption, and energy expenditure compared to running on the treadmill at similar effort (Draper et al., 2020). Although no study to date has compared energy consumption and expenditure in mini trampoline exercises and walking, studies have shown that physiological responses are generally lower during walking compared to running (de Castro Cesar, Gomes Gonelli, Seber, Pellegrinotti, & de Lima Montebelo, 2007). Interestingly, the only significant difference between home-based exercises and trampoline exercise were found in RER and oxygen consumption. For submaximal exercise, a relative increase in exercise intensity, as seen with the oxygen consumption is associated with a small increase in carbohydrate oxidation rate and therefore the increased rate of RER (van Loon, Greenhaff, Constantin-Teodosiu, Saris, & Wagenmakers, 2001). Resistance exercises have been associated with higher energy expenditure and oxygen uptake when performed with larger muscle mass compared to smaller muscle mass (Farinatti, Neto, & Amorim, 2016). These results may suggest that the mini trampoline exercises may be of higher intensities and rely on greater carbohydrate utilisation than home-based strength exercises. However, further research is needed to confirm this finding and to explore the potential implications for exercise programming.

While there were significant differences of physiological responses between trampoline exercises, walking and home exercises, there was a lack of significant differences for muscle activity patterns between these two exercises. Only the gastrocnemius medialis showed significantly larger number of bursts during trampoline exercises compared to walking. Furthermore, there were only significant increases of percentage of muscle on for the gluteus maximus during trampoline exercises compared to walking and for the tibialis anterior during walking when compared to trampoline exercises and walking. The gastrocnemius muscles are known to be the major force behind propulsion during walking (Schache, Dorn, Williams, Brown, & Pandy, 2014). However, during mini trampoline jumping this upward propulsion is higher compared to walking, thus a higher activation of the gastrocnemius muscles during trampoline exercises compared to walking was expected. The only other significant difference during muscle activation was found for the gluteus maximus, which was activated for longer during walking compared trampoline and home exercises. Research has indicated that even low level of gluteus maximus activation may contribute to hip extension during the stance phase of gait to restrain hip flexion during swing (Lieberman, Raichlen, Pontzer, Bramble, & Cutright-Smith, 2006). Considering that one of the main roles of the gluteus maximus is to extend the hip it might not be all that surprising that activity levels were higher during walking, as both the trampoline exercises and home-based exercises were more stationary.

Research in an older population showed that during stair climbing mean muscle activity was 120% of maximal voluntary contraction while oxygen consumption remained submaximal (Tikkanen et al., 2016). It is important to note that while EMG activity shows momentary activity, oxygen consumption takes a certain amount of time to reach the level demanded by the activity (Tikkanen et al., 2016).

Nonetheless, this research highlighted that muscle activity rather than cardiovascular functioning may be the limiting factor in performing daily activities in later life; however more research in this area is needed to confirm this hypothesis. Other research highlighted that decreased muscle strength and age related modelling contribute to increased muscle activity and bursts during daily activities in an older population (Theou, Edwards, Jones, & Jakobi, 2013). It is therefore surprising that there was an overall lack of significant differences for muscle activity between the different modalities, while several significant differences were found for cardiovascular performance. Tikkanen et al. (2016) research examined muscle activity and cardiovascular performances during stair climbing and it simply may be that the demand on the cardiovascular system was considerably higher during our exercises compared to the ones designed by Tikkanen et al. (2016). It was also surprising that there we no significant differences of muscle activity for the adductor longus, particularly as the trampoline and home exercises included specific adductor longus exercises (squeezing a ball between the knees) while the walking exercise did not. However, it is important to note that muscle activity was compared between the three different modalities using an average of muscle activity of the entire trials. It is possible that 30 seconds of ball squeezing activity was not enough to elicit a significant difference of adductor muscle activity.

While the examination of these three exercise interventions is a novel one, the study does have limitations. One potential limitation of this study is that the study sample was small and that the exercise history and current exercise participation patterns of participants were not recorded. However, the focused cohort was specifically homogenous in an effort to design effective exercise programs that are tailored to the needs of postmenopausal women. The findings support the use of intentional exercise, such as trampoline exercises and home-based strength exercises, as more effective forms of exercise that improve cardiovascular and metabolic health compared to activities of daily living such as walking.

In conclusion, this study aimed to investigate fitness-related physiological responses to mini trampoline jumping, compared to activities more commonly undertaken by postmenopausal women. The results showed significant differences in cardiorespiratory responses between trampoline exercises, walking, and home-based exercises. The trampoline exercise was associated with higher HR, METs, energy expenditure, and oxygen consumption. Although, there was a lack of significant differences for muscle activity patterns between these exercises, mini trampoline and home-based exercises are both more effective exercises modalities to improve cardiovascular fitness compared to walking. Further research is needed to confirm the findings and to explore the potential implications for exercise programming.

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# Chapter 4

## Mini trampoline jumping as an exercise intervention in postmenopausal women to improve female specific health risk factors*


### Abstract

Women tend to outlive men and are at higher risks of functional disability compared to men. Specifically, women are more likely to develop conditions like osteoporosis and stress urinary incontinence which can further increase the risk of functional disability. Regular physical activity and/or exercise programmes can minimise the physiological decline that occurs during aging and can improve overall physical fitness, bone health, and pelvic floor muscle function; however, exercise programmes tend to focus on only one parameter. Mini trampoline jumping is a low-impact aerobic exercise capable of improving aerobic fitness, balance, muscle strength and potentially bone health as well as pelvic floor muscle functioning. The aim of the proposed research project was to examine the benefits of a 3-month mini trampoline exercise intervention on bone health, pelvic floor muscle functioning, and physical fitness in postmenopausal women. Thirty-seven postmenopausal healthy women aged 50-69 years were recruited. Assessments on bone health of the calcaneus via a quantitative ultrasound, pelvic floor muscle functioning via EMG, and physical fitness (aerobic fitness, walking speed, balance, lower extremity strength, flexibility) occurred within one week before and after the exercise intervention, including a 3-month follow-up assessment. The exercise intervention lasted 12 weeks, with 3 sessions of 40 minutes each per week. Furthermore, efficacy of the exercise intervention was examined via an online questionnaire, which consisted of 13 anonymous open-ended questions examining participants perceptions of the intervention.

## Keywords

Women health; mini trampoline; physical fitness; osteoporosis; pelvic floor muscle

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*Notes:*

This chapter has been adapted from the original research article published in *International Journal of Preventative Medicine.* This chapter was re-written in past-tense to reflect the past-tense nature of the thesis. The aims of this manuscript were re-arranged and the secondary aim of examining intervention efficacy was added. Appropriate changes to the statistical analysis were also made. The original version of this methodology article can be found in *Appendix H,* or online at the link below.

Available at: https://www.ijpvmjournal.net/text.asp?2021/12/1/10/307474

## Introduction

Physical functional ability is key to elderly individuals maintaining an independent lifestyle (Christensen, Støvring, Schultz-Larsen, Schroll, & Avlund, 2006). Any deficits in muscle strength, mass, power, and endurance can limit mobility and activity, especially for women (Matsouka, Harahousou, Kabitsis, & Trigonis, 2003). Older women are more likely to develop conditions like osteoporosis and urinary incontinence compared to older men, which can both decrease overall activities of daily living (MacLean et al., 2008; McGarry & Kiel, 2000). Bone mass loss and osteoporosis are greatly influenced by menopause (McGarry & Kiel, 2000) and are known to affect four times as many women as men. A loss of bone mass is known to significantly increase the risk of fractures, disability, and chronic pain (MacLean et al., 2008).

Stress urinary incontinence is considered to be the most prevalent form of urinary incontinence (Weiss, 1998) and commonly occurs during some form of physical exertion or during sneezing and coughing (Norton & Brubaker, 2006). Urinary incontinence can create serious medical conditions (e.g. urinary tract infections) but also social problems (e.g. embarrassment), reducing social interactions and physical activity (Bø, 2004). Women are specifically susceptible to stress urinary incontinence because the pelvic floor musculature in women weakens with older age due to sarcopenia, childbirth trauma, and/or menopause (Norton & Brubaker, 2006).

Regular physical activity can minimise the physiological decline that occurs during aging and improve overall physical fitness, bone health, and pelvic floor muscle function; however, exercise programmes tend to focus on only one parameter (Bø, 2004; Norton & Brubaker, 2006). Several studies have shown that sedentary adults are at larger risk of functional decline compared to adults who exercise regularly, and exercise is highly recommended to reduce these risks (Christensen et al., 2006). Although studies have shown significant improvements for overall physical performance when participating in an exercise intervention, no study to date also included other functional ability measures that specifically focus on health risks associated with postmenopausal women.

The ability to remain functionally independent is reliant on several physical abilities and thus it is important that exercise interventions do not rely on a single measure to improve general function. Furthermore, research on exercise programmes that could improve pelvic floor muscle functioning is sparse, with no clear exercise intervention identified. Mini trampoline jumping is a highly beneficial low-impact aerobic exercise capable of improving aerobic fitness, balance, muscle strength and postural control in young as well as older adults (Aragão, Karamanidis, Vaz, & Arampatzis, 2011; Miklitsch, Krewer, Freivogel, & Steube, 2013; Correa, Cunha, Marques, Oliveira-Reischak, & Pinto, 2016). Mini trampoline exercises incorporate a multi-component approach, which affects many physical factors including strength, body stability, muscle coordinative responses, joint movement amplitudes and spatial integration (Aragão et al., 2011). Yet no research has examined the effects of a mini trampoline exercise intervention on older women's health.

Therefore, the primary aims of this intervention study were to understand the benefits of a 3-month mini trampoline exercise intervention on i) female specific health risk factors (bone health and pelvic floor muscle functioning), and ii) functional fitness. A secondary aim examined adherence and efficacy of the intervention.

## Methods

### Study design

This exercise intervention study included pre-, post- and follow-up measures. Figure 4.1 represents a schematic timeline of the study design following the initial recruitment. The study gained ethical approval from the Massey University Ethics Committee (Southern A 18/52).

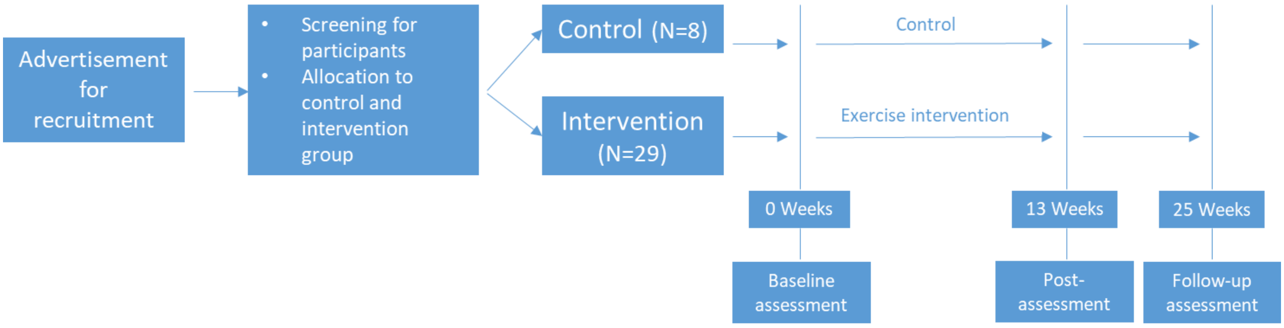


Figure 4. 1 Schematic timeline of proposed study

## Participants

Women aged 50-69 years were targeted for recruitment for the study. It is believed that this aged cohort would benefit the most from the mini trampoline exercise intervention: physical function has started to decline but women would still be able to safely perform the exercises (Peeters, Dobson, Deeg, & Brown, 2013). Eligible participants underwent pre-screening for inclusion and exclusion criteria (Table 4.1). A health history questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q) were used to determine eligibility and readiness to participate in exercise. Participants were recruited from the Wellington region via flyers and advertisements. Regional companies and sports clubs were contacted directly via e-mail and phone to increase engagement with external stakeholders.

Eight of the recruited women were assigned to a control group while 29 were assigned to an exercise group. Very little change was expected in the control group; thus, the relatively small amount of variability reduces the sample size required for the control group.

Table 4.1. Inclusion and exclusion criteria

| | |
|---|---|
| **Inclusion criteria** | • Female aged 50-69 years<br>• Postmenopausal for at least 12 months<br>• Able to walk independently without any aid<br>• Agree not to take bone altering medication and supplements<br>• Able to travel independently to research and exercise sites |
| **Exclusion criteria** | • Neuromuscular conditions such as multiple sclerosis and Parkinson's<br>• Lower extremity bone fractures or knee and hip replacements within last 12 months<br>• Uncontrolled hypertension<br>• Uncontrolled cardiovascular diseases<br>• Severe lower extremities arthritis<br>• Severe lower extremity orthopaedic diseases |

## Assessments

The primary outcome measures for this study were indicators of bone health in the calcaneus and pelvic floor muscle functioning. Secondary outcome measures included physical fitness, sub-categorised as aerobic fitness, gait, balance, lower extremity muscular strength, lower extremity flexibility. All parameters were measured within one week prior to commencing the exercise intervention, within one week following the exercise intervention and 3-months following the exercise intervention.

### *Primary outcome measures*

Primary outcome measures included bone health and pelvic floor muscle functioning. Both outcome measures are specific health risks for aging women, which are known to decline in functioning in postmenopausal women (McGarry & Kiel, 2000; Weiss, 1998). Based on previous research, a mini trampoline exercise intervention might have the potential to improve bone health in the calcaneus as well as pelvic floor muscle functioning (Aragão et al., 2011; Cunha et al., 2016; Miklitsch et al., 2013).

Bone health in the calcaneus might be improved through the mechanical loads that will be applied through contact with the base of the mini trampoline. Any tension, compression and torsion at the tendon and bone complex creates electrical signals that stimulate bone metabolism and possibly inhibit bone reabsorption (Moreira et al., 2014). The pelvic floor muscles are believed to be highly active during trampoline exercises and thus might be strengthened following an exercise programme.

*Bone health*

Bone health of the calcaneus was assessed via a quantitative ultrasound measure. The ultrasound parameters taken from the calcaneus have shown high correlations with bone mineral density in the hips of older women. A quantitative ultrasound measure is therefore recommended as an inexpensive tool to screen for bone health in older women (Lappa et al., 2007). Calcaneal bone health (bone mineral density; BMD) was assessed via quantitative ultrasound (QUS) (Sahara Clinical Bone Sonometre Hologic Inc, USA). Participants were seated on a chair while the participant's right foot was cleaned. Ultrasound gel was applied to the pads of the transducers of the ultrasound machine prior to testing. The right foot was then placed on the ultrasound machine; direct contact was ensured between the transducer pads and the heel. The device directly measured broadband ultrasound attenuation (BUA) and speed of sound (SOS). The Sahara ultrasound machine estimated BMD using the following calculation: Estimated heel BMD = 0.0025926 x (BUA + SOS) x 73.687. Normative estimated BMD values using QUS measurements have been reported in women aged 50-59years (0.501±0.108g/cm2) and 60-69 years (0.452±0.105g/cm2) (Sosa et al., 2002).

*Urinary incontinence and pelvic floor muscle functioning*

The degree of urinary incontinence was assessed with the female urinary incontinence diagnosis questionnaire. This short 6 item urinary incontinence symptom questionnaire has previously been validated to be used as an outcome measure in clinical trials (Bradley et al., 2010). The functioning of the pelvic floor musculature was examined via surface electromyography (EMG) (Noraxon, Arizona, USA). During the initial meeting prior to the first testing session, participants were taught the structure and anatomy of the pelvic floor muscle to help create awareness of this muscle group, its location and function. Participants were instructed to try and stop voiding during micturition on only a couple of occasions to feel the pelvic floor muscles. This protocol has been used in previous studies in order for participants to contract the correct muscle group during testing (Kim, Yoshida, & Suzuki, 2011). Participants voided their bladder immediately prior testing in order to standardise bladder volume. Participants were provided with verbal instructions to insert a vaginal probe as they would do when inserting a tampon; the two conducting plates must be placed laterally (with one plate facing their right side of the body and the other plate facing left side of the body). Participants performed a maximum voluntary contraction of the pelvic floor muscle while in a standing positing and held this contraction for 10 seconds. Following a one-minute rest period, participants then performed three maximal effort coughs. Testing was repeated for three times with one-minute rest breaks in between each trial. This protocol aligns with previously validated and reliable protocols (Koenig, Luginbuehl, & Radlinger, 2017; Peschers, Gingelmaier, Jundt, Leib, & Dimpfl, 2001).

### *Secondary outcome measures*

The second primary outcome measure for this intervention was functional fitness, which comprises aerobic fitness, walking ability, balance, strength, and flexibility. As all of these components are known to decline in functioning with increasing age, they are directly targeted in the exercise intervention (Peeters et al., 2013). A mini trampoline exercise programme has the potential to improve overall functional fitness with its multi component approach (Aragão et al., 2011).

#### *Aerobic Fitness*

Aerobic fitness was assessed with the 6-minute walk test. The test was performed indoors on a flat surface in a rectangular course (5 meters in length and 1 meter in width). Participants walked as fast as they comfortably could for 6 minutes and the total distance covered at the end of the 6 minutes was measured. The 6-minute walk test has previously demonstrated to produce good test-retest reliability in measuring aerobic fitness in older adults (Rikli & Jones, 1998).

### *Walking speed*

Walking speed and lower extremity strength were assessed during a 6-meter walking test. Participants walked a total of 10 meters (with 2 meters provided at the beginning and the end for acceleration and deceleration, respectively) at their comfortable walking speed on a flat and straight surface. Timing gates at the start and end of the 6 meters recorded the time. Participants performed three trials with one-minute rest breaks between each trial. This test has previously been validated to measure lower leg strength and walking speed for older adults (Peters, Fritz, & Krotish, 2013).

### *Balance*

#### *Dynamic balance*

Dynamic balance was assessed with participants standing on a force platform (AMTI, Watertown, MA, USA) with feet shoulder width apart and arms stabilised with the hands at the hip. Participants shifted their weight anteriorly and posteriorly, and then laterally to the right and left sides as far as possible while retaining their balance. Tasks were performed repeatedly over a period of 20 seconds, whereby participants shifted their weight in all directions as far and fast as possible during that time period. Maximal range of sway in the anterior-posterior as well as medial-lateral direction, and maximal velocity along the medial-lateral and anterior-posterior axes were assessed. Centre of pressure measurements have been deemed valid and reliable in testing balance in older adults (Li, Liang, Wang, Sheng, & Ma, 2016).

#### *Static balance*

Static balance was measured during a two-legged stance with participants standing on the force platform shoulder width apart with eyes closed for 30 seconds. Three trials for each condition were performed. Balance was estimated by using the standard deviation of the centre of gravity in the x (medial-lateral) and y (anterior -posterior) directions.

*Lower extremity strength*

Lower extremity muscle strength was further assessed with the chair-based sit-to-stand-test. Participants were seated on a standardised 40cm high chair and stood up from the seated position for 10-times as fast as possible. The time it took to sit and stand 10 times was recorded. The chair-to-stand test provided good test-retest reliability and good criterion-related validity in measuring lower limb strength in older adults (Jones, Rikli, & Beam, 1999).

*Flexibility*

Hamstring flexibility was assessed with the sit-and reach test. Participants placed the soles of their feet against the sit-and-reach box. Participants slowly reached forward with both hands as far as possible to a position that could be maintained for two seconds. Hands were to be in parallel position to each other and fingertips had to be in contact with the measuring tape of the sit-and-reach box. The score that was the most distant point reached with fingertips and held for 2 seconds was recorded in cm. Three trials were performed, while the best out of three trials was recorded. The sit-and-reach test has been validated to be a good predictor of hamstring flexibility (Jones, Rikli, Max, & Noffal, 1998).

## Exercise intervention

Twenty-nine of the 37 recruited participants were assigned to the intervention group and 8 participants were assigned to the control group. The control group only attended the pre-, post-, and follow-up assessments, and was instructed to continue with their daily routines for the 12-week period between assessments. Participants in the intervention group participated in a mini trampoline exercise programme for 12 weeks, with 40-minute sessions occurring three times a week. Mini trampoline exercises concentrated on movements to improve aerobic fitness, flexibility, lower extremity strength and balance, as well as pelvic floor muscle activation. Exercises were chosen for their ability to scaffold in progression throughout the programme. Specifically, exercises started with simple and basic movements and progressed to more challenging and interactive tasks throughout the 12 weeks.

Exercises were performed on a mini trampoline with handlebars. During the course of the exercise programme participants were encouraged to perform exercises without holding onto the handlebar; however, this was dependent on individual ability, progress and confidence. The researcher conducted each training session in a small group with a maximum of six participants. Exercise sessions were performed at Massey University in Wellington and at the Petone library in the Hutt Valley to minimise the burden of travel on participants. Each participant was provided with a heart rate monitor during the exercise sessions. For the exercise to be effective the heart rate should continuously be between 60% - 75% of the age predicted maximum heart rate (HRmax = 208 – 0.7 x age). If heart rate reached near maximal values (80%HRmax), participants were able to reduce intensity or take short rest breaks.

### Adherence and Efficacy

A potential challenge considered in the design of this intervention study was adherence to the exercise programme. The most commonly reported motivators to exercise were those that are linked to health and fitness benefits in older adults (Newson & Kemps, 2007). The potential health benefits of this intervention study are vast, which could have enhanced adherence to this exercise programme. Furthermore, exercise sessions of our study were performed in small groups of six people, allowing for social interactions. It has been well documented that individuals' compliance to exercise programmes are greatly increased if social interactions and social integration are well maintained during the exercise programme (Duncan & McAuley, 1993). The intended participants for this intervention study were aged 50-69 years, therefore it was expected that the majority of participants were still in the work force. For individuals who work full-time, time might be a compliance issue. However, this study offered the opportunity for testing and exercise sessions to occur within the premises of participating companies if a suitable room can be provided, allowing participants to participate in the intervention study without having to travel. Furthermore, exercise sessions were only 40 minutes long and could therefore occur during lunch time hours. Participants were also offered the opportunity to attend a different exercise session if they were unable to participate in their usual timeslot. Attendance rate of each participant was recorded at each session. To further examine the efficacy of the intervention, all women who participated in the intervention group of the exercise intervention study were contacted via email after completing the intervention. Each e-mail included a link to an online questionnaire created with google forms. Questions were developed by two authors (AF, SS). Questions asked participants to discuss their current physical activity levels, their perceptions of various components of the mini trampoline, exercise intervention and their future physical activity plans. All 13 questions were open ended and anonymous. Since questions were open ended, participants were able to provide more than one answer for each question. Excel (Version 2002) was used for data management of participants' responses. Principles of thematic analysis were used to analyse participants' open ended responses from the questionnaire (Green & Thorogood, 2005). Answers for each question were independently coded by two coders (AF, ER) into themes. A thematic framework was utilised whereby each response was coded and categorised into a higher order theme. The two coders discussed the thematic coding for every individual response to each question until 100% agreement was achieved. Each question resulted in a varying number of themes in which illustrative responses were identified for each of the higher order themes.

## Statistical analysis

To address both primary aims, standard t-tests analysed any significant differences between the intervention group and control group baseline characteristics. A series of 2 (Group: Control vs Intervention) x 3 (Test: baseline, post-assessment, follow-up) repeated measures ANOVA analysed each of the dependent variables: resting heart rate, resting blood pressure, BMI, maximal voluntary PFM contraction, maximal effort cough, urinary incontinence, bone mineral density, aerobic fitness, walking speed, lower extremity strength, flexibility, and balance (static and dynamic). Data were analysed using SAS (version 9.3; SAS Institute Inc., Cary, NC), with a significance level set at $\alpha$=.05.

## Discussion

The ability to live independently becomes increasingly important in modern society as the population ages. New Zealand district health boards spent over $900 million on support services, and specifically residential care, for older people in 2014/2015 alone ("DHB spending", 2016). It is not just a financial burden on the government but more importantly has detrimental health impacts on the individual and reduces overall quality of life. People who live in retirement villages and residential care are often away from their former homes and neighbourhoods as well as separated from their extended families. It is therefore not uncommon for residents to become lonely, which often directly contributes to depression and reduction in quality of life (Noro & Aro, 1996). Furthermore, a decline of functional fitness has been associated with a decline of overall quality of life (Maria, Therese, Dawn, & Astrid, 2018). Thus, functional ability is a key factor for older individuals to both maintain independent living and participate in family and community services (Christensen et al., 2006).

This study aimed to improve functional ability in older adults with an innovative and fun exercise programme that is new to most people and thus had the potential to increase adherence. The mini trampoline exercise programme also had the potential to improve specific risk factors in aging women, which include bone health and pelvic floor muscle functioning. Improving any or all of these functions could in turn improve overall quality of life and help to maintain an independent living situation in the older population. Results of this study could help guide the development of exercise intervention for older adults and particularly for older women with specific health risks.

## Implications

This study addressed the health and wellbeing of healthy postmenopausal women, aiming to improve female specific health risk factors and functional fitness. Extending the knowledge of a mini trampoline exercise intervention in this population group could potentially improve health benefits in postmenopausal women, increasing their physical function and overall quality of life and decreasing the effects of age-related functional decline.

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# Chapter 5

## Mini trampoline jumping to improve female specific health risk factors in postmenopausal women

### Abstract

Mini trampoline jumping is a highly beneficial low-impact aerobic exercise capable of potentially improving female-specific health risk factors. The aim of this research was to examine the benefits of a 3-month mini trampoline exercise intervention on bone mineral density and pelvic floor muscles functioning in postmenopausal women. Thirty-seven healthy postmenopausal women were recruited and participated in the 12-week mini trampoline exercise intervention. Baseline, post-intervention, and 3-month follow-up assessments included bone mineral density, pelvic floor muscles functioning, and urinary incontinence. BMD increased significantly at post-intervention compared to the control group. The exercise group demonstrated decreased SUI scores at post-intervention, with the difference being statistically significant at follow-up. No significant differences were found for the cough assessment or UUI scores. A mini trampoline exercise intervention has the potential to improve female-specific health risk factors in postmenopausal women.

Keywords: urinary incontinence, bone density, menopause, pelvic floor, exercise

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## Introduction

The health status of women is a major public health concern. Although women are expected to live longer, women are generally in worse health than men (Bergland & Engedal, 2011). Compared to men, postmenopausal women report greater levels of depression, physical disability, and physical performance (MacLean et al., 2008; McGarry & Kiel, 2000). Menopause, which occurs at an average age of 51 years, greatly affects overall bone mass loss and osteoporosis (McGarry & Kiel, 2000). With a loss of bone mass the risk of fractures, disability, and chronic pain significantly increases. Importantly, decreased bone mass significantly increases the risk of fractures, disability, and chronic pain (MacLean et al., 2008).

Urinary incontinence is often further classified into stress urinary incontinence, urge urinary incontinence and overflow urinary incontinence. The most common form of urinary incontinence is stress urinary incontinence and women largely predominate this affected group (Weiss, 1998). Stress urinary incontinence (SUI) can be defined as an involuntary loss of urine that commonly occurs during some form of physical exertion and effort or during sneezing and coughing (Norton & Brubaker, 2006). SUI can lead to serious medical conditions like urinary tract infections and perineal rash but also to social problems, creating embarrassment and reducing social interactions and physical activity (Bø, 2004a). The pelvic floor musculature commonly weakens with age due to sarcopenia, childbirth trauma, and menopause, although the full effects of menopause and loss of pelvic floor tissues are not yet clearly understood (Seshan, AlKhasawneh, & Al Hashmi, 2016).

It is well understood that regular physical activity can minimize the physiological effects of aging as well as improve bone health and stress urinary incontinence symptoms (Bø, 2004b; Ciolac, 2013; Norton & Brubaker, 2006). Exercise interventions targeting the pelvic floor muscles have been shown to improve pelvic floor muscles (PFM), urinary incontinence symptoms and quality of life measures in older women (Ferreira, Santos, Duarte, & Rodrigues, 2012; Kim, Yoshida, & Suzuki, 2011). Even interventions that produced co-contractions of PFM improved PFM strength and urinary incontinence symptoms (Bø, 2004a). Although it is difficult to significantly improve bone mineral density in postmenopausal women, bone mineral density can be maintained through muscle-tendon-bone interaction during exercises (Marques et al., 2011). Even low-intensity exercise may improve bone mineral density in sedentary, elderly women, thus highlighting the importance of exercise for women in postmenopausal ages to maintain or even improve bone health (McGarry & Kiel, 2000).

Mini trampolines are relatively inexpensive, small, portable, and offer many benefits, particularly as a low impact exercise, while being able to be performed in small confined spaces, including at home (Weston, 2001). Mini trampoline exercise programmes improve physical fitness but also female specific health risk factors (Aragão, Karamanidis, Vaz, & Arampatzis, 2011). Results from one study concluded that even though mini trampoline exercise is considered to be of low impact, several bone health markers improved following the exercise programmes (Namboolu, Bunyaratavej, & Kritpet, 2012). However, research was only conducted on healthy young women without documented benefits in older cohorts. Jumping on a mini trampoline can significantly stimulate PFM activity in healthy adults (Saeuberli, Schraknepper, Eichelberger, Luginbuehl, & Radlinger, 2018), however it is not yet known if mini trampoline exercises also strengthen the PFM in women at risk of, or diagnosed with, urinary incontinence.

The aim of this research was to examine the benefits of a 12-week mini trampoline exercise programme on female specific health risk factors in postmenopausal women. Specifically, this research examined the benefits on bone mineral density and pelvic floor muscle functioning as well as urinary incontinence. It was hypothesised that a 12-week mini trampoline exercise programme can maintain bone mineral density in postmenopausal women and improve PFM functioning as well as urinary incontinence.

## Methods

This study was 3-month mini trampoline exercise intervention with assessments one week prior (baseline), within one week following (post-intervention), and 3 months following (follow-up) the intervention. While the intervention included a range of outcome variables, for the purpose of our study aim, this analysis only focuses on those variables that directly impact female-specific healthy aging. The study gained ethical approval from the institutional Research Ethics Committee (Southern A 18/52) and all participants provided informed consent prior to baseline testing following an informational meeting. The informational meeting occurred prior to the first testing session, wherein participants learned the structure and function of pelvic floor musculature to help create awareness of this muscle group.

### Participants

Participants were recruited via social media and flyers in community and sport centres. Participants were included if they were female and aged 50-69 years, healthy and postmenopausal for at least 12 months, able to walk independently without any aid, agreed not to take bone altering medication and supplements, and able to travel independently to research and exercise sites. Exclusion criteria included any neuromuscular conditions (e.g., multiple sclerosis), lower extremity bone fractures or knee and hip replacements within the last 12 months, uncontrolled hypertension and cardiovascular diseases, as well as severe lower extremity arthritis and orthopaedic diseases. Sample size was estimated previously to be 10 in control group and 40 in the intervention group (Fricke et al., 2021a). Recruitment delays and COVID19 lockdown events restricted recruitment to a total of 37 women, who self-assigned to the control (n=8) or intervention group (n=29). Because mini trampoline jumping is a novel intervention, it was important to have the females self-select to do this exercise (Oliveira, Deslandes & Santos 2015). Post-hoc analysis on the current cohort confirmed acceptable statistical power for the measures of interest.

## Procedures

Participants' demographic information included height, weight, and body mass index (BMI). Height was measured to the nearest 0.1 cm with a Harpenden stadiometer (Holtain Ltd, Wales). Body mass was measured to the nearest 0.1 kg using an electronic scale. These measurements were then used to calculate BMI (kg/m2). Outcomes included PFM function, bone mineral density, and urinary incontinence. Pelvic floor muscle function was examined via surface electromyography (EMG) (Noraxon, Arizona, USA). During the testing session, participants were provided with verbal instructions to insert the vaginal probe (TensCare Liberty Vaginal probe, TensCare, Epsom, UK) as they would insert a tampon, with the two conducting plates placed facing the right and left sides of the body. Maximum voluntary contraction (MVC) of the PFM was performed from a standing position for 10 seconds. Participants then performed three maximal effort coughs. Testing was repeated three times for the MVC and for the maximal effort coughs with one-minute rest breaks between each trial. This protocol aligns with previously validated and reliable protocols (Koenig, Luginbuehl, & Radlinger, 2017; Peschers et al., 2001). EMG data analysis was performed with MyoResearch (Noraxon Inc, USA) and data were recorded at a sampling frequency of 1000Hz. EMG data were processed with a Butterworth High pass filter (cut-off: 5Hz), full wave rectification and a Butterworth Low-pass filter (cut-off: 400Hz). Data were smoothed using 50ms RMS envelopes and normalised to the peak of the MVC according to Pereira-Baldon et al. (2020). Normalised amplitude was recorded as a mean across all trials. Calcaneal bone health (bone mineral density; BMD) was assessed via quantitative ultrasound (QUS) (Sahara Clinical Bone Sonometre Hologic Inc, USA). Participants were seated on a chair while the participant's right foot was cleaned. Ultrasound gel was applied to the pads of the transducers of the ultrasound machine prior to testing. The right foot was then placed on the ultrasound machine; direct contact was ensured between the transducer pads and the heel. The device directly measured broadband ultrasound attenuation (BUA) and speed of sound (SOS). The Sahara ultrasound machine estimated BMD using the following calculation:

Estimated heel BMD = 0.0025926 x (BUA + SOS) x 73.687. Normative estimated BMD values using QUS measurements have been reported in women aged 50-59years (0.501±0.108g/cm2) and 60-69 years (0.452±0.105g/cm2) (Sosa et al., 2002).

The degree of urinary incontinence was measured with the female questionnaire for urinary incontinence diagnosis. The survey is a short 6-item urinary incontinence symptoms questionnaire, which has measurement reliability and validity in determining urinary incontinence type and symptom frequency before and after a treatment (Bradley et al., 2010). Each item has 6 frequency-based options, which are scored from 0 to 5 points. Scores are then added and can range from 0 to 15 total points for a stress urinary incontinence (SUI) score and urge urinary incontinence (UUI) score (Bradley et al., 2010). Participants in the intervention group exercised on a mini trampoline for 12 weeks, with 40-minute sessions three times a week. Exercises were performed on a 91.5 cm wide mini trampoline with handlebars (HART SPORT, Auckland NZ). During the exercise program, participants were encouraged to perform exercises without holding onto the handlebar; however, their capacity to do so was dependent on individual ability, progress and confidence. Exercises were performed in small groups with a maximum of six participants in each group. Participants wore heart rate monitors during the exercise sessions. To ensure that the exercise was at a moderate exercise intensity, heart rate was maintained between 60-75% of the age predicted maximum heart rate (HRmax = 208 – 0.7 x age) (Riebe et al., 2018). Mini trampoline exercises concentrated on movements to improve aerobic fitness, flexibility, lower extremity strength and balance, as well as PFM activation. Exercises were chosen for their ability to scaffold in progression throughout the program. Specifically, exercises started with simple and basic movements and progressed to more challenging and interactive tasks throughout the 12 weeks. A detailed list of exercises can be found in table 5.1 (Fricke et al., 2021b).

Table 5.1. 12-week mini trampoline exercise intervention programme

| Weeks | Warm-up | Exercises | Cool-down |
|---|---|---|---|
| **1-3** | • 5 minutes dynamic stretching | • Heel lifts (not airborne)<br>• Knee raises (not airborne)<br>• Light bouncing with feet shoulder width apart (not airborne)<br>• Light bouncing with feet in walking stance (not airborne)<br>• Small step back and forth (walking stance)<br>• Small step sideways<br>• Jogging in place<br>• Bouncing with both feet | • 5 minutes stretching focusing on lower body and lower torso |
| **4-6** | • 4 minutes dynamic stretching and 1-minute light bouncing on trampoline | • Heel lifts (airborne)<br>• Knee raises (airborne)<br>• One leg stance light bounce (not airborne)<br>• Bouncing with both feet and arm punches<br>• Soft ball between knees and light bouncing<br>• Soft ball between knees and light bouncing adding rotation<br>• Soft ball between knees and bouncing (airborne)<br>• Jumping jacks (holding onto handrail) | • 5 minutes stretching (all body) |
| **7-9** | • 4 minutes dynamic stretching and 1-minute light bouncing on trampoline | • Bouncing with both feet half rotations<br>• Scissor steps bouncing back and forth<br>• Bouncing on one leg<br>• Softball between knees, bouncing high<br>• Bouncing on both feet punching arms (including hand weight)<br>• Jogging with bicep curls (including hand weight)<br>• Light squad jumps (not airborne)<br>• Jumping jacks | • 5 minutes stretching (all body) |
| **10-12** | • 4 minutes dynamic stretching and 1-minute light bouncing on trampoline | • Ball between knees light squad bouncing<br>• Ball between knees squad bouncing<br>• Bouncing on one leg, bicep curl with contralateral arm (including weight)<br>• Heel raise alternating legs with alternating punching arms (including weight)<br>• Knee raises with rotation<br>• Scissor jumps back and forth (including hand weights)<br>• Lateral bouncing with feet together<br>• Jumping jacks (including hand weight) | • 5 minutes stretching (all body) |

During the 3-month period following the exercise program, participants were instructed to continue their lifestyle activities as they desired.

### Data analysis

Baseline group contrasts were analysed using paired sample t-tests. Estimates of the effect of treatment on outcomes were analysed using liner mixed model analysis of covariance. Within the model, the Pre-intervention score was the numeric covariate. In the random effects model, separate variability was assigned to the control group justified based on the higher SD. The random coefficients model was unstructured. Outcomes were presented as least-squares means estimates and 95% confidence interval. Statistical significance was set at the conventional 5% rejection threshold. All analyses were conducted in SAS (version 9.3; SAS Institute Inc., Cary, NC.

## Results

Participant characteristics at baseline are found in Table 5.2. No significant differences at baseline were found between the intervention and control groups. Furthermore, no significant differences at baseline were found between the intervention and control groups during the cough assessment (p=0.67), BMD (p=0.43), SUI (p=0.37), and UUI (p=0.16). 9 Twelve weeks of mini trampoline exercise significantly increased BMD at post-intervention (0.550g/cm2), relative to women in the control group (0.498g/cm2; p=0.02) (Table 5.3). The improvement in BMD continued to be significant at the 3-month follow-up, although the magnitude of difference between groups lessened at this later timepoint (group difference: 0.027 g/cm2; p=0.05). The exercise group demonstrated decreased SUI scores at post-intervention (-0.7; p=0.12), and the magnitude of the difference between groups became statistically significant at follow-up (-1.3; p=0.01). No significant differences were evident for the cough assessment or UUI scores.

Table 5.2. Participant characteristics at baseline

| | Intervention (n=29) | Control (n=8) | P value |
|---|---|---|---|
| **Age (y)** | 59.34 ± 5.82 | 57.12 ± 5.59 | P=0.344 |
| **Height (cm)** | 163.27 ± 6.52 | 165.62 ± 8.88 | P=0.501 |
| **Weight (kg)** | 76.71 ± 18.06 | 79.79 ± 18.99 | P=0.689 |
| **BMI** (kg/m²) | 27.62 ± 7.85 | 29.04 ± 7.05 | P=0.632 |

Table 5.3. Effect of 12-week trampoline intervention on BMD, SUI, UUI, and Cough outcomes

| | | Post Treatment LSmean Group Scores (95% Confidence Limits) | | | | Group (Int-Con) LSmean Differences (95% Confidence Limits) | | | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | Group and Time | Estimate | Lower | Upper | Contrast | Estimate | Lower | Upper | |
| **BMD ($g/cm^2$)** | INT Post | 0.550 | 0.535 | 0.564 | Difference @ Post | 0.051 | 0.012 | 0.090 | 0.02 |
| | INT Follow-up | 0.525 | 0.511 | 0.539 | Difference @ Follow-up | 0.027 | -0.000 | 0.053 | 0.05 |
| | CON Post | 0.498 | 0.459 | 0.538 | Total Difference | -0.025 | -0.073 | 0.024 | 0.28 |
| | CON Follow-up | 0.498 | 0.473 | 0.524 | | | | | |
| **SUI (score)** | INT Post | 2.2 | 1.2 | 3.1 | Difference @ Post | -0.7 | -1.6 | 0.2 | 0.12 |
| | INT Follow-up | 2.4 | 1.5 | 3.4 | Difference @ Follow-up | -1.3 | -2.2 | -0.5 | 0.01 |
| | CON Post | 2.9 | -2.7 | 8.6 | Total Difference | -0.6 | -1.8 | 0.5 | 0.26 |
| | CON Follow-up | 3.7 | -1.3 | 8.8 | | | | | |
| **UUI (score)** | INT Post | 2.7 | 1.8 | 3.7 | Difference @ Post | 1.8 | -1.1 | 4.6 | 0.18 |
| | INT Follow-up | 2.6 | 1.6 | 3.5 | Difference @ Follow-up | 0.9 | -2.3 | 4.0 | 0.52 |
| | CON Post | 0.9 | -2.0 | 3.8 | Total Difference | -0.9 | -2.1 | 0.3 | 0.12 |
| | CON Follow-up | 1.7 | -1.5 | 4.8 | | | | | |
| **Cough (%)** | INT Post | 50.8 | 43.1 | 58.5 | Difference @ Post | 4.1 | -3.9 | 12.0 | 0.31 |
| | INT Follow-up | 47.5 | 40.0 | 55.3 | Difference @ Follow-up | 1.1 | -14.6 | 14.9 | 0.98 |
| | CON Post | 42.6 | 17.9 | 67.3 | Total Difference | -4.0 | -20.1 | 12.1 | 0.63 |
| | CON Follow-up | 43.2 | 18.0 | 68.5 | | | | | |

Data are least-squares mean (LSmean) estimates and 95% confidence limits adjusted for pre-intervention baseline within the random effects mixed model ANCOVA. Differences at post-intervention and 3-month follow-up were calculated as Intervention-Control. Total Difference was calculated as Intervention (Follow-up – Post) – Control (Follow-up – Post). Abbreviations. BMD, bone mineral density; Diff, differences; SUI, stress urinary incontinence; UUI, urgency urinary incontinence; INT, intervention group; CON, control group

## Discussion

This research examined potential female-specific health benefits of a 12-week mini-trampoline exercise program in postmenopausal women. Significant improvements in the intervention group were found in stress urinary incontinence scores and BMD following the intervention compared to the control group. However, the exercise intervention produced no significant change in UUI or PFM activation during the cough, relative to the control group. Although mini trampoline jumping is often considered low-impact exercise, calcaneal BMD scores increased significantly in the intervention group compared to the control group. Schiehll et al. (2019) found that while some mini trampoline exercises show similar impact forces to movements normally classified as low impact, most impact forces during mini trampoline exercises are more similar to high impact movements. It is likely that the continuous reaction forces applied through the calcaneus, as well as the contact forces between extrinsic foot musculature and the calcaneus, stimulated bone metabolism in the calcaneus. In contrast to our findings, Posch et al. (2019) found no significant difference in femoral neck and lumbar spine BMD following a 12-week mini trampoline exercise program in older women with osteopenia. However, Posch et al. (2019) included an older cohort (mean age 69.6± 5.3y) and required a diagnosis of osteopenia. Participants in our study may have been able to sustain increased mechanical loading, at least at the calcaneus. A mini trampoline exercise intervention could improve lower limb bone mineral density in postmenopausal women. It is important to note, however, that while BMD was still higher than previously reported normative values at the 3-month follow-up, (Sosa et al., 2002) the mean differences of BMD between intervention and control group approximately halved at follow-up. These results could highlight the importance of continuous weight-bearing exercise even in older age to maintain bone health.

Surprisingly, there was no significant difference found for the cough assessment, indicating no significant changes in PFM functioning. Previous research found that maximum PFM contraction is only possible with synergistic muscle co-contraction (Ayeleke et al., 2013; Bo et al., 2014). Muscles that co-activate with the PFM include abdominal muscles, adductor thigh muscles, and pelvic girdle muscles (Arab et al., 2010; Ayeleke et al., 2013; Halski et al., 2014; Madill & McLean 2008; Ptaszkowski et al., 2019). Furthermore, hip adductors are considered to act as synergists and may even increase contraction of the PFM (Ayeleke et al., 2013; Arab et al., 2010). Pelvic floor muscles exercises, even if performed indirectly via co-contraction of synergist muscles, could potentially improve functioning of the PFM by helping women with SUI contract pelvic floor musculature more quickly (Madill et al., 2010). The exercise intervention in this research did not isolate PFM. Instead, it included exercises whereby abdominal muscles and hip adductors were contracted and as a result should have caused co-contraction of the PFM. It is possible that the trampoline exercises used in the intervention did not produce a co-contraction of the PFM. Conversely, the exercises may have produced a co-contraction of the PFM, but the training magnitude was insufficient to cause significant changes in PFM amplitude.

The exercise intervention also showed a decrease of SUI scores at post-intervention and a significant decrease at follow-up compared to the control group. The results of a decrease in SUI score and no significant changes of PFM EMG amplitude could further support the hypotheses of Madill et al. (2010) that a reduction of PFM activation is not a major factor in stress urinary incontinence in women. Instead, it is suggested that timing of PFM activation in relation to intra-abdominal pressure is more important when predicting stress urinary incontinence (Madill et al., 2010). Unfortunately, our study was unable to examine timings of activation patterns during the cough, but the improvement of SUI scores seen in the intervention group with a lack of significant changes of PFM EMG amplitude could indeed indicate that improvements of SUI scores were due to changes in timing of PFM activation rather than amplitudes. In contrast, the UUI scores did not significantly change at post-intervention or follow-up. Although urge urinary incontinence can be improved with some behavioural interventions, UUI is driven more by the detrusor muscle of the urinary bladder (smooth muscle), and more effectively treated with medication rather than exercise interventions (Brown et al., 2006).

This intervention study did have some limitations. It is difficult to draw conclusions to a wider population as the sample size was relatively small, particularly in the control group. While randomisation is considered important from the perspective of bias, it is not without its limitations, and there are other study designs that are equally relevant (Deaton & Cartwright, 2018). Indeed, it could be argued that in the instance of exercise interventions, self-selection would be more ecologically valid as it would mimic choices made in real life (Andrade, 2018). Thus, participants were self-assigned rather than randomly selected to their group. Baseline measures showed no significant differences between the intervention and control groups, and therefore, bias was limited. To provide some data to answer questions of statistical power, we conducted a post-hoc power calculation based on the effect size and error of the Post-intervention BMD outcome. The resulting sample size for the same design was n=20 or 10 per group. While the results of this research indicate a positive proof of concept for the efficacy of mini trampoline jumping for older women specifically, these limitations serve as a call for further research to expand the generalizability of our findings. The control group did not actively participated in any other form of exercise intervention and it is therefore unclear if the mini trampoline exercises may have different results than other types of exercise interventions. Given the changes seen in our study, further research is warranted in understanding how mini-trampoline exercises might compare to more common or traditional physical activities. Caution should still be taken when interpreting the bone mineral density results as measurements where only taken on the calcaneus of one foot. However, previous research has indicated that qualitative ultrasound measures at the calcaneus were highly correlated to BMD in the hip (but not spine) in older postmenopausal women (Lappa et al., 2007). Measurements of PFM function still remain difficult. Firstly, maximal voluntary contractions of PFM can be difficult to perform for some women, thus a true reading of maximal voluntary contraction can often not be obtained. This research was also unable to examine the timing of PFM contraction during a cough; however, results could indicate that mini trampolining can potentially improve the timing of PFM activation rather than amplitudes. Future research could examine PFM as well as synergistic muscles contraction during mini trampoline jumping to establish the activation patterns during the actual exercise.

## Conclusion

This novel research examined the benefits of a 12-week mini trampoline exercise intervention on female-specific health factors in postmenopausal women. Women in the intervention group improved their stress urinary incontinence scores and bone mineral density measures compared to the control group. While these results are encouraging, a decline in calcaneal BMD difference between the intervention and control group at follow-up indicates the need to continue mini trampoline exercise in order to maintain the improvements in bone health.

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# Chapter 6

## Mini trampoline jumping to improve functional fitness in postmenopausal women


### Abstract

Mini trampoline jumping is a low-impact aerobic exercise capable of improving functional fitness. The aim of this research project was to examine the benefits of a 3-month mini trampoline exercise intervention in postmenopausal women on functional fitness A total of 37 postmenopausal healthy women (N=8 control, 29 intervention; Age: 58.8±5.7 y; Height: 163.8±0.1 cm; Weight:77.4±18.5 kg; BMI:28.6±6.3 kg/m$^2$) participated in this intervention study. The exercise intervention lasted for 12 weeks, with three 40-minute sessions per week. Assessments were performed within one week before (baseline), one week after (post-intervention), and 3-month after (follow-up) the intervention. Resting heart rate and blood pressure, the 6-minute walk test, 6-meter timed walk test, sit-to-stand test, and sit-to-reach test were used to assess aerobic fitness, walking speed, lower extremity strength, and flexibility respectively. Compared to baseline values, women in the intervention group showed significant improvements at the post-intervention assessment in resting heart rate (p=0.01), aerobic fitness (p<0.001), lower extremity strength (p<0.0001), walking speed (p=0.01), flexibility (p<0.0001). The follow-up assessment showed a significant decline from post-intervention in aerobic fitness (p=0.01), and a significant increase of resting heart rate (p=0.0013). The control group showed significant deterioration at the follow-up compared to baseline in resting heart rate (p=0.01) and significant improvements at follow-up compared to baseline in aerobic fitness (p=0.03) and lower extremity strength (p=0.01). The follow-up assessment indicated that in order to specifically maintain aerobic fitness and resting heart rate, continuation of the exercise intervention might be necessary. In contrast, improvements seen after the intervention in lower extremity strength, walking speed, and flexibility did not dissipate in the three months following programme completion. Thus, mini

trampoline exercise has the potential to significantly improve physical fitness in postmenopausal women.

Statement of contribution: Methodology design: Fricke A., Fink, P. W., Lark, S.D., Mündel, T., Shultz, S. P; Exercise intervention: Fricke A., Data collection: Fricke A.; Data processing: Fricke A., Fink P.W.; Data analysis: Fricke A., Rowlands D.S.; Write-up: Fricke A., Fink, P. W., Lark, S.D., Mündel, T., Shultz, S. P., Rowlands D.S.

## Introduction

The worldwide population of people aged ≥65 years is projected to triple from 524 million in 2010 to nearly 1.5 billion in 2050 (World Health Organization, 2015). Although women are expected to live longer, women are generally in worse health than men (Oksuzyan, Singh, Christensen, & Jasilionis, 2018). Compared to men, older women report greater levels of depression, physical disability, and physical performance (Oksuzyan et al., 2018). Currently, it is estimated that around 40% of women aged ≥65 years live alone (World Health Organization, 2015).

In order to maintain an independent lifestyle and continue being able to participate in family and community activities, it is important that older women maintain a good level of functional fitness. (Christensen, Støvring, Schultz-Larsen, Schroll, & Avlund, 2006). Functional fitness entails being able to rise from a seated to standing position, walk at fast speeds safely enough to cross a road, step onto or avoid raised objects, and maintain an upright posture (Peeters, Dobson, Deeg, & Brown, 2013). During aging, changes to the nervous, skeletal, muscular, and cardiovascular systems result in a decline of muscle strength, mass, power, and endurance, as well as cardiovascular fitness. A decline of functioning in these system can further result in limited mobility and activity by affecting balance, gait, and flexibility and thus increasing the risks of not being able to live independently and subsequently developing depression (Matsouka, Harahousou, Kabitsis, & Trigonis, 2003; Rice & Keogh, 2009).

Detriments to muscular structure and function are exacerbated with menopause, which can lead to a decrease in the quality of life in older women (Teoman, Özcan, & Acar, 2004). Postmenopausal women have lower oestrogen concentrations compared to premenopausal women. This lack of oestrogen is often associated with symptoms such as hot flashes, irritability, sleeping disorders, fatigue, anxiety, and loss of concentration in the early phases (Teoman et al., 2004). The risk of coronary artery disease, and particularly arterial stiffness, is increased and further reduces overall quality of life and physical fitness (Ho et al., 2020; Teoman et al., 2004). Participating in regular physical activity has long been recommended to reduce postmenopausal symptoms and increase physical functioning as well as quality of life (Shangold, Sherman, & DiNubile, 1998; Tolar, Teitelbaum, & Orchard, 2004).

Physical activity is considered to be the most important factor in promoting health and quality of life in the later years of life (Christensen et al., 2006). It is well known that regular physical activity and/or an exercise programme can minimise the physiological alterations that occur during aging and can improve physical functioning including cardiovascular health, muscular strength, balance, and flexibility (Hallage et al., 2010; Judge, Lindsey, Underwood, & Winsemius, 1993; Giovani, Nise, Ãlvaro, & Ronei, 2016; Silva et al., 2018). Novel high impact exercises such as Scottish dancing, step aerobics or paddle tennis, have demonstrated improvements in aerobic fitness and muscular strength in older women (Hallage et al., 2010; Courel-Ibáñez et al., 2018; Dewhurst, Nelson, Dougall, & Bampouras, 2014). However, high impact exercises can also increase the risk of injuries and falls in older women.

Mini trampolines offer all the benefits of a low impact exercise, are small, portable, comparatively inexpensive, and can be performed in small confined spaces, including at home (Weston, 2001). Mini trampoline exercises are capable of improving aerobic fitness, balance, muscle strength and postural control in younger and older adults (Aragão, Karamanidis, Vaz, & Arampatzis, 2011; Cunha et al., 2016; Giagazoglou et al., 2013; Maharaj & Nuhu, 2016; Miklitsch, Krewer, Freivogel, & Steube, 2013; Nuhu & Maharaj, 2017). Exercises incorporate a multi-component approach, affecting many physical factors including strength, body stability, muscle coordinative responses, joint movement amplitudes and spatial integration (Aragão et al., 2011). Several studies have examined the effects of a mini trampoline exercise intervention in older adults and concluded that a mini trampoline exercise intervention can greatly improve dynamic balance, lower leg strength, and cardiovascular fitness (Aragão et al., 2011; Hanachi & Kaviani, 2010; Maharaj & Nuhu, 2016). Although research on mini trampoline exercise intervention is still limited, it can be presumed that mini trampoline exercise is an enjoyable alternative aerobic exercise that could improve overall physical health and can safely be performed by middle aged and older people. The benefits of mini trampolining would be especially pertinent to post-menopausal women who are at greater risk of declining physical function; yet, no research so far has examined the benefits of a mini trampoline exercise programme on this cohort.

The aim of this research was therefore to examine the benefits of a 12-week mini trampoline exercise intervention in post-menopausal women on aerobic fitness, gait, lower leg strength, flexibility, and balance. It was hypothesised that the 12-week intervention can show meaningful improvements in aerobic fitness, lower leg strength, flexibility, and balance.

## Methods

This investigation was part of a larger study, which also included measurements on female specific health risk factors (Fricke, Fink, Mündel, Lark, & Shultz, 2021). The research design included a 3-month mini trampoline exercise intervention with assessments one week prior (baseline), one week following (post-intervention), and 3-months following the intervention (follow-up). The study gained institutional ethical approval from the Massey University Ethics Committee (Southern A 18/52) and all participants provided informed consent prior to the baseline testing. A total of 37 post-menopausal healthy women aged 50-69 years were recruited and assigned to a control group (N=8) or an intervention group (N=29). Participant characteristics at baseline can be found in table 6.1. Participants were included if they were female and aged between 50-69 years, post-menopausal for at least 12 months, able to walk independently without any aid, agreed not to take bone altering medication and supplements, and able to travel independently to research and exercise sites. Exclusion criteria included any neuromuscular conditions (such as multiple sclerosis), lower extremity bone fractures or knee and hip replacements within the last 12 months, uncontrolled hypertension and cardiovascular diseases, as well as severe lower extremities arthritis and orthopaedic diseases.

Table 6.1. Participant characteristics at baseline

| | Intervention (n=29) | Control (n=8) | P value |
|---|---|---|---|
| **Age (y)** | 59.3± 5.8 | 57.1 ± 5.5 | P=0.34 |
| **Height (cm)** | 163.3 ± 6.5 | 165.6 ± 8.8 | P=0.50 |
| **Weight (kg)** | 76.7 ± 18.1 | 79.8 ± 18.9 | P=0.69 |
| **BMI (kg/m$^2$)** | 27.6 ± 7.9 | 29.0 ± 7.1 | P=0.63 |

## Exercise intervention

Participants in the intervention group exercised in 40-minute sessions on a mini trampoline, three times a week for a total of 12 weeks. Mini trampoline exercises concentrated on movements to improve aerobic fitness, flexibility, lower extremity strength and balance. Exercises were chosen for their ability to scaffold in progression throughout the programme. Specifically, exercises started with simple and basic movements and progressed to more challenging and interactive tasks throughout the 12 weeks. A detailed list of exercises and their progressions can be found in Fricke, Fink, Lark, Mündel, & Shultz (2021).

Exercises were performed on a 91.5cm diameter mini trampoline with handlebars (HART SPORT, Auckland NZ). During the exercise programme, participants were encouraged to perform exercises without holding onto the handlebar; however, their capacity to do so was dependent on individual ability, progress and confidence. Exercises were performed in small groups with a maximum of six participants in each group. Participants wore heart rate monitors during the exercise sessions. For the exercise to be effective the heart rate was maintained between 60 - 75% of the age predicted maximum heart rate (HRmax = 208 – 0.7 x age).

## Outcome measures

### *Cardiovascular measures*

Participants rested supine for 10 minutes prior to assessment of resting heart rate in the same position. Blood pressure was measured manually by the same examiner in the seated position with the arm resting at the same level as the heart.

### *Aerobic Fitness*

The previously validated 6-minute walk test was used to assess aerobic fitness (Rikli & Jones, 1998). The test was performed indoors on a flat surface in a rectangular course (5 meters in length and 1 meter in width). Participants walked around the course perimeter as fast as they comfortably could for 6 minutes. The measured outcome was total distance covered at the end of the time period.

### *Walking speed*

Walking speed and lower extremity strength were assessed during a previously validated 6-meter timed walking test (Peters, Fritz, & Krotish, 2013). Participants walked a total of 10 meters (with 2 meters provided at the beginning and the end for acceleration and deceleration, respectively) at their comfortable walking speed on a flat and straight surface. Timing gates at the start and end of the 6 meters recorded the time. Three trials were performed with 30 seconds rest between each trial. Average walking speed was calculated across trials.

### *Lower extremity strength*

Lower extremity muscle strength was further assessed with the previously validated chair-based sit-to-stand-test (Jones, Rikli, & Beam, 1999). Participants were seated on a standardised chair that was 40cm high and repeatedly stood up from the seated position 10 times as fast as possible. The time it took to sit and stand 10 times was recorded.

### *Flexibility*

Hamstring flexibility was assessed with the previously validated sit-and-reach test (Jones, Rikli, Max, & Noffal, 1998). Participants placed the soles of their feet against the sit-and-reach box and slowly reached forward with both hands as far as possible to a position that could be maintained for two seconds. Hands were in a parallel position to each other and fingertips in contact with the measuring tape of the sit-and-reach box. The score that was the most distant point reached with fingertips and held for 2 seconds was recorded in cm. The best out of three trials was recorded.

### *Balance*

#### *Dynamic balance*

Dynamic balance was assessed with participants standing on a force platform (AMTI, Watertown, MA, USA) with feet shoulder width apart and arms stabilised with the hands at the hip. Participants shifted their weight anteriorly and posteriorly, and then laterally to the right and left sides as far as possible while retaining their balance. Tasks were performed repeatedly over a period of 20 seconds, whereby participants shifted their weight in all directions as far and fast as possible during that time period. Maximal range of sway in the anterior-posterior as well as medial-lateral direction, and maximal velocity along the medial-lateral as well as anterior-posterior axis were assessed. Centre of pressure measurements have been deemed valid and reliable in testing balance in older adults (Li, Liang, Wang, Sheng, & Ma, 2016).

#### *Static balance*

Static balance was measured during a two-legged stance with participants standing on the force platform shoulder width apart with eyes closed for 30 seconds. Three trials for each condition were recorded. Balance was estimated by using the standard deviation of the centre of gravity in the x (medial-lateral) and y (anterior-posterior) directions.

## Statistical analysis

Standard t-tests analysed any significant differences between the intervention group and control group baseline characteristics. A series of 2 (Group: Control vs Intervention) x 3 (Test: baseline, post-assessment, follow-up) repeated measures ANOVA analysed each of the dependent variables: resting heart rate, resting blood pressure, BMI, aerobic fitness, walking speed, lower extremity strength, flexibility, and balance (static and dynamic). Data were analysed using SAS (version 9.3; SAS Institute Inc., Cary, NC), with a significance level set at $\alpha$=.05.

## Results

Results of functional fitness measures are displayed in table 6.2. There was a significant group*session interaction effect for resting heart rate (p=0.04), diastolic blood pressure (p=0.04), the 6-minute walk test (p=0.01), the 6-meter walk test (p=0.02), and the sit-to-reach test (p<0.0001). Resting heart rate decreased significantly in the intervention group between baseline and post-intervention (p=0.04) but increased significantly from post-intervention to follow-up (p=0.01). Resting heart rate for the control group increased significantly from baseline to follow-up (p=0.01), as well as from post-intervention to follow-up (p=0.04). Distance covered in the 6-minute walk test increased significantly in the intervention group at the post-intervention assessment (p<0.001) but decreased significantly in the follow-up compared to post-intervention (p=0.01). However, overall distance covered at the follow-up was still significantly higher compared to the baseline assessment (p=0.02). Distance covered in the 6-minute walk test in the control group increased significantly from post-intervention to follow-up (p=0.03) as well as baseline to follow-up (p=0.01). Average walking speed measured during the 6-meter timed walk test increased significantly in the intervention group from baseline to post-intervention (p=0.01). More importantly participants were able to maintain their walking-speed in the follow-up (p=0.10), and significant differences between baseline and follow-up remained (p=0.01). Participants from the intervention group were able to perform the chair-to-stand test in significantly less time post-intervention compared to baseline (p<0.0001). Significant decreases remained at follow-up, compared to baseline (p<0.0001). The control group performed the chair-to-stand test significantly faster at follow-up compared to baseline (p=0.01). A significantly greater amount of hamstring flexibility was shown at the sit-to-reach test for the intervention group post-intervention compared to baseline (p<0.0001), and flexibility was retained at the follow-up with significant differences between baseline and follow-up (p<0.0001).

Table 6.2. Functional fitness results

| | Intervention group | | | Control group | | |
|---|---|---|---|---|---|---|
| | *Baseline* | *Post-Intervention* | *Follow-up* | *Baseline* | *Post-Intervention* | *Follow-up* |
| ***BMI (kg/m2)*** | 28.74 ± 1.11 | 28.55 ± 1.12 | 28.68 ± 1.15 | 27.65 ± 1.93 | 27.62 ± 2.03 | 27.87 ± 2.05 |
| ***Waist/Hip*** | 0.79 ± 0.01 | 0.80 ± 0.01 | 0.80 ± 0.01 | 0.81 ± 0.01 | 0.81 ± 0.01 | 0.81 ± 0.01 |
| ***Resting HR (bpm)*** | 69.28 ± 1.69 | 64.14 ± 1.69*^ | 71.67 ± 2.22 | 66.41 ± 3.09 | 71.11 ± 4.40^ | 75.88 ± 4.13[#] |
| ***Resting diastolic BP (mm/Hg)*** | 83.64 ± 1.61 | 82.57 ± 1.74 | 83.39 ± 1.80 | 91.06 ± 3.43 | 87.74 ± 4.04 | 78.38 ± 3.08 |
| ***Resting systolic BP (mm/Hg)*** | 130.82 ± 2.92 | 130.36 ± 2.61 | 126.96 ± 2.75 | 132.32 ± 6.37 | 130.05 ± 6.15 | 118.61 ± 5.74 |
| ***6-Minute walk test (distance in meters)*** | 354.32 ± 8.51 | 398.11 ± 8.31*^ | 378.68 ± 8.68[#] | 312.60 ± 21.33 | 355.45 ± 22.38^ | 390.82 ± 8.03[#] |
| ***6-meters walk test (kph)*** | 5.94 ± 0.15 | 6.32 ± 0.18* | 6.49 ± 0.15[#] | 6.16 ± 0.16 | 6.07 ± 0.22 | 6.30 ± 0.21 |
| ***Chair-to-stand (seconds)*** | 24.16 ± 0.94 | 19.44 ± 0.92* | 19.24 ± 0.75[#] | 20.39 ± 2.17 | 17.96 ± 1.31 | 17.55 ± 1.54[#] |
| ***Sit-to-reach (cm)*** | 19.42 ± 1.56 | 22.75 ± 1.62* | 22.17 ± 1.57[#] | 16.36 ± 4.48 | 13.56 ± 4.69 | 13.09 ± 4.58 |

Note. BMI: body mass index; HR: heart rate; BP: blood pressure. *Significant difference between baseline and post-intervention. ^Significant difference between post-intervention and follow-up. [#]Significant difference between baseline and follow-up

Table 6.3. Dynamic balance results

| | Intervention group | | | Control group | | |
|---|---|---|---|---|---|---|
| | *Baseline* | *Post-Intervention* | *Follow-up* | *Baseline* | *Post-Intervention* | *Follow-up* |
| ***Range in x-direction (m)*** | 0.13 ± 0.03 | 0.15 ± 0.01*^ | 0.16 ± 0.01 | 0.15 ± 0.01 | 0.14 ± 0.02 | 0.16 ± 0.02 |
| ***Range in y-direction (m)*** | 0.21 ± 0.05 | 0.24 ± 0.04* ^ | 0.26 ± 0.04# | 0.24 ± 0.02 | 0.24 ± 0.06 | 0.26 ± 0.04 |
| ***Maximum velocity y+ (m/s)*** | 0.25 ± 0.11 | 0.27 ± 0.12 | 0.30 ± 0.12# | 0.25 ± 0.10 | 0.30 ± 0.14 | 0.26 ± 0.08 |
| ***Maximum velocity y- (m/s)*** | 0.26 ± 0.11 | 0.30 ± 0.13*^ | 0.34 ± 0.12# | 0.28 ± 0.09 | 0.31 ± 0.28* | 0.28 ± 0.09 |
| ***Maximum velocity x+ (m/s)*** | 0.17 ± 0.07 | 0.19 ± 0.07*^ | 0.24± 0.10# | 0.18 ± 0.05 | 0.23 ± 0.07 | 0.23 ± 0.10 |
| ***Maximum velocity x- (m/s)*** | 0.23 ± 0.09 | 0.27 ± 0.10* | 0.30 ± 0.10# | 0.25 ± 0.10 | 0.29 ± 0.07 | 0.29 ± 0.12 |

*Significant difference between baseline and post-intervention. ^Significant difference between post-intervention and follow-up. #Significant difference between baseline and follow-up

Table 6.3 shows the results and significant difference of the dynamic balance assessments. Significant group*session interaction effects during the dynamic balance tests were found at the displacement in the x-axis (medial-lateral direction) (p= 0.01), y-axis (anterior-posterior direction) (p= 0.01), and at the maximal velocity in the negative y direction (p=0.02). No significant differences for the control group were found. The intervention group significantly increased distance moved in the x-axis (p<0.0001) and y-axis (p= 0.01) between baseline and post-intervention. Similarly, the intervention group significantly increased the maximal velocity in the negative y direction (0.02), positive x direction (p=0.04), and negative x direction (p=0.01) at post-intervention compared to baseline. Significant differences remained at follow-up (compared to baseline) for displacement in the y-axis (p<0.0001) and x-axis (p<0.0001), while the maximal velocity significantly increased from baseline to follow-up in the positive y direction (p= 0.01), negative y direction (p<0.0001), and positive x direction (p<0.0001). The intervention group also showed significant improvements from post-intervention to follow-up for displacement in the x-axis (p=0.02) and y-axis (p=0.04), as well as maximal velocity in the negative y direction (p=0.03), positive x direction (p=0.01), and the negative y direction (p<0.0001). Significant difference for the control group were only found at the maximal velocity in the negative y direction (p=0.03) between baseline and post-intervention.

No significant differences in the static balance test with eyes open were found (Table 6.4). The intervention group demonstrated significant improvements in the x- and y-directions during the static balance test with eyes closed between post-intervention and follow-up (p<0.01). Significant improvements remained in the y-direction for the intervention group from baseline to follow-up (p<0.01) (Table 6.5). No significant differences in the static balance assessments were found for the control group.

Table 6.4. SD values in the x, y, and d direction for the static balance with eyes open

| | **Baseline** | | **Post-intervention** | | **Follow-up** | |
|---|---|---|---|---|---|---|
| | *Intervention* | *Control* | *Intervention* | *Control* | *Intervention* | *Control* |
| **SDx** | 0.0055 ± 0.0026 | 0.0053 ± 0.0007 | 0.0053 ± 0.0026 | 0.0057 ± 0.0025 | 0.0055 ± 0.0025 | 0.0050 ± 0.0029 |
| **SDy** | 0.0046 ± 0.0073 | 0.0029 ± 0.0006 | 0.0031 ± 0.0045 | 0.0040 ± 0.0052 | 0.0041 ± 0.0053 | 0.0048 ± 0.0056 |

SD=Standard deviation

Table 6.5. SD values in the x, y, and d direction for the static balance with eyes closed

| | **Baseline** | | **Post-intervention** | | **Follow-up** | |
|---|---|---|---|---|---|---|
| | *Intervention* | *Control* | *Intervention* | *Control* | *Intervention* | *Control* |
| **SDx** | 0.0078 ± 0.0032 | 0.0049 ± 0.0010 | 0.0089 ± 0.0079^ | 0.0054 ± 0.0018 | 0.0063 ± 0.0029 | 0.0053 ± 0.0021 |
| **SDy** | 0.0103 ± 0.0452 | 0.0092 ± 0.0018 | 0.0093 ± 0.0106^ | 0.0049 ± 0.0023 | 0.0041 ± 0.0052 | 0.0040 ± 0.0053 |

SD=Standard deviation. ^Significant difference between post-intervention and follow-up. #Significant difference between baseline and follow-up.

## Discussion

This research examined the potential benefits of 12-week mini trampoline exercise programme in postmenopausal women and functional fitness. Specifically, this research found the 12-week mini trampoline exercise intervention was effective in improving resting heart rate, diastolic blood pressure, aerobic fitness, average walking speed, flexibility, and dynamic balance compared to no structured exercise. Furthermore, the intervention group alone saw significant improvements in all outcome measures except weight, BMI, blood pressure, and waist-to-hip ratio. As the goal of this intervention was to improve physical fitness rather than weight-loss, no weight-loss plan was included in this study; thus no differences in weight, BMI, or waist-to-hip ratio were expected.

A high resting heart rate, particularly in older adults, has been associated with cardiovascular risk factors such as metabolic disorders, abdominal obesity, and higher blood pressure (Ehrenwald et al., 2019; Farah et al., 2015; Palatini, 2013). While some studies reported a significant decline of resting heart rate in young-to-middle aged adults following an exercise programme (Carter, Banister, &

Blaber, 2003; Wilmore, Stanforth, Gagnon et al. 1996) others have reported no changes in resting heart rate in older adults following an exercise programme (Carroll, Convertino, Pollock, Graves, & Lowenthal, 1995; Perini et al., 2002). O'Hartaigh et al (2014) recently highlighted the importance of examining the effects of aerobic training programmes in resting heart rate values in older people. Although the 12-week mini trampoline exercise intervention was relatively short, women in this study reported significantly lower resting heart rate and blood pressure values following the exercise intervention. Mini trampoline exercises involve the entire body and improvements in cardiovascular fitness are believed to be due to the cyclical jumping on the elastic surface that facilitates musculoskeletal function of the entire body and with that an increased heart rate and respiratory rate. Together, these functions facilitate an improvement in vascular function of the entire body (Maharaj & Nuhu, 2016) even in postmenopausal women who are at higher risk of coronary artery disease.

Average walking speed is influenced by lower limb flexibility and strength (Klein, Stone, Phillips, Gangi, & Hartman, 2002; Kulkarni & Fernandes, 2017). Muscular weakness in the lower limbs of older adults can often lead to gait patterns that are associated with postural instability, which increases the risks of falls and a decreased quality of life (Correa, Cunha, Marques, Oliveria-Reischak, & Pinto (2016). An increase in physical activity is correlated with greater muscle strength and several exercise interventions have shown significant improvements in muscle strength in older women (Rantanen, Era, & Heikkinen, 1994). Muscles and fascia are also responsible for at least 40% of a joint's resistance to movement, suggesting that any exercise can lead to training-mediated reduction in passive tension and stiffness of these tissues and translate into grater range of motion (Carneiro et al., 2015). Participants in this study showed significant improvements of lower limb strength and hamstring flexibility, which subsequently resulted in significant improvements of walking speed. These results support the findings of Posch et al. (2019), whereby lower extremity strength improved significantly following a 12-week exercise programme in older women with osteopenia. Previous studies have shown that an improvement of 0.36kph in average walking speed is substantial and can improve physical functioning and quality of life (Hardy, Perera, Roumani, Chandler, & Studenski, 2007;

Studenski et al., 2011). Participants in this study increased average walking speed by 0.38kph, thus this exercise intervention was highly effective in improving average walking speed. Furthermore, the 3-months follow-up showed no significant decline in lower leg strength, hamstring flexibility, or average walking speed, indicating that these positive training effects were maintained even after 3-months of not completing the exercise programme.

Average walking speed is also a good indicator of functional balance (Posch et al., 2019). Participants in the intervention group showed significant improvements in most of the dynamic balance assessments compared to the control group where significant improvements were only found at the maximal velocity in the y-direction at post-intervention compared to baseline. Participants who completed the exercise intervention were able to move further with increasing velocity, and the improvements of dynamic balance persisted at the 3-months follow-up. Exercises on unstable surfaces are commonly prescribed to improve balance, as they are highly integrative and place higher demands on the neuromuscular system (Kidgell, Horvath, Jackson, & Seymour, 2007). Previous studies have shown that a mini trampoline exercise programme can improve dynamic balance in older adults (Aragão et al., 2011; Hanachi & Kaviani, 2010). As postmenopausal women are at higher risk of osteoporosis compared to men, maintaining or improving dynamic balance becomes critical to decrease the risk of falls and consequent complications, such as bone fractures, which can greatly reduce overall quality of life (MacLean et al., 2008). Results of static balance in this exercise intervention however did not show any significant improvements post-intervention. Significant improvements for the intervention group were only found at the follow-up after the intervention was already completed. These results are similar to a recent study, which found no significant improvements in static balance following a trampoline exercise programme (Tay, Lin, Kee, & Kong, 2019). Similar to our study Tay et al. included healthy subjects without any balance impairments or any pre-existing conditions (Tay et al., 2019). It is possible that the women in our study already had sufficient levels of balance to perform the two-legged static balance test with ease and thus no further improvements could be found. Furthermore, trampoline exercises may also include exercises that are specific to dynamic conditions and have no large effect on static balance performance (Tay et al., 2019). Improvements at the follow-up for the intervention group however remain unexplained. Future studies should consider more challenging balance tasks to get a better representation of possible improvements in static balance.

## Limitations

This study is not without limitations. It is difficult to draw conclusions to a wider population as the sample size was relatively small, particularly in the control group. Furthermore, participants were assigned to the group via convenience rather than randomly. However, baseline measures showed no significant differences between the intervention and control group. This study also did not document the physical activity participation pattern of participants outside of the study. While none of the participants had previous experiences with mini trampoline jumping, it is possible that other physical activities might have influenced the responses to the intervention. However, all participants were encouraged to maintain their usual lifestyle habits throughout the entire study.

## Conclusion

This novel research examined the benefits of a 12-week mini trampoline exercise intervention on functional fitness in postmenopausal women. Women in the intervention group significantly improved resting heart rate, aerobic fitness, average walking speed, flexibility, lower extremity strength, and dynamic balance. Furthermore, significant improvements in aerobic fitness, average walking speed, flexibility, and lower extremity strength remained 3-months following the completion of the intervention. A mini trampoline exercise programme therefore has the potential to decrease the health risks associated with postmenopausal women by improving cardiovascular and functional fitness. Future studies should consider focusing on an even older population who is showing effects of aging already.

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# Chapter 7

## Perceptions of a 12-week mini trampoline exercise intervention for postmenopausal women*

### Abstract

Only 27% of older women meet the recommended daily activity goals. Mini trampoline exercise is a non-traditional option that may appeal to older women. The aim of this study was to examine the views and attitudes of postmenopausal women who participated in a mini trampoline exercise intervention. Twenty-nine postmenopausal women completed an open ended and anonymous questionnaire consisting of 13 questions about their current activity levels, their perceptions of the mini trampoline exercise intervention, and their future exercise plans. Principles of thematic analysis were utilised to analyse survey responses whereby each response was coded and categorised into a higher order theme. Attendance rate of the mini trampoline exercise intervention was 89.3%. Twenty-four percent of women's responses indicated they enjoyed the social interactions during the intervention. Most responses (89%) suggested it was easy to participate. The most salient barriers to participation included work (24%) and personal commitments (20%). Women's responses (43%) suggested they would participate in a similar exercise intervention if it were offered at a gym. The ideal frequency and duration of the programme was reported to be 3 times a week (59%) and 40 minutes per session (31%). Adherence to the mini trampoline exercise intervention was high and general attitudes were positive. Local gyms could consider implementing a flexibly scheduled, group-based mini trampoline exercise programme that occurred at least 3 times a week for 40 minutes as these programme characteristics appear to be key for increase adherence to exercise in postmenopausal women.

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## Introduction

The health status of women is a major public health concern, and the number of older women is increasing all over the world (Bergland & Engedal, 2011). The population of adults in the United States aged ≥65 years is projected to double from 49 million in 2016 to 95 million in 2090 (Vespa, Medina, & Armstrong, 2020). In New Zealand alone, the number of people aged 50-69 years rose by 21.5% in 2013 compared to 2006 ("Statistics NZ", 2015), with this aging cohort making up almost a quarter of the national population ("Statistics NZ", 2015). Functional disability is a major health risk factor for older women as they are also more likely to develop conditions such as osteoporosis and urinary incontinence compared to older men, which can decrease overall activities of daily living (MacLean et al., 2008; McGarry & Kiel, 2000). Regular exercise has long been recommended to reduce postmenopausal symptoms and increase physical functioning as well as quality of life (Shangold, Sherman, & DiNubile, 1998; Tolar, Teitelbaum, & Orchard, 2004).

The US Department of Health and Human Services (2018) recommends at least 150 minutes of moderate or 75 minutes of vigorous exercise throughout the week for adults and older adults. Exercise is particularly recommended for older women, as they are known to have lower physical activity levels than men; just 27% of women over the age of 65 years meet daily recommended activity goals (Findorff, Wyman, & Gross, 2009). Even though the benefits of regular exercise are well-known, older adults often have difficulties adhering to exercise programmes (Moore, Holden, Foster, & Jinks, 2020; Tak Erwin, van Uffelen, Mai, van Mechelen, & Hopman-Rock, 2012) such that 10-15% of older adults who start a structured exercise programme are known to drop out during the first 6 months (Tak, van Hespen, van Dommelen, & Hopman-Rock, 2012). The majority of relapses typically occur during the first 3 months of starting an exercise programme (Tak Erwin et al., 2012).

There are a number of commonly observed facilitators (i.e. motivators) to exercise in older women such as enjoyment, length of exercise bout, appropriate setting, level of self-efficacy, and programme tailoring (White, Randsdell, Vener, & Flohr, 2005). Common barriers that could decrease adherence to exercise in older women include insufficient time, the lack of social support, no place or transportation to exercise, insufficient money, and lack of exercise experience (Forkan et al., 2006; Moore et al., 2020; Tak Erwin et al., 2012). In order to increase adherence to exercise, it is important that future exercise interventions try to overcome the previously mentioned barriers.

Mini trampoline jumping is a form of aerobic exercise that has recently gained popularity (Höchsmann, Rossmeissl, Baumann, Infanger, & Schmidt-Trucksäss, 2018; McGlone, Kravitz, & Janot, 2002). Mini trampolines are relatively inexpensive, small, portable, and offer all the benefits of a low impact exercise, while being able to be performed in small confined spaces, including at home (Weston, 2001). Mini trampoline exercise programmes can improve physical fitness and also female specific health risk factors, such as osteoporosis (Aragão, Karamanidis, Vaz, & Arampatzis, 2011; Bunyaratavej, 2015; Cunha et al., 2016). Mini trampoline exercises enable the individual to self-adjust intensities easily, thus allowing for an effective workout for different women with different fitness levels (Aragão et al., 2011). A mini trampolining programme does not necessarily need professional supervision once a supervised training programme has been completed (Maharaj & Nuhu, 2016). Most research-based exercise interventions however often only focus on the physical outcomes and if the intervention was successful in improving these outcomes. Sustainability and adherence of exercise interventions can be greatly impacted if participants' motivators are negatively impacted. It is therefore important to also consider participants views of an exercise programme to examine its acceptability and feasibility for participants in addition to its effectiveness.

Unfortunately, no research to our knowledge has examined the views and attitudes from participants who took part in a mini trampoline exercise intervention. The purpose of this study was to examine the current views and attitudes of the programme from participants who completed a mini trampoline exercise intervention study. We hypothesise that women who participated in the mini trampoline exercise intervention would perceive the intervention as generally positive, which could lead to good adherence rates.

## Methods

Participants of this research were involved in a larger mini trampoline exercise intervention study. The aim of the exercise intervention was to improve functional fitness and female specific health risk factors in postmenopausal women. The 12-week exercise intervention comprised of 3 x 40-minute weekly sessions (Fricke, Fink, Mündel, Lark, & Shultz, 2021). Assessments prior (pre-intervention), immediately following (post-intervention), and 3-months following the intervention (follow-up), were performed to address the female specific health risk factors (calcaneal bone mineral density, urinary incontinence, pelvic floor muscle functioning) and functional fitness (aerobic fitness, lower extremity strength, balance, flexibility, and walking speed). The original research project gained ethical approval from the Massey University Ethics Committee (Southern A 18/52). All women who participated in the intervention group of the exercise intervention study were contacted via email after completing the intervention. Each e-mail included a link to an online questionnaire created with google forms. Questions were developed by two authors (AF, SS). Questions asked participants to discuss their current physical activity levels, their perceptions of various components of the mini trampoline exercise intervention and their future physical activity plans. All 13 questions were open ended and anonymous. Since questions were open ended, participants were able to provide more than one answer for each question. One hundred percent of participants ($N$ = 29) who completed the intervention also completed the questionnaire.

Excel (Version 2002) was used for data management of participants' responses. Since the questions were open-ended, quantitative assessment of data was not possible. Therefore, principles of thematic analysis were used as a qualitative approach to analyse participants' open-ended responses from the questionnaire (Green & Thorogood, 2005). Principles of thematic analysis are often described as a method to identify, analyse, and report patterns or themes within data. A thematic analysis provides a qualitative, detailed, and nuanced account of data (Vaismoradi, Turunen, & Bondas, 2013). Answers for each question were independently coded by the first author and a second researcher (ER) into themes. A thematic framework was utilised whereby each response was coded and categorised into a higher order theme. The two coders discussed the thematic coding for every individual response to each question until 100% agreement was achieved. Each question resulted in a varying number of themes in which illustrative responses were identified for each of the higher order themes.

## Results

### Participants

The completion rate for this intervention was 100% with all 29 women completing the intervention. The average attendance rate of women in this study was 89.3%, with a range of 80.5% - 100%. All 29 women (Age: 59.34±5.82y; BMI: 27.62±7.85kg/$m^2$) who completed the exercise intervention completed the questionnaire. All but one woman (96.6%) reported to have participated in regular exercise prior to participating in the mini trampoline intervention. Among the women who reported exercising prior to the intervention (*n*=28; 96.6%), 62.1% (*n*=18) reported to have performed walking exercises, while 13.8% of women (*n*=4) reported they participated in fitness classes and another 13.8% women (*n*=4) participated in aqua jogging prior the intervention. Exercise frequency varied from infrequently (*n*=1; 3.4%), daily (*n*=2; 6.9%), 3 times a week (*n*=4; 13.8%), 3-4 times a week (*n*=5; 17.2%) and twice weekly (*n*=5; 17.2%). Prior to this exercise intervention, 24.1% of total participants *(n*=7) reported that nothing has ever stopped them from exercising. In contrast 27.6% *(n*=8) reported that injury has previously stopped them from participating in exercise, 13.8% (*n*=4) reported other health issues, another 13.8% (*n*=4) mentioned a lack of motivation, while 10.3% (*n*=3) reported pain or soreness throughout the body as a barrier to previously participating in exercise.

A detailed description of the five most salient higher order themes along with illustrative quotes can be found in Table 7.1. To determine the percentage in which a theme emerged, the following calculation was used:

$N_{theme}$ / $N_{responses}$ *100, where

$N_{theme}$ is the number of times a particular theme was mentioned and

$N_{responses}$ is the total number of responses for that question. $N_{responses}$ varied between questions depending on the number of total responses provided. The following summarises the higher order themes for each question.

### Enjoyable characteristics of the programme

The most common theme identified from 24% of the total responses (*n*=22) from women was that they enjoyed the social interaction that occurred during this group exercise intervention. Ten percent of the total responses (*n*=9) mentioned that they enjoyed the short duration of the sessions and the instructor. Music and general fun and enjoyment were also mentioned in 7% of the total responses (*n*=6).

### Unenjoyable characteristics of the programme

The most salient theme from women regarding characteristics they did not enjoy in the programme was that there was nothing that they disliked about this programme (41% of total responses; *n*=14). The next common theme for this question was that women did not enjoy the travel to and from the exercise sessions (18% of total responses; *n*=6). Less commonly discussed themes (6% of total responses for each of the following; *n*=2) were that the women did not like if they missed a session, they did not like specific movements of the exercises (for example squats), and the music.

### What made participants take part in this intervention?

The most common theme identified from women's responses was that they took part in this exercise intervention to contribute to research (23% of total responses; *n*=12). The next most common theme (21% of total responses; *n*=11) identified for this question was that women participated in the intervention because they were interested in the potential health benefits. Some responses (10% of total responses; *n*=5) stated that they were interested in the novel exercise programme, while another 10% of total responses from women (*n*=5) mentioned that they participated because they thought the intervention would be fun. Women also indicated that they took part in this intervention because the exercise was free (8% of total responses; *n*=4) and offered regularly (8% of total responses; *n*=4).

### Ease of participation in this programme and barriers to participating in the programme

The most common theme discussed when being asked about ease of participation was that women felt it was easy to participate in this programme (89% of total responses; *n*=16), while only 6% of the total responses from women (*n*=1) indicated they thought it was very easy and another 6% of the total responses from women (*n*=1) thought it was somewhat easy. The most commonly discussed theme regarding barriers for participating in the programme was work commitments (24% of total responses; *n*=6), followed by personal commitments (20% of total responses; *n*=5), and transportation to sessions (16% of total responses; *n*=4). Interestingly, a more commonly discussed theme across the total responses from women (38%; *n*=11) was that they mentioned that the programme offered positive reinforcements to enable them to overcome barriers such as being able to make up for missed sessions (45% of responses; *n*=5) and the general enjoyment of the classes (27% of responses; *n*=3).

### Did participants find the intervention difficult and were they fatigued?

While a common theme in total responses from women (36%; *n*=9) was that they thought the exercise intervention was easy, 24% of the total responses from women (*n*=6) indicated that the programme became easier as the intervention progressed, and 20% of the total responses from women (*n*=5) thought the intervention required a reasonable amount of effort. The most commonly reported theme regarding fatigue from the intervention was that women did not experience fatigue after the exercise sessions (56% of total responses; *n*=9), while some women's responses were around the theme of experiencing some fatigue that dissipated during the intervention (13% of total responses; *n*=2).

### Would women participate in a mini trampoline exercise programme at the gym?

When women were asked if they would participate in a mini trampoline programme at a gym, the most salient theme discussed by women was that they stated they would partake in this programme if it was offered at the gym (43% of total responses; *n*=13). Another theme identified from the responses was that women reported that they generally would participate in this programme if offered at a gym, but it depended on the cost (17% of total responses; *n*=5). Less commonly discussed themes included that the women would maybe participate (13% of total responses; *n*=4), and that they would not participate in a similar programme at all (10% of total responses; *n*=3).

### Changes in attitude towards exercise following the intervention

Themes about the changes in attitude towards exercise varied greatly. The most common theme discussed by women was that there were no changes in attitude towards exercise following the exercise intervention (16% of total responses; *n*=5), followed by women reporting that they now enjoyed group exercises (13% of total responses; *n*=4), and have learned to enjoy exercise in general (13% of total responses; *n*=4).

### Changes that could improve the exercise programme

The most commonly identified theme was that nothing needed to be added to this programme (48% of total responses; *n*=14), while the next most common theme discussed by women was that they suggested more variety in music (10% of total responses; *n*=3), and that they did not know what could be added to this programme to improve it (10% of total responses; *n*=3). Less commonly reported themes included more variety to the sessions in general (7% of total responses; *n*=3) or more stretching exercises (7% of total responses; *n*=3).

### Frequency and duration of exercise programme

The most salient theme identified from women's responses were that women thought the exercise sessions should take place three times a week (59% of total responses; *n*=17), followed by twice weekly (21% of total responses; *n*=6), 2-3 times weekly (10% of total responses; *n*=3), 3-4 times weekly (3% of total responses; *n*=1), and 5 times weekly (3% of total responses; *n*=1). Other themes identified were that an exercise duration of 40 minutes per session (31% of total responses; *n*=9) or 30 minutes per session (31% of total responses; *n*=9) were considered ideal. Less common themes included 30-

45 minutes per session (10% of total responses; *n*=5), and longer than 40 minutes (7% of total responses; *n*=1).

## Activity plans for the future

When women were asked about their activity plans in the future, the most salient themes identified were that they would return to their original activities (34% of total responses; *n*=10), and that they would continue with their mini trampoline exercises at home (21% of total responses; *n*=6). A less notable identified theme was that they had activity plans for the future but did not specify the details (10% of total responses; *n*=3).

## Are women interested in buying a mini trampoline?

The most common theme discussed in response to being asked if the women were considering buying a mini trampoline was that they were considering buying a mini trampoline (34% of total response; *n*=10). The next most common theme identified was that they had already bought a mini trampoline (14% of total responses; *n*=4), followed by being given a mini trampoline following the intervention (10% of total responses; *n*=3). Less commonly discussed themes included that they already had a mini trampoline prior starting the intervention (7% of total responses; *n*=2), and that they were actively planning to buy a mini trampoline (7% of total responses; *n*=2).

Table 7.1. Questionnaire items with five most commonly cited themes, frequency of responses within each theme, and example quotations.

| **Question 1: List three things you like about this programme.** | | |
|---|---|---|
| **Theme** | ***N* (%) theme in response** | **Example quotation** |
| Social interaction | 22 (24) | "Doing exercise with other likeminded and same age group.  Doing exercise that was achievable in short burst. Doing exercise with women only." |
| Duration of session | 9 (10) | "Music, socialisation, duration, intense but shortish" |
| Instructor | 9 (10) | "Fabulous teacher, great social event, fitness level increased" |
| Music | 6 (7) | "Music, social support, leadership" |
| Fun/enjoyment | 6 (7) | "Trainer, I saw fast results, fun" |
| **Question 2: List three things you didn't like about the programme.** | | |
| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
| There was nothing that was unenjoyable | 14 (41) | "None"; "Travel to and from class"; "Having to miss sessions, jumping with the ball between your legs"; "just that one exercise (2kg weights while running and arms to front!)"; "Distance travelled, some of the music" |
| Travel to sessions | 6 (18) | "Travel to and from class" |
| Missing sessions | 2 (6) | "Having to miss sessions, jumping with the ball between your legs" |
| Specific movement of exercises | 2 (6) | "Just that one exercise (2kg weights while running and arms to front!)" |
| Music | 2 (6) | "Distance travelled, some of the music" |
| **Question 3: Why did you take part in this intervention?** | | |
| **Theme** | ***N* (%) theme in responses** | **Example quotation** |

| | | |
|---|---|---|
| Contribute to research | 12 (23) | "Thought it was a really interesting research programme" |
| Potential health benefits | 11 (21) | "Good for me and needed improve health and fitness<br>Commitment to attend easier knowing it was helping research<br>Timing workable for me" |
| Novel exercise | 5 (10) | "Its's a novel form of exercise" |
| Fun exercise | 5 (10) | "Sounded like fun" |
| Free exercise | 4 (8) * | "No cost to me; regular, healthy exercise; to help out." |
| *equal number of responses with "regular exercise" | | |
| **Question 4: What barriers did you need to overcome to participate in this exercise intervention?** | | |
| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
| Work commitments | 6 (24) | "It was a bit tricky balancing it with work" |
| Personal commitments | 5 (20) | "It was easy except missing once for other commitments/appointments" |
| Transportation to sessions | 4 (16) | "Just a long way to travel" |
| Poor weather | 3 (12) | "Cold, rain, winter" |
| Organisation | 2 (8) | "Organising my time to make it every week" |
| **Question 5: How hard did you find the mini trampoline sessions?** | | |
| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
| Easy | 9 (36) | "Not hard at all. I looked forward to each session" |
| Easier as programme progressed | 6 (24) | "After a few weeks it was easy even though we 'knew' the sessions were increasingly more energetic and longer" |
| Required reasonable effort | 5 (20) | "Had to push myself. I felt tired afterwards, especially for the first month" |

| | | |
|---|---|---|
| Somewhat hard | 1 (4) | "It was tiring but achievable" |
| Certain exercises were hard | 1 (4) * | "The weights were the toughest – when we started using them a lot. My arms would ache for a few days" |

*equal number of responses with "easy if sessions were not missed", "coordination was difficult but exercise easy", "difficulty level was progressive"

**Question 5: Were you fatigued for days after?**

| Theme | *N* (%) theme in responses | Example quotation |
|---|---|---|
| No fatigue | 9 (56) | "No issues with fatigue" |
| Fatigue that dissipated | 2 (13) | "Didn't find them hard. Tried to keep up reasonable pace so good workout. First week or two tiring" |
| Experienced some soreness | 1 (6) | "Not till the last couple of weeks, not so fatigued but very sore and stiff" |
| It was fatiguing | 1 (6) | "It was exhausting and tiring but I knew it was good for me so I just did the best I could" |
| Experienced some fatigue | 1 (6) * | "First session was really hard and I was sore afterwards but then got better. Exhausting and tiring but knew it was good" |

*equal number of responses with "experienced soreness towards end of the programme" and "experienced tired muscles but not fatigued"

**Question 6: If the same programme was run at a gym/community centre, would you take part?**

| Theme | *N* (%) theme in responses | Example quotation |
|---|---|---|
| Yes | 13 (43) | "Yes most definitely" |
| Yes, depending on affordability | 5 (17) | "Yes, provided it was not too expensive" |
| Maybe | 4 (13) | "Quite possibly" |
| No | 3 (10) | "No" |

| | | |
|---|---|---|
| Yes, depending on location | 2 (7) | "Yes I think so. Dependent on closeness of venue" |
| **Question 7: How do you view sport and exercise now?** | | |
| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
| No changes in attitude towards exercise | 5 (16) | "No different than before as I already exercise regularly. I look forward to exercise" |
| Enjoys group exercise | 4 (13) | "; "It is a chore mostly but it has made me think of the class style being easier rather than individual." |
| Enjoys exercise | 4 (13) | "I enjoy exercise, I'm going to find something else to fill the gap." |
| Enjoys exercise but lack of time to do it | 2 (6) | "I have never minded exercise, but the time to do is not always available" |
| Motivation for exercise can be hard | 2 (6) | "I never look forward to exercise but I know I have to do it so that I don't cease up later in life." |
| **Question 8: What would you like to see added to this programme?** | | |
| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
| Nothing | 14 (48) | "Nothing" |
| More variety in music | 3 (10) | "More variation in steps and music to maintain interest." |
| Don't know | 3 (10) | "Don't know" |
| More variety | 2 (7) | "Perhaps more variation but not sure what that would consist of" |
| More stretching | 2 (7) | "More stretching afterwards" |
| **Question 9: How many times a week do you think this programme should take place?** | | |
| **Theme** | ***N* (%) theme in responses** | **Example quotation** |

| | | |
|---|---|---|
| 3 times a week | 17 (59) | "3 times a week was good. 12 times a month." |
| 2 times a week | 6 (21) | "Twice a week"; |
| 2-3 times a week | 3 (10) | "2-3 times a week" |
| 3-4 times a week | 1 (3) | "3-4 times a week" |
| 5 times a week | 1 (3) * | "5 times a week" |

*equal number of responses with "3 times a week with a weekend option"

**Question 10: How long should each session last?**

| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
|---|---|---|
| 40 minutes | 9 (31) | "40 minutes was good for me." |
| 30 minutes | 9 (31) | "30 minutes is great" |
| 30-45 minutes | 3 (10) | "30-45 minutes" |
| 30-40 minutes | 2 (7) | "30-40 minutes is good" |
| Longer than 40 minutes | 2 (7) | "I found the exercise sessions were a little short especially as I gained fitness and expertise" |

**Question 11: Do you have activity plans for the future?**

| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
|---|---|---|
| Back to original activities | 10 (34) | "Back to yoga and beginning swimming" |
| Continue trampoline exercises at home | 6 (21) | "I hope to keep jumping at home" |
| Yes | 3 (10) | "Yes" |

| | | |
|---|---|---|
| Back to original activities and looking for something new | 2 (7) | "I will continue to walk, participate in zumba and stretch. I am looking at arthritis exercises for seniors." |
| Back to original activities and continue trampoline at home | 2 (7) * | "I will continue with pilates, Mt Kaukau walks and commuter cycling and get back into my garden, but I also hope to continue using the mini tramp 3 times per week." |

*equal number of responses with "Nothing planned but need to make plans"

**Question 12: Are you considering buying a mini trampoline or have already bought one?**

| **Theme** | ***N* (%) theme in responses** | **Example quotation** |
|---|---|---|
| Yes, considering buying one | 10 (34) | "Yes I am considering it" |
| Yes, already bought one | 4 (14) | "I have bought one. I'm enjoying it." |
| Was given a trampoline from the intervention | 3 (10) | "I was lucky enough to win one" |
| Had one prior the intervention | 2 (7) | "Already had one which is also why I was keen to participate" |
| Yes, planning to buy one | 2 (7) | "I was hoping to win one but I didn't! I now have it on a watchlist on trademe". |

## Discussion

This study examined the current views and attitudes from participants of a mini trampoline exercise intervention study. The high attendance rate of 89.3% of participants in this study was further supported by the overall positive views and attitudes towards the mini trampoline exercise programme. Our mini trampoline exercise programme aimed to address some of the most common exercise barriers observed in postmenopausal women by providing the exercises for free, offering different locations and times and offering women to participate in a different exercise session if they were unable to attend their usual session.

Participants in the current study showed higher adherence rates than typically observed in research with older women. According to Pisters et al. (2010) an adherence level of at least 80%-85% is recommended if the results of an intervention are to be satisfactory and if the intervention is to have therapeutic value. The considerably high adherence rate is likely reflected in the overall positive views of participants about the mini trampoline intervention, particularly as nearly half the participants mentioned that there was nothing unenjoyable about this exercise intervention.

The most enjoyable characteristics of this mini trampoline intervention were the social aspects of exercising in a group, the short duration bursts of exercise as well the instructor. Research has shown that exercise interventions that involve socialisation, support, and a sense of group cohesion promote adherence to the programme (Caserta & Gillett, 1998). This mini trampoline intervention only included women who were of similar age and postmenopausal. The similarities shared between participants potentially enhanced the opportunities for participants to bond and feel more confident about participating in the programme (White et al., 2005). The duration of exercise sessions in an exercise programme is also an important determinant for improving adherence (White et al., 2005). Women in our exercise intervention reported to like the short duration of each exercise session (40 minutes). Jakicic et al. (1995) indeed reported that women preferred shorter exercise duration as these are more feasible for women with career or family responsibilities. Participants in Jakicic et al. (1995) study however also preferred multiple bouts of even shorter sessions (10 minutes) compared to one longer session (30 minutes). Considering that the most unenjoyable characteristic of our intervention was travelling to the sessions, multiple bouts of shorter durations might only be favourable for home-based exercise interventions.

Research studies have shown that supervised exercise is more effective for improving adherence compared to unsupervised exercise and that older women preferred to follow supervised exercise programmes (Jordan, Holden, Mason, & Foster, 2010; Picorelli, Pereira, Pereira, Felício, & Sherrington, 2014). The preferred exercise method of supervised exercise was further supported with our results, as participants mentioned the instructor as one of the most enjoyable characteristics in this intervention. Adherence to exercise programmes for older women can be improved when exercise classes include a knowledgeable instructor, who can provide feedback and can be seen as a peer with the women who participate (Caserta & Gillett, 1998). Studies have shown that women had higher adherence rates to exercise interventions that were scheduled, as is typical for supervised exercise sessions, and women might not make time for exercise unless they have a specific class to go to (Caserta & Gillett, 1998).

Barriers to exercise, such as lack of time, lack of transport or insufficient money, can greatly reduce overall adherence to an exercise programme. The majority of women in our intervention (89%) said it was easy to participate; however, there were some barriers for participants to overcome. The most common barriers reported for participation included work, personal commitments, and transportation to sessions. Women in our research also enjoyed being able to make up for missed sessions by joining one of the other classes that were offered. Thus, to increase adherence for an exercise programme tailored to older middle-aged women, a mixture of supervised scheduled sessions and home-based sessions might be ideal, as it includes some structure but still offers flexibility by exercising at home anytime as well. Furthermore, offering a mixture of supervised scheduled sessions and home-based sessions would reduce barriers around transportation and other commitments since an at home workout can be completed at any time.

Responses regarding the difficulty of mini trampoline exercises of this intervention varied slightly, although most women considered the exercises to be easy and did not feel any fatigue. Evidence suggests that adherence to an exercise programme is increased at lower perceived intensity levels (White et al., 2005). Exercise intensities that are perceived to be low may increase adherence as women will not sweat, have to change clothes, or anticipate soreness that comes with higher perceived intensities (White et al., 2005). Furthermore, studies have reported significantly higher injury and drop-out rates for higher intensity exercises compared to moderate or lower intensity exercises (Cox, Burke, Gorely, Beilin, & Puddey, 2003; Perri et al., 2002). Middle-aged and older women may be particularly susceptible to injuries from higher intensity exercises (Perri et al., 2002). Lower intensity exercises may also lead to greater adherence rates due to increased self-efficacy (Woodgate, Brawley, & Weston, 2005). However, other factors such as social aspects, location, and duration seem to have larger impacts on adherence than exercise intensities (White et al., 2005).

Following the exercise intervention, the attitude of participants towards exercise did not seem to change, although some reported that they now enjoy exercise and have learned that exercising in a group is more enjoyable than exercising alone. It is important to note however, that most women (96.7%) reported that they performed some form of exercise regularly prior to starting the intervention. As these women were already previously active, they likely already perceived exercise as positive, thus no further positive changes in attitude were expected.

The mini trampoline exercise intervention was generally positively received and well accepted by participants as the majority of women reported to be interested in purchasing a mini trampoline and/or would participate in a similar programme if offered at the gym, depending on the cost. As suggested by participants, if a mini trampoline exercise programme was to be offered at a gym, the programme should consider including a larger variety of music and exercises, as well as more stretching exercises at the end of a session. Exercise sessions of 40 minutes for three times a week were deemed as the most enjoyable option.

Although the adherence and attendance rate of this exercise intervention was considerably high, the intervention was only 3 months long. Attendance rates of exercise programmes tend to be higher at the start of the programme, but can decrease quickly and significantly after six months (Caserta & Gillett, 1998; White et al., 2005). Further research is needed to determine adherence to a mini trampoline exercise intervention for postmenopausal women after more than 3 months duration.

### Implications for Practice and/or Policy

Mini trampoline jumping has the potential to provide an exercise programme to postmenopausal women with high adherence rates. Practitioners who wish to implement a mini trampoline exercise intervention should consider the barriers that might stop women from taking part in such interventions. The intervention should include group exercises, it should be offered at flexible locations and times, and be of short duration in order for the programme to be perceived positively and well accepted by postmenopausal women.

## Conclusion

This qualitative research report examined the views and attitudes of postmenopausal women who participated in a 3-months mini trampoline exercise intervention. The adherence rate of this exercise intervention was considerably high, and the majority of women enjoyed the exercise intervention. Most women enjoyed the social aspect of the group exercises, as well as the short durations of exercise sessions and the instructor. Although participation of this programme was generally viewed as easy, some women did report barriers such as personal or work commitments or travelling to the exercise sessions. Nonetheless, most women deemed the programme acceptable and would consider taking part in a mini trampoline exercise programme if it was offered at a local gym depending on cost. To increase exercise adherence in postmenopausal women, local gyms could implement a mini trampoline exercise programme that occurred at least 3 times a week for 40 minutes, include a large variety of exercise and music, and consider offering exercise plans that participants could perform at home.

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# Chapter 8

## Mini trampoline jumping as an exercise intervention for postmenopausal women who experienced a stroke – A case report*


### Abstract

This case report details a mini trampoline exercise intervention for a 56-year-old postmenopausal woman who experienced a stroke seven years ago, which left her partially paralysed on the right side of her body. The patient was diagnosed with a cerebral infarction on the left hemisphere following three aneurysms at 49 years of age. The patient underwent extensive physical rehabilitation for 6 years which included physiotherapy, swimming, walking, and attending a cardiac exercise clinic. Although she is able to walk unaided, she still experiences a right sided hemiparetic gait. The patient showed great improvements in walking speed, lower leg strength, flexibility, pelvic floor muscle strength, bone health and some aspects of balance following a supervised 12-week mini trampoline exercise intervention and 12-week follow up. This article represents a case in which a mini trampoline exercise intervention improved physical function and female specific health risk factors in a postmenopausal woman who experienced a stroke seven years ago.



Keywords: Mini trampoline, stroke, postmenopausal, female specific


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## Introduction

A stroke, commonly caused by a disturbance of cerebral perfusion, results in a sudden loss of neurological function. The degree of disability caused by a stroke varies depending on the size and area of the damage (Hahn, Shin, & Lee, 2015). Most people who experience strokes continue to live with physical impairments, such as decreased muscular function, impaired balance, decreased joint range of motion, reduced motor control (commonly associated with hemiplegia) and urinary incontinence (Cheng et al., 2014; Pang, Eng, Dawson, McKay, & Harris, 2005; Takai et al., 2009). A decrease of muscle function following a stroke is commonly a result of a loss in muscle strength, muscle power and muscle contraction velocity (Kostka, Niwald, Guligowska, Kostka, & Miller, 2019). The ability to remain functionally independent is highly reliant on lower limb function, as it allows an individual to stand up, maintain balance and control, and ensure an efficient gait (Kostka et al., 2019). Falls frequently occur during circumstances with increased environmental demands, which require sufficient velocity and force generated by the lower limb muscles (Cheng et al., 2014). Because muscle power is a product of muscle strength and contraction velocity (Cheng et al., 2014), decreased muscle power is often related to a higher occurrence of falls. Furthermore, a hemiplegic gait results in decreased loading of the hemiparetic leg, which in turn can lead to a decline of bone mineral density at the hip (Winstein et al., 2016). With a decreased bone mineral density and a higher risk of falls due to poor balance and motor control, people who have experienced strokes are also at higher risk of fractures (MacLean et al., 2008; Winstein et al., 2016). Postmenopausal women who have experienced a stroke are also at higher risk of developing urinary incontinence and fractures compared to men (McGarry & Kiel, 2000; Yea-Ru, Ray-Yau, Kuei-Han, Mou-Yu, & Rai-Chi, 2006). A common secondary complication observed after a stroke is poor general cardiorespiratory fitness, which is associated with poor functional performance and further increases the risk of strokes and cardiovascular diseases (Winstein et al., 2016).

Several studies have confirmed that an exercise programme can improve muscular strength, general mobility, physiological fitness, balance, hip bone mineral density, flexibility and overall quality of life in patients who experienced strokes (Aragão, Karamanidis, Vaz, & Arampatzis, 2011; Hahn et al., 2015; Ki Hun, Kyoung Jin, & Chang Ho, 2012; Macko et al., 2001; Marigold et al., 2005; Miklitsch, Krewer, Freivogel, & Steube, 2013; Silver, Macko, Forrester, Goldberg, & Smith, 2000; Winstein et al., 2016). Most of these studies only rely on a single measure to improve physical function, such as balance (Hahn et al., 2015) or strength (Yea-Ru et al., 2006). However, the ability to remain functionally independent is reliant on several physical abilities and thus it is important that exercise interventions for patients who experienced strokes involve multiple functional components. A mini trampoline exercise programme is a multi-component approach involving physical fitness, balance, strength, spatial orientation, and body stability (Aragão et al., 2011; Hanachi & Kaviani, 2010; Marigold et al., 2005; Miklitsch et al., 2013). Previous research has shown that a mini trampoline exercise programme can improve balance and falls efficacy in patients who experienced previous strokes (Aragão et al., 2011; Hahn et al., 2015). Hahn et al. (2015) found that a 6-week mini trampoline exercise intervention significantly improved dynamic as well as static balance in people who previously experienced strokes. However, Hahn et al. (2015) used a training protocol that specifically focused on improving balance, with participants performing different tasks on the mini trampoline while maintaining their balance. The benefits of a mini trampoline intervention have not been explored beyond motor competency and falls risk in patients diagnosed with a stroke, and specifically female patients who have increased risk. Therefore, this case report investigates further benefits of a mini trampoline exercise intervention on complications specific to a postmenopausal female patient with a stroke. This case study follows CARE guidelines (Riley et al., 2017).

## Case description

The patient was a 56-year old female who presented with a right sided hemiparetic gait and general weakness and limited movement on the right side of her body. The patient experienced three aneurysms and underwent a craniotomy with a clipping of the left anterior choroidal artery aneurysm at the age of 49 years. Postoperatively the patient did not regain full consciousness until after 48 hours and there was a weakness of her right arm and leg upon consciousness, which was not present prior to the surgery. The patient was diagnosed with a cerebral infarction on the left hemisphere that occurred during the surgery.

The patient lives independently with a husband and two children. Prior to her cerebral infarction she was physically very active, performing sports daily. Treatment included extensive physical rehabilitation from 2013-2019 to improve her physical functioning (Table 8.1) as well as medication to treat seizures. Her seizures have since subsided and she no longer takes medication. Immediately following the cerebral infarction in 2013 she was unable to walk, but after extensive rehabilitation she is able to walk unaided and has improved her general physical fitness. However, her improvements plateaued once the patient no longer received physical therapy. Currently, the patient can walk unaided; however, she walks with a right sided hemiparetic gait and continues to demonstrate foot drop at initial contact. There is limited movement in her right shoulder, and almost no active movement at the right elbow and right wrist. The patient is unable to grip and does not have full use of her right hand. Informed consent was obtained for this case report. The patient reported with a resting heart rate of 66 beats per minute (bpm), a resting blood pressure of 154/96 (mm/hg), and a body mass index of 30.1 kg/m2.

Table 8.1. Patient rehabilitation following the stroke

| Start Date | Intervention | Duration | Outcome |
|---|---|---|---|
| **February 2013** | Outpatient exercise classes | Weekly sessions for 6 weeks. | Learned to get up from the ground, walk up a step, navigate around with a quad stick |
| **March 2013** | Physiotherapy at home | Weekly sessions for 6 weeks. | Going out into the community and navigating around safely |
| **May 2013** | Aqua jogging | Weekly sessions ongoing | Improved general muscular strength |
| **May 2015** | Walking group for people with disabilities | Weekly sessions ongoing | Learned to walk unaided safely |
| **October 2015** | Rehabilitation clinic for people who suffered TIA's | Weekly sessions for 2 years | Improved general physical fitness |

## Methods

### Intervention

The patient volunteered to participate in a 3-month supervised mini trampoline exercise intervention, which was part of a larger study (Fricke, Fink, Mündel, Lark, & Shultz, 2021). The patient continued unsupervised exercises on the mini trampoline at home following the completion of the supervised exercise intervention. Outcome measures were assessed one week prior to commencing the supervised intervention, within one week following the supervised intervention and 3 months following the unsupervised exercise. All tests were performed only once at each time point and within the same day. The study had gained ethical approval from the appropriate institution. Outcome measures included measures of general health and physical fitness (cardiovascular measures, aerobic fitness, walking speed, lower extremity strength, dynamic balance, and flexibility), as well as female specific health risk factors (bone mineral density, urinary incontinence, and pelvic floor muscle functioning). The outcome measures of functional fitness and female specific health risk factors are all known components to decline in functioning with increasing age particularly in postmenopausal women who had experienced strokes and are directly targeted in the exercise intervention (Peeters, Dobson, Deeg, & Brown, 2013).

## Evaluation of general health and physical fitness

Blood pressure was measured manually in the seated position with the arm resting at the same level as the heart. Blood pressure was only assessed after the patient rested supine for 10 minutes prior to assessment of resting heart rate in the same position. Aerobic fitness is defined as the ability to maintain submaximal aerobic exercise for an extended time; thus, the 6-minute walk test has been identified as a feasible method to measure aerobic fitness in a postmenopausal stroke patient (Rikli & Jones, 1998). The 6-minute walk test has previously shown good test-retest reliability (R values of >0.84) and moderate validity in predicting physical endurance (R values of >0.71) (Rikli & Jones, 1998). The test was performed indoors on a flat surface in a rectangular course (5 meters in length and 1 meter in width). Average walking speed is an important aspect of gait and a decline of average walking speed has been associated with a decline in physical functioning and loss of independence (Peters, Fritz, & Krotish, 2013). Average walking speed was assessed during the previously validated 6-meter walking test (Peters et al., 2013). The 6-meter walk test has shown excellent test-retest reliability (ICC values of >0.96) and good validity in predicting walking speed (ICC value of 0.93) (Peters et al., 2013). The patient walked a total of 10 meters (with 2 meters provided at the beginning and the end for acceleration and deceleration, respectively) at her comfortable walking speed on a flat and straight surface. Lower extremity muscle strength and power are predictors of frailty and dependence in later life. A decline of lower extremity muscle strength and power can lead to deteriorations of gait, stair climbing, rising from a chair, and balance (Jones, Rikli, & Beam, 1999). Lower extremity muscle strength and power were assessed with the previously validated chair-based sit-to-stand-test (Jones et al., 1999). Sit-to-stand tests have previously shown good test-retest reliability (R values of >0.80) and good validity in predicting lower extremity strength and lower extremity power (R values of >0.71 and 0.68 respectively) (Jones et al., 1999; Lindemann et al., 2003). The patient was seated on a standardised chair that was 40cm high and repeatedly stood up from the seated position 10 times as fast as possible. Dynamic balance is commonly impaired in former stroke patients, which can result in a decline of activities of daily living such as walking and stair climbing (Chen et al., 2014). Dynamic balance was assessed with the patient standing on a force platform (AMTI, Watertown, MA, USA) with feet shoulder width apart and one arm holding onto a handrail to reduce fall risk. The patient shifted her weight as far as possible in anterior, posterior, and lateral (right, left) directions while maintaining her balance. Tasks were performed repeatedly over a period of 20 seconds, whereby the patient shifted her weight in all directions during that time period. Maximal range of sway and maximum sway velocity along both medial-lateral and anterior-posterior axes were assessed. Centre of pressure measures have shown good test-retest reliability (ICC values of 0.75-0.99) and good validity in predicting dynamic balance (R values of 0.62-0.88) (Li, Liang, Wang, Sheng, & Ma, 2016). A lack of hamstring flexibility can be associated with postural deviations, gait limitations, and an increased risk of falling (Jones, Rikli, Max, & Noffal, 1998). Hamstring flexibility was therefore assessed with the previously validated and reliable sit-and-reach test, showing good test-retest reliability (R values of 0.92-0.96) and good validity in predicting hamstring flexibility (R values of 0.71-0.74) (Jones et al., 1998).

## Evaluation of female specific health outcomes

Bone mineral density of the calcaneus was assessed via a quantitative ultrasound measure (Sahara Clinical Bone Sonometre Hologic Inc, USA). Measurements were taken at the heel of the hemiparetic leg only. The degree of urinary incontinence was measured with the previously validated female urinary incontinence diagnosis questionnaire, which has shown moderate to good test-retest reliability (R values of 0.65-0.87) and moderate validity in predicting urinary incontinence (r values of 0.45-0.68) (Bradley et al., 2010). The functioning of the pelvic floor musculature was examined via surface electromyography (EMG) (Noraxon, Arizona, USA). During the initial meeting prior to the first testing session, the patient was taught the structure and anatomy of the pelvic floor muscle to help create awareness of this muscle group, its location and function. The patient was provided with verbal instructions to insert the vaginal probe (TensCare Liberty Vaginal probe, TensCare, Epsom, UK) as she would do when inserting a tampon; the two conducting plates were to be placed laterally (with one plate facing their right side of the body and the other plate facing left side of the body). The patient performed a standing trial while standing with both feet positioned shoulder width apart and eyes open for 30 seconds. Following one-minute rest, the patient performed a maximum voluntary contraction of the pelvic floor muscle for 10 seconds while in the standing position. This protocol aligns with previously reliable protocols, which have shown high reliability (ICC values of 0.78-0.99) (Koenig, Luginbuehl, & Radlinger, 2017; Peschers, Gingelmaier, Jundt, Leib, & Dimpfl, 2001). EMG data were recorded at a sampling frequency of 1000Hz and processed with MyoResearch (Noraxon Inc, USA) using Butterworth Highpass (cut-off: 5Hz) and Lowpass (cut-off: 400Hz) filters. Data were smoothed at 50ms RMS and normalised to the standing trial. Mean amplitudes across all trials were then recorded.

### Exercise intervention

The exercise intervention occurred for 12 weeks with 40-minute sessions taking place three times each week. Mini trampoline exercises concentrated on movements to improve aerobic fitness, flexibility, lower extremity strength and balance, as well as pelvic floor muscle activation. Exercises were chosen for their ability to scaffold in progression throughout the programme (Table 8.2).

Exercises were performed on a mini trampoline with handlebars. During the intervention the patient held on to the handlebar to ensure safety. Exercises were performed in small groups with other healthy postmenopausal women; each group comprised a maximum of six participants. The patient also wore a heart rate monitor during the exercise sessions. Exercise was deemed effective when the heart rate range was between 60% - 75% (105-131 bpm) of the age predicted maximum heart rate (174 bpm). The patient was provided with a trampoline to continue exercising at home at the completion of the intervention. During the follow-up assessment, the patient reported having used the mini trampoline for 30 minutes every day by completing exercises from phase 4 of the programme.

Table 8.2. 12-week mini trampoline exercise intervention programme

| Weeks | Warm-up | Exercises | Cool-down |
|---|---|---|---|
| **1-3** | • 5 minutes dynamic stretching | • Heel lifts (not airborne)<br>• Knee raises (not airborne)<br>• Light bouncing with feet shoulder width apart (not airborne)<br>• Light bouncing with feet in walking stance (not airborne)<br>• Small step back and forth (walking stance)<br>• Small step sideways<br>• Jogging in place<br>• Bouncing with both feet | • 5 minutes stretching focusing on lower body and lower torso |
| **4-6** | • 4 minutes dynamic stretching and 1-minute light bouncing on trampoline | • Heel lifts (airborne)<br>• Knee raises (airborne)<br>• One leg stance light bounce (not airborne)<br>• Bouncing with both feet and arm punches<br>• Soft ball between knees and light bouncing<br>• Soft ball between knees and light bouncing adding rotation<br>• Soft ball between knees and bouncing (airborne)<br>• Jumping jacks (holding onto handrail) | • 5 minutes stretching (all body) |
| **7-9** | • 4 minutes dynamic stretching and 1-minute light bouncing on trampoline | • Bouncing with both feet half rotations<br>• Scissor steps bouncing back and forth<br>• Bouncing on one leg<br>• Softball between knees, bouncing high<br>• Bouncing on both feet punching arms (including hand weight)<br>• Jogging with bicep curls (including hand weight)<br>• Light squad jumps (not airborne)<br>• Jumping jacks | • 5 minutes stretching (all body) |
| **10-12** | • 4 minutes dynamic stretching and 1-minute light bouncing on trampoline | • Ball between knees light squad bouncing<br>• Ball between knees squad bouncing<br>• Bouncing on one leg, bicep curl with contralateral arm (including weight)<br>• Heel raise alternating legs with alternating punching arms (including weight)<br>• Knee raises with rotation<br>• Scissor jumps back and forth (including hand weights)<br>• Lateral bouncing with feet together<br>• Jumping jacks (including hand weight) | • 5 minutes stretching (all body) |

## Results

Changes to general health and physical fitness, as well as female specific health outcomes, can be found in Table 8.3. There were no large changes between baseline, post-intervention, or follow-up assessments of the 6-minute walk test (3% and 4% respectively) and no changes in urinary stress score. The patient's resting heart rate increased by 9% from baseline to post-intervention and a further 3% from post-intervention to the follow-up. Her resting blood pressure, however, decreased by 8% in systolic value from baseline to post-intervention. The patient improved her lower extremity strength: her average walking speed increased by 12% from baseline to follow-up while her sit-to-stand test times were nearly 20% faster during the follow-up compared to baseline. The patient increased her hamstring-gluteal flexibility by 160% from baseline to follow-up. Although the patient performed the dynamic balance test with slightly less range of motion (4% in x direction and 20% in y direction) between baseline and post-intervention, her maximal velocity increased, particularly in the negative x direction (17%).

Table 8.3. Results across all three assessments

| | **Baseline** | **Post Intervention** | **Follow-up** |
|---|---|---|---|
| **Cardiovascular measures** | | | |
| *HR (bpm)* | 66 | 72 | 74 |
| *BP (mm/hg)* | 154/96 | 142/109 | 147/95 |
| **Bone Health** | | | |
| *Bone mineral density (T-score)* | 0.530 (-0.5) | 0.577 (0.0) | 0.545 (-0.3) |
| **Functional fitness** | | | |
| *6-Minute walk test (m)* | 233 | 241 | 231 |
| *Average walking speed (kph)* | 3.80 | 4.13 | 4.25 |
| *Sit to stand (sec)* | 25.66 | 21.47 | 20.56 |
| *Sit and reach (cm)* | 11 | 24 | 29 |
| **Dynamic balance** | | | |
| *Range of motion in x axis (m)* | 0.117 | 0.113 | 0.136 |
| *Range of motion in Y axis (m)* | 0.197 | 0.157 | 0.205 |
| *Maximum velocity y+ (m/s)* | 0.206 | 0.118 | 0.362 |
| *Maximum velocity y- (m/s)* | 0.204 | 0.196 | 0.362 |
| *Maximum velocity x+ (m/s)* | 0.153 | 0.152 | 0.362 |
| *Maximum velocity x- (m/s)* | 0.196 | 0.236 | 0.362 |

The patient's bone mineral density improved from baseline to post-intervention (9%) and baseline to follow-up (3%). Some improvements were also seen in her pelvic floor muscle functioning (Figure 8.1). Her maximal voluntary contraction values increased by 20% from baseline to post-intervention but decreased by 11% from baseline to follow-up. The amplitude of her cough activity decreased by 41% from baseline to post-intervention but increased by 13% from baseline to follow-up.

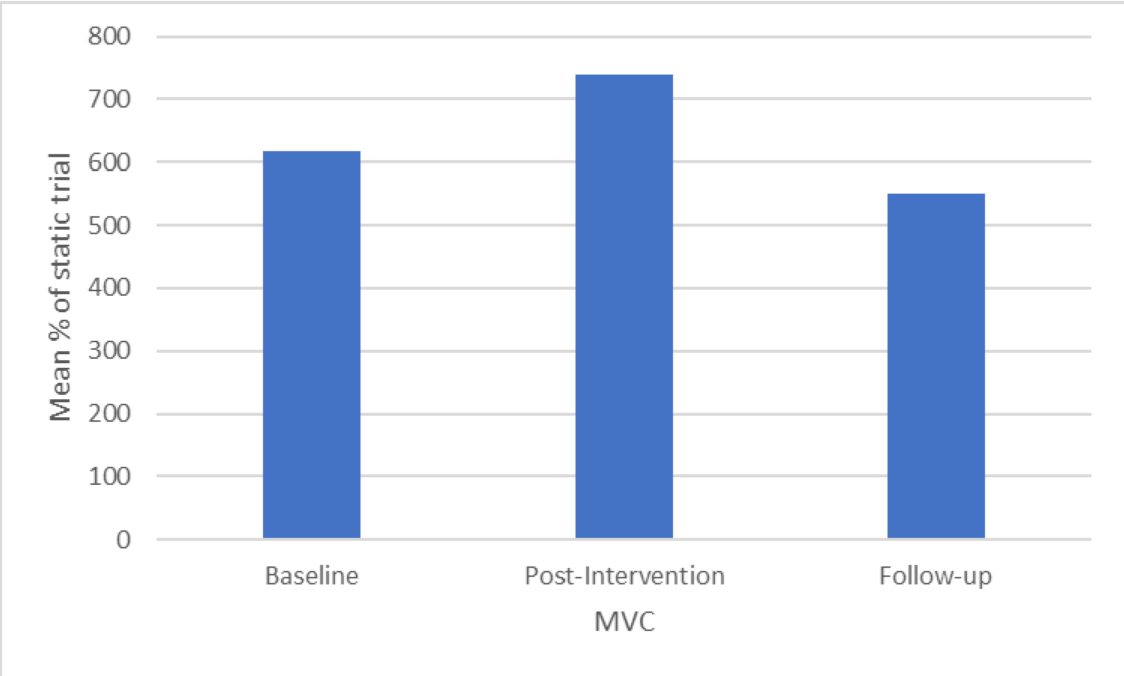


Figure 8.1 Mean amplitude of MVC across all three assessments

The patient volunteered to participate in the exercise intervention in hopes that it might improve her physical fitness and increase strength. Although she found the exercise sessions to be relatively fatiguing, she reportedly felt good after each session and felt a great sense of achievement. The patient reported to have enjoyed the fellowship and laughter associated with the exercise intervention. She enjoys the trampoline exercises thoroughly and has been able to see improvements (particularly in strength and balance) that she has not seen in the past years. She reports feeling stronger since completing the intervention and pushes herself even more during exercises as she can still see improvements. She continues to use the mini trampoline daily.

## Discussion

The purpose of this case report was to examine the effects of a 12-week mini trampoline exercise programme on physical fitness, bone mineral density, urinary incontinence and pelvic floor muscle functioning in a postmenopausal woman who had experienced a stroke seven years ago. The patient continued the mini trampoline exercises alone and unsupervised for a further 12 weeks following the initial intervention. She showed general improvement in physical fitness (walking speed, flexibility, lower leg strength, and some balance aspects), pelvic floor muscle strength and bone mineral density. These results indicate that mini trampoline exercises could be beneficial to people who experienced strokes or partial paralysis, and particularly for women who have increased health risks for additional diseases such as incontinence and osteoporosis. Although the patient showed no large improvements in resting heart rate or the 6-minute-walk test, previous research has found that a mini trampoline exercise intervention can improve resting heart rate, blood pressure and aerobic fitness in healthy young and older adults as well as overweight women (Cugusi et al., 2016; Rodrigues et al., 2018; Weston, 2001).

A lack of hamstring flexibility or lower leg strength and power can result in gait limitations, reduced walking speed, and increased risk of falling (Cheng et al., 2014; Lindemann et al., 2003; Takai et al., 2009). The patient showed an improvement of 12% during the 6-meter timed walk test, indicating an increased walking speed. During the sit-to-stand test the patient was able to perform the same amount of repetitions in less time. Since muscle power is the result of muscle strength and contraction velocity, the results of the sit-to-stand test indicated that the patient not only improved lower limb strength but also power by 20% (Cheng et al., 2014). The mini trampoline exercises involved a downward push of the legs, which limit the upward propulsion and increases the amount of physical work performed by the lower extremities (Höchsmann, Rossmeissl, Baumann, Infanger, & Schmidt-Trucksäss, 2018). Thus, lower extremity power might have been improved through the repetitive downward push of the legs.

Furthermore, the patient achieved 160% gain in hamstring flexibility via the sit-and-reach test. The improvements of lower limb strength, power, and flexibility combined with the dynamic balance improvements could therefore indicate a decreased risk of falls and increased functional performance. Although the patient saw improvements of general walking speed and lower extremity strength and power, improvements in overall endurance were comparatively small. Previous studies have shown that a mini trampoline exercise intervention can improve general endurance in young and older adults (Cugusi et al., 2016; Rodrigues et al., 2018). It has been suggested that an improvement of 13% in the 6-minute walk test could be meaningful (Jones et al., 1998). The patient in this study only achieved an improvement of 3% in the 6-minute walk test. It is possible that 30 minutes of exercise three times a week on a mini trampoline was not sufficient enough to overcome the high endurance demands of the patient's hemiparetic gait.

Other exercise interventions have shown improvements in fitness parameters. A treadmill-based intervention demonstrated greater gains in aerobic fitness than our patient, with a minimum improvement in aerobic fitness of at least 9% to 33% in patients who experienced strokes (Macko et al., 2001; Silver et al., 2000). However, these studies were specifically designed to improve aerobic fitness and no other functional fitness measures. Similarly, a study by Yea-Ru et al. (2006) focused on strength training for patients who experienced strokes and found larger mean improvements (37.1% vs 12% reported here) in lower extremity strength but smaller improvements in walking endurance (10.3%), balance (3.3%), and the lower limb functional test (13.2%). While these studies demonstrated greater gains in one measurement when the exercise intervention focused on one parameter, they were not able to produce the varied gains seen in our patient by using a multi-component approach.

Although mini trampoline is considered a low-impact exercise, relatively large improvements were seen in the patient's bone mineral density. Bone tissue responds to mechanical loads applied either through muscle contraction or gravitational forces. Bone mineral density can be maintained through muscle contraction due to the muscle tendon and bone interaction during exercises. Mechanical signals that stimulate bone metabolism and inhibit bone reabsorption, can be created with any form of tension, compression, and torsion at the tendon and bone complex (Moreira et al., 2014). While research has shown that a weight-bearing low impact exercise programme can maintain bone mineral density at the femoral neck in older individuals with chronic stroke, Pang et al did not see the significant gains presented in this case study (Pang et al., 2005). It is possible that the patient's jumping motions during the mini trampoline exercise increased the mechanical loads applied to the calcaneus through interaction from her gastrocnemius and soleus muscles and Achilles tendon. The increased mechanical loads would be disproportionately higher for her hemi-paretic leg than her unaffected limb and thus increased bone mineral density in the measured calcaneus of her affected limb.

The patient had no complaints of urinary incontinence prior to beginning the study; thus, no differences were found. However, the patient did produce slightly elevated pelvic muscle activation during the maximal voluntary contraction, and decreased muscle activation during the cough. The mini trampoline exercise programme included exercises involving indirect co-contraction of the pelvic floor muscle. During these exercises, the patient was asked to place a ball between her knees and squeeze it as hard as possible while performing squats and squat jumps. Previous research has indicated that indirect co-contraction of the pelvic floor muscle can potentially increase pelvic floor muscle strength (Martinho et al., 2016). It is possible that co-activation of the pelvic floor muscle during these exercises resulted in an increased muscle activation during the maximal voluntary contraction. Increased pelvic floor muscle strength can also indirectly improve walking speed and balance. Muscles that co-contract during pelvic floor muscle contraction include the abdominal muscles, adductor muscles of the thigh, and muscles of the lower limb girdle (Madill & McLean, 2008). Research has indicated that strong hip adductors can stabilise the pelvis and potentially improve walking speed and balance (Kim, Kwon, Yi, Cynn, & Choi, 2013).

Dynamic balance of the patient remained largely unchanged between baseline and post-intervention. However, the patient continued unsupervised exercises on the mini trampoline every day at home for three months post-intervention. During the follow-up assessment, the patient showed large improvements, and was able to move further and faster in each direction. Previous studies have shown dynamic balance improvements following an intervention on a mini trampoline (Aragão et al., 2011; Hahn et al., 2015; Hanachi & Kaviani, 2010). It is important to note however, that Hahn et al. (2015) employed a training protocol specifically focusing on balance improvement. The training protocol used in our study employed a multi-component approach, focusing on muscular strength, aerobic fitness, balance, and flexibility. Nonetheless, the patient in our case study showed large improvements in dynamic balance at the follow-up. During trampoline jumping, the patient was continuously forced to respond to changes in gravity, which provides deep proprioception as well as other sensory inputs (Hahn et al., 2015). Furthermore, the patient was continuously required to adapt to the unstable surface of the trampoline, which might result in alterations of the sensory motor stimulation (Hahn et al., 2015).

According to the patient she has not seen such strong improvements, particularly in strength and balance in the previous years. The positive improvements in physical fitness combined with the enjoyment she experienced during the exercise classes could indicate the use of multi-component mini trampoline exercise interventions as therapy options in participants who have previously experienced strokes (White, Randsdell, Vener, & Flohr, 2005).

## Limitations

This study is not without limitations. This is a case report which reports associations rather than causations, thus interpretation of results to a larger population cannot be made. The patient was part of a larger study, which included other healthy postmenopausal women without disability. The exercise programme as well as the assessment were therefore not tailored to the patient directly but rather to overarching purpose of the bigger study (to improve women specific health risks factors). A mini trampoline exercise intervention tailored to former stroke patients or people with partial paralysis might possibly produce even greater results. Nonetheless, the patient was able to perform most exercises and assessments the same way the other participants did, and adjustments were made where necessary.

## Conclusion

The aim of this case study was to examine the benefits of mini trampoline exercise intervention on physical fitness, pelvic floor muscle functioning, and bone mineral density in a postmenopausal woman who had previously experienced a stroke. While other exercise interventions have focused on one functional deficit in patients with stroke, the current protocol utilised a multi-component approach. Subsequently, the patient showed great improvements in walking speed, lower leg strength, flexibility, pelvic floor muscle strength, bone mineral density and some aspects of balance. Dynamic balance was improved in the follow-up after the patient used the trampoline for 30 minutes each day for an additional 3 months after the intervention. Results of this case study support previous research in patients who experienced strokes and extend the benefits of mini trampoline exercise in this population. Specifically, a multi-component mini trampoline exercise intervention would be recommended for improving physical function in people who experienced strokes or are partially paralysed, particularly postmenopausal females.

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# Chapter 9

## Conclusion

This research project sought to examine the potential health benefits of mini trampoline exercise intervention in postmenopausal women. Previous studies have confirmed that a mini trampoline exercise can improve muscular strength, general mobility, aerobic fitness, balance, flexibility, and potentially improve bone health in healthy adults (Aragão, Karamanidis, Vaz, & Arampatzis, 2011; Bunyaratavej, 2015; Hahn, Shin, & Lee, 2015; Hanachi & Kaviani, 2010; Miklitsch, Krewer, Freivogel, & Steube, 2013; Winstein et al., 2016). However, most of these studies only focused on a single measure of health, such as balance (Hahn et al., 2015; Hanachi & Kaviani, 2010). Several physical abilities influence an individual's capacity to remain functionally independent and exercise interventions should involve multiple inter-related functional components. Because women are more likely to live alone in later life and also develop conditions like osteoporosis and urinary incontinence (Bergland & Engedal, 2011), it is important to test whether specific interventions can improve these female specific health risk factors. Lastly, no study so far has examined the perceptions and preferences in participants of a mini trampoline exercise programme. The sustainability and adherence of exercise interventions can be greatly impacted by participants' general perceptions of an exercise programme. While a mini trampoline exercise intervention has the potential to improve physical factors it is also important to examine the efficacy of an intervention.

Therefore, the 12-week mini trampoline exercise intervention was developed for postmenopausal women to:

1) Examine the benefits of this exercise on female specific health risk factors including bone mineral density and urinary incontinence; which were addressed in **Chapter 5**;

2) Examine the benefits of this exercise on functional fitness including physical endurance, walking speed, muscle strength, flexibility, and balance; which were addressed in **Chapter 6**;

3) Examine the differences of metabolic and muscle activity responses for mini trampoline exercise and more commonly prescribed exercises such as walking and home-based strength exercises, which were addressed in **Chapter 4**.

4) Examine the efficacy of this exercise intervention and if there is interest and potential for similar mini trampoline exercises in the future; which were addressed in **Chapter 7**.

5) Examine the benefits of mini trampoline exercise intervention on complications specific to a postmenopausal female patient with a stroke; which were addressed in **Chapter 8**.

It was hypothesised that a 12-week mini trampoline exercise programme could maintain bone mineral density in postmenopausal women and improve pelvic floor muscle functioning as well as urinary incontinence. This hypothesis was confirmed in **Chapter 5** as well as in the case report in **Chapter 8.** Although mini trampoline jumping is often considered to be a low-impact exercise, bone mineral density in the calcaneus was improved, likely through continuous reaction forces applied through the calcaneus as well as contraction of the extrinsic foot musculature, thus stimulating bone metabolism in the calcaneus (Moreira et al., 2014). Interestingly, research so far has shown that is rather difficult to significantly improve bone health in postmenopausal women and exercise intervention are generally only able to maintain bone health (Marques et al., 2011; Ville et al., 2016). One possible explanation was that forces applied to the calcaneus during mini trampoline exercises might be higher than initially thought, and some exercises on the mini trampoline might indeed be classified as high impact (Schiehll, Chaida Sonda, Souza, Fagundes Loss, & De Oliveira Melo, 2019). However, these data are so far limited to only one study. Osteoporosis has been linked to a loss of bone mass, reduced muscle strength, and a decrease in vertebrae height, which combined can lead to changes in postural alignment and a shift of centre of mass position, subsequently leading to poor balance control (Hsu, Chen, Tsauo, & Yang, 2014). Osteoporosis is thought to contribute to a loss of muscle mass, as it is often associated with a low level of physical activity, a reduction in dietary protein, hormonal changes, and chronic inflammation (Hsu et al., 2014). Improving bone health and reducing the risk of developing osteoporosis can therefore help to reduce the risk of muscle loss and associated muscle weakness and poor balance control.

Pelvic floor muscle exercises are the first recommended treatment option to reduce urinary incontinence symptoms. Results in **Chapter 5** highlighted that while the control group had a significant decrease of pelvic floor muscle amplitudes over time, the intervention group showed maintenance of pelvic floor muscle amplitudes during the mini trampoline exercise programme. **Chapter 5** also revealed that urinary incontinence symptoms significantly improved following the intervention. Although the case report in **Chapter 8** had no urinary incontinence complaints, pelvic floor muscle activation during the maximal voluntary contraction was slightly increased following the intervention, indicating that pelvic floor muscle strength might have been slightly improved. The intervention did not include exercises whereby the pelvic floor muscles were contracted in isolation; it is possible, however, that maintenance of pelvic floor muscle functioning was possible through exercises that caused a co-contraction of the pelvic floor muscle. Results from **Chapter 4** showed that the adductor longus muscle, which commonly contributes to co-contraction of the pelvic floor muscle was highly active during the mini trampoline exercises (50% of the time). However, results from **Chapter 4** also highlighted that there was a lack of differences in muscle activity between mini trampoline, home-based, and walking exercises. These results could suggest that in order to see stronger differences in muscle activation and possible strength gains, exercises need to be more demanding for example by adding weights or a stiffer ball for the adduction exercises during the mini trampoline jumping (Hirono et al., 2023). Stress urinary incontinence can adversely affect women's daily lives, work, and recreational activities (Kao, Hayter, Hinchliff, Tsai, & Hsu, 2015). Women who experience stress urinary incontinence tend to avoid social contacts as well as exercising due to embarrassment, which can further lead to an increased risk of developing depression (Kao et al., 2015). A lack of exercise in turn is associated with a decrease of functional fitness, resulting in an increased risk of a dependent lifestyle (Christensen, Støvring, Schultz-Larsen, Schroll, & Avlund, 2006).

It was hypothesised that the mini trampoline exercise intervention could show improvements in aerobic fitness, lower extremity strength, flexibility, and balance. This hypothesis was confirmed in **Chapter 6** as well as the case report in **Chapter 8**. **Chapter 6** revealed that functional fitness was improved following the intervention programme. Specifically, women in the intervention group significantly improved lower extremity strength and flexibility, average walking speed, aerobic fitness and dynamic balance. **Chapter 4** further supported the findings of improved aerobic fitness, as mini trampoline exercises showed increased HR, energy expenditure, METs and oxygen consumption compared to walking or home-based exercises. Average walking speed has also been known to be a good indicator of functional balance (Posch et al., 2019). Maintaining or improving parameters of functional fitness such as lower extremity strength, flexibility, average walking speed, and balance, are important to decrease the risk of falls and consequent complications. Improvements of functional fitness were also highlighted in the case report in **Chapter 8**. Following the 12-week mini trampoline exercise intervention the patient showed improvements in walking speed, flexibility, lower extremity strength, and some balance aspects. Improvements of hamstring flexibility and lower extremity strength as seen in the case report can improve general gait, increase walking speed, and decrease the risk of falls (Cheng et al., 2014). Risk of falls is also increased with impaired balance. Balance in postmenopausal women can be impaired through a range of factors including decreased muscle strength, decreased flexibility, as well as osteoporosis (Hsu et al., 2014). The improvements of hamstring flexibility, lower extremity strength, dynamic balance, increased walking speed, and bone health combined, can therefore decrease the risk of falls and related fractures.

It was hypothesised that women who participated in the mini trampoline exercise intervention would perceive the exercise intervention as generally positive. This hypothesis was confirmed in **Chapter 7** as well as the case report in **Chapter 8**. Exercise interventions need to consider the motivators and possible barriers of middle-aged women to increase adherence to exercise programmes (White, Randsdell, Vener, & Flohr, 2005). Exercises that promote high self-efficacy, short sessions, appropriate locations, moderate intensities, and a social support network can increase adherence to an exercise intervention. Results of **Chapter 7** as well as **Chapter 8** reiterated these findings, as the women in this exercise intervention enjoyed the social aspects of group exercise sessions and enjoyed exercising in a group of like-minded women who started to form friendships. Women in the intervention group also enjoyed the short duration, moderate intensity, and flexibility as exercise sessions were offered at different locations and several times throughout the week. Self-efficacy was also likely improved, as women noticed the physical improvements shown in **Chapters 5** and **6** in themselves. Women reported improved fitness, increased energy, and feeling generally mentally positive following the exercises. Self-efficacy has long been established to be the strongest predictor of exercise adherence (Azizan, Justine, & Kuan, 2013). As the exercise intervention progressed, women improved their physical functioning as well as female specific health risk factors as seen in **Chapters 5** and **6**. Women started to improve their balance, improved their aerobic fitness, got more flexible and stronger, and with that their confidence in performing the mini trampoline exercises also increased leading to improved self-efficacy (Azizan et al., 2013). Women with improved self-efficacy are also more likely to continue with an exercise programme, which can then further improve the physical functioning and female specific health risk factor mentioned in **Chapters 5**, **6,** and **8**. Additionally, the adherence rate of this study was higher than recommended in order for results to be satisfactory and the intervention to have therapeutic value. It is important to note however, that this intervention only lasted for 12-weeks, and attendance rates are known to significantly drop only after six months (White et al., 2005; Caserta & Gillett, 1998). Nonetheless, women in this intervention particularly the social aspects of this intervention as well as the supervision. While the mini trampoline exercise could be implemented in peoples' own homes and exercises could be performed on their own, it is likely that adherence rates would be smaller and that women may stop with the intervention early. To ensure effectiveness of a mini trampoline exercise intervention, it should be offered in group settings and with an experienced instructor.

Lastly, this thesis examined the differences of muscle activity and cardiovascular and metabolic responses for mini trampoline exercises compared to more commonly prescribed exercises such as walking and home-based strength exercises. Findings of **Chapter 4** showed that the trampoline exercises were associated with higher HR, METs, energy expenditure, and oxygen consumption compared to walking. The only differences between the trampoline exercises and home-based exercises were higher oxygen consumption and RER in the trampoline exercises. Most surprisingly, **Chapter 4** did not find any differences of muscle activity for the adductor longus muscles between the different exercise modalities. One of the primary aims of this thesis was to improve pelvic floor muscle functioning, thus when comparing the exercise modalities exercises to specifically activity the adductor muscles and potentially pelvic floor muscles were included in the mini trampoline and home-based strength exercises (squeezing a ball that is placed between the knees). All exercise modalities were performed for 5 minutes each; however the adductor muscle activity was only for 30 seconds and it is likely that these 30 seconds were not enough to generate a response that was significantly different compared to walking. Even though there was an overall lack of differences in muscle activity between the exercise modalities, the metabolic responses showed that mini trampoline and home-based exercise are more effective than walking, with mini trampoline exercises eliciting even higher oxygen consumption and RER compared to home-based exercises.

Overall, the results of **Chapters 4, 5, 6, 7, 8** indicate that mini trampoline exercises could be implemented to improve overall wellbeing of postmenopausal women, while maintaining high adherence rates. Figure 9.1 represents the interactions of female specific health risk factors, functional fitness parameters, and self-efficacy.

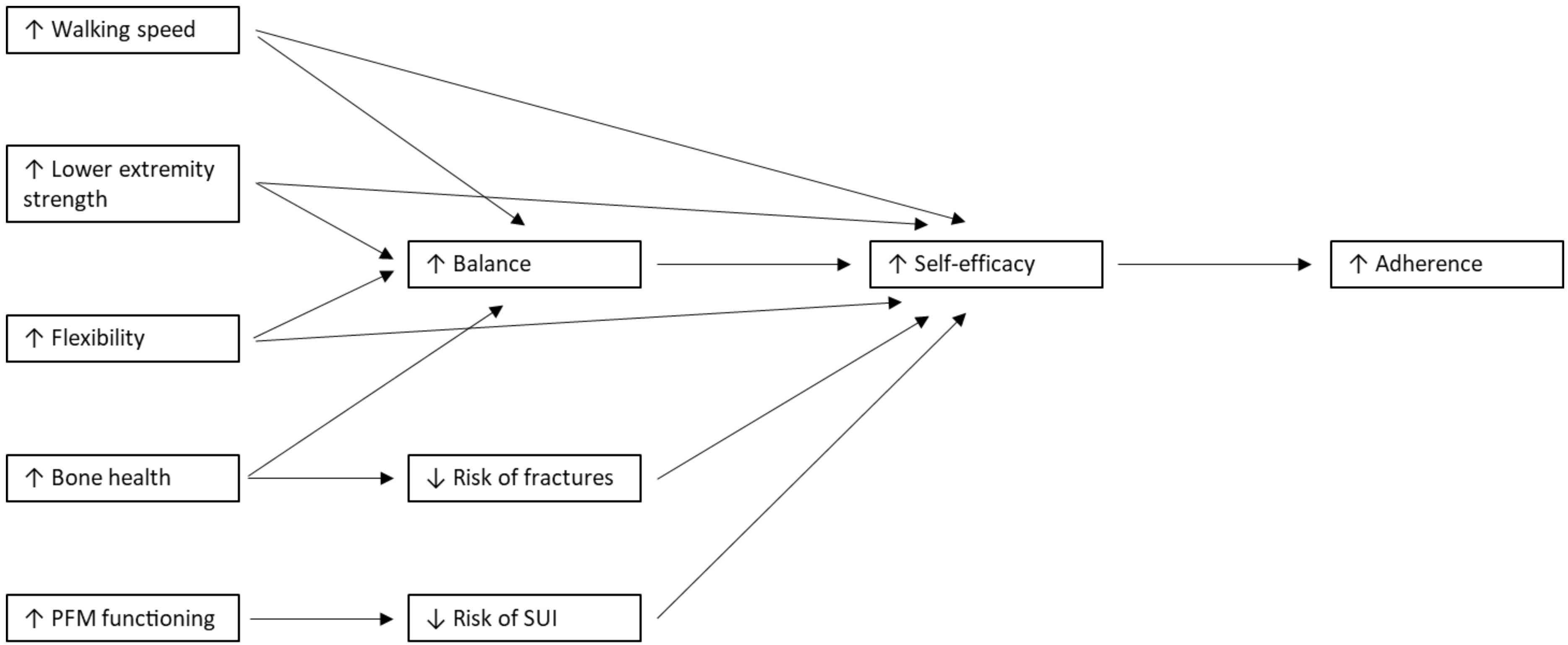


Figure 9.1 Interaction of the aims and results. PFM=Pelvic floor muscle; SUI=Stress urinary incontinence

## Limitations of this research

As with all research, this thesis had a few limitations.

### Lack of randomisation and small control group

While randomisation in intervention studies is considered important from the perspective of bias, it is not without its limitations or feasibility in some settings (Deaton & Cartwright, 2018). Indeed, it could be counter-argued that in the instance of exercise interventions, self-selection would be more ecologically valid as it would mimic choices made in real life (Andrade, 2018). Thus, participants were self-assigned rather than randomly selected to their group. Baseline measures showed no significant differences between the intervention and control group, suggesting little bias in the selection process. Due to time constraints with the campus of the School of Sport, Exercise, and Nutrition closing on the Wellington campus and COVID-19 interruptions, the control group in this intervention was rather small. Although no statistically significant improvements were found in the control group following the intervention period, it is possible that any changes that did occur were due to just one or two participants potentially skewing the results. Furthermore, the control group in this study showed some improvements in aerobic fitness (6-minute walk test). Although these improvements were not significant it is important to note that this control group was a non-active control group and these improvements may have been a result of placebo effect. It is argued that an active control group might attribute any changes in dependent variable to the independent variable, potentially reducing the chance of any confounding factors and bias (Boot, Simon, Stothart, & Stutts 2013). While the results of this research indicate a positive proof of concept for the efficacy of mini trampoline jumping for older women specifically, these limitations serve as a call for further research to expand the generalisability of our findings.

### Lack of exercise history and physical activity patterns

This thesis only included a brief exercise history of participants prior to commencing this exercise intervention. Physical activity patterns of participants during the study and particularly between the post-intervention and follow-up assessment outside of the intervention were not documented. Although participants were encouraged to maintain their usual lifestyle habits during the entire study, it is possible that some of the results were influenced by potential other physical activities outside of the intervention study.

### Surface EMG

Surface EMG measurement has limitations. Contracting the pelvic floor muscle in isolation remains difficult and most women tend to contact adductor and gluteal muscles simultaneously (Grape, Dedering, Jonasson, & Society, 2009). Surface electrodes cannot register the activity from a single muscle alone but rather registers all activity that is reached by the electrode (Grape et al., 2009). Co-contraction of synergist muscles during the pelvic floor muscle assessment might have provided higher activity readings compared to when the pelvic floor muscle was truly contracted in isolation. Therefore, ensuring validity of the surface EMG remains difficult for the scope of this study; however surface EMG to evaluate pelvic floor muscle activity has shown to be reliable, particularly in clinical evaluations (Grape et al., 2009). While this study showed at least maintenance of pelvic floor muscle functioning and improvements of urinary incontinence, the exact mechanism of how pelvic floor muscle functioning might have improved urinary incontinence symptoms with the mini trampoline intervention remains unexplained. Future research should examine pelvic floor muscle activation as well as activation patterns of synergist muscles during the actual mini trampoline exercises in order to understand how the pelvic floor muscle might be activated and strengthened during these exercises. This research was also unable to examine the timing of pelvic floor muscle contraction during the cough assessment. One research study (Madill, Harvey, & McLean, 2010) suggested that the timing of pelvic floor EMG activation during the cough assessment was more important than the amplitude in order to remain continent. Examining EMG amplitude as well as EMG activation timing during the cough assessment for continent and incontinent women could provide future intervention studies with a more detailed and accurate measurement of pelvic floor muscle functioning and related urinary incontinence symptoms.

## Bone health measure

Bone health assessments in this study were performed via quantitative ultrasound on the calcaneus and were only taken on participants' dominant feet. The spine and hip are commonly the two skeletal locations most prone to fracture (Genant, Engelke, & Prevrhal, 2008). Quantitative ultrasound measures are highly correlated with bone mineral density in the hips (but not spine) of older women (Lappa et al., 2007); however definitive assumptions cannot be made. Furthermore, measures were only taken of the dominant foot, and providing measurements of the non-dominant foot as well as including DXA measurements of the hip and spine could help produce more conclusive results. Neither qualitative or DXA measurements for bone health are able to provide information about biochemical markers of bone formation, which would provide a more detailed and differential diagnosis of bone health and potential metabolic bone disease (Seibel, 2005). Age, low bone density and prevalence of fractures are the most important risk factors for future fractures; however, these variables are still insufficient to identify high-risk groups (Genant et al., 2008). Bone mineral density measures correlate with bone strength and can predict fracture risks to some extent; however, bone mineral density does not reflect bone quality, the second main feature affecting bone strength and fracture risk (Bauer & Link, 2009). Examining bone quality in addition to bone mineral density helps to assess bone strength and can further discriminate healthy and osteoporotic patients (Bauer & Link, 2009). Bone quality details as well as including information about biochemical bone properties could help identify how mini trampoline exercises could improve bone health in postmenopausal women. Therefore, future studies, examining the effects of bone health in mini trampoline exercises in postmenopausal women could assess bone health via DXA scans as well as 3D imaging techniques (e.g. MRI) or CT scans to provide detailed information about bone health.

## Suggestions for future research

As highlighted in the general conclusion and limitations of the thesis sections, a number of questions still need to be addressed, while further questions have been raised following the observations made throughout this thesis:

### Examining impact forces of trampoline jumping

Mini trampoline jumping exercises have long been attractive as they can provide the same physiological benefits as regular aerobic exercises but produce less impact forces on the musculoskeletal system when compared to the same exercises performed on the ground (Schiehll et al., 2019). Most studies so far have only examined mini trampoline exercises on the physiological characteristics involved (e.g. heart rate), thus the intensity of each part of mini trampoline exercises has been prescribed exclusively on physiological parameters. However, a perfect relationship between a physiological variable and another biomechanical variable (e.g. impact force) during aerobic exercises does not exist (Schiehll et al., 2019). Only one study so far has examined the impact forces of a range of mini trampoline exercises and found that some of the exercises performed on a mini trampoline (e.g. double jumping and double twist) more closely represented force values that have been classified in the literature as being of high impact (Schiehll et al., 2019). Exercises on a mini trampoline that are in fact considered to be high impact could increase the risk of bone and ligament injury as well as the risk of experiencing stress urinary incontinence (Schiehll et al., 2019; Yang et al., 2019). Thus, in order to prescribe mini trampoline exercises to a specific cohort, more research is needed to examine the impact forces of mini trampoline exercises.

### Mini trampoline exercises for stroke survivors

This thesis included a case report about a postmenopausal stroke survivor experiencing hemiparetic gait and partial paralysis at the upper extremities. Results of this case study showed improvements in general fitness as well as female specific health risk factors; however, conclusions to a wider population cannot be drawn as case studies report associations rather than causations. Some studies have shown that mini trampoline exercises are able to improve balance, gait, falls efficacy in patients who experienced previous strokes (Hahn et al., 2015; Winstein et al., 2016). However, these studies did not explore the benefits of a mini trampoline exercise intervention beyond motor competency and falls risk, and specifically female patients who have increased risks. Future studies could examine the potential benefits of a mini trampoline exercise programme in functional fitness and female specific health risk factors in a larger cohort of postmenopausal stroke survivors.

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# List of Appendices

## Appendix A – Ethics Approval Letters

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 11 September 2018

Dear Anja Fricke

Re: Ethics Notification - **SOA 18/52 - Exploring potential benefits of a 3-months mini-trampoline jumping intervention in healthy older women**

Thank you for the above application that was considered by the Massey University Human Ethics Committee: **Human Ethics Southern A Committee** at their meeting held on **Tuesday, 11 September,**

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

**Research Ethics Office, Research and Enterprise**
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand T 06 350 5573; 06 350 5575 F 06 355 7973
E humanethics@massey.ac.nz W http://humanethics.massey.ac.nz

SEATTLEU
INSTITUTIONAL REVIEW BOARD

Admin 201 | 206-296-2585
irb@seattleu.edu

May 20, 2022

Sarah Shultz
Dept. of Kinesiology
Seattle University

Dear Sarah,

As I indicated in my May 10 email, your protocol **FY2022-022 Comparing physical and physiological responses to varying exercise modalities in older women** is now approved.

Please note these post-approval IRB policies and always check our website for most current forms.

- If you wish to make any changes in the course of your study, you must first submit a **Modification Request** and obtain *written* IRB approval before implementing any modifications.
- If any **unexpected problem** arises that introduces an unforeseen risk or complication, please notify the IRB immediately.
- If you conclude data *collection* and will no longer work with or contact participants (i.e., data analysis stage only), you may email the IRB to request downgrading your study to **Exempt** status, thereby ending IRB oversight of your study.
- If you conclude your study, please email the IRB with a brief summary paragraph of your concluded research, so we may formally end IRB oversight.
- In accordance with new federal regulations, the SU IRB no longer issues approval deadlines or requires formal Continuing Review applications for expedited studies. Instead, we will email you a year from the approval date (**May 10, 2023**) to inquire briefly about the project status.

If you have further questions, I'm happy to assist. Please save this letter with your study files, and best wishes with your research project.

Sincerely,

Andrea McDowell, PhD
IRB Administrator

cc: Anja Fricke, Co-Investigator

901 12th Avenue | P.O. Box 222000 | Seattle, WA 98122-1090

# Appendix B – Health and Activity Recruitment Questionnaires

The following Health and Activity Recruitment Questionnaire was used to screen potential participants for eligibility to take part in the study.

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

# The mechanical and physiological implications of a 3-months mini-trampoline exercise programme with healthy older women

## Health and Activity Recruitment Questionnaire

Participant Name: _________________________________ DOB: ____ Age: _____ Gender: _____

Address: _______________________________________________________ Postcode: _________

Contact Phone: (H):________________ (W):_______________ Mobile: ____________________

*The following questionnaire aims to identify any health problems so that we can avoid any risk of illness or injury. The information provided by you on this form will be treated with the strictest confidentiality.*

**PART A:**

**Have you recently (within the last 12 months) had an acute injury to the lower body that required medical attention?  (i.e. fracture, sprain, strain, hip or knee replacement)**

**YES** **NO**

- If yes please provide details: _____________________________________________

**Are you able to walk independently without the use of any aid?**

**YES** **NO**

- If no please provide details: ______________________________________________

**Do you suffer or have been diagnosed with cardiovascular diseases?**

**YES** **NO**

- If yes please provide details: _____________________________________________

**Do you suffer from or have been diagnosed with any orthopaedic diseases?**

**YES** **NO**

- If yes please provide details: _____________________________________________

**Are you currently prescribed to take any bone altering medications? (i.e. vitamin D, calcium)**

**YES** **NO**

- If yes please provide details: _____________________________________________

**Have you been diagnosed with any of the following conditions?  (If so, please circle whichever apply)**

| | | |
|---|---|---|
| Multiple Sclerosis | Parkinson | Hypertension |
| Autism | Cerebral palsy | Moderate/severe Arthritis |

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

# PAR-Q & YOU

**(A Questionnaire for People Aged 15 to 69)**

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

| YES | NO | |
|---|---|---|
| ☐ | ☐ | **1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?** |
| ☐ | ☐ | **2. Do you feel pain in your chest when you do physical activity?** |
| ☐ | ☐ | **3. In the past month, have you had chest pain when you were not doing physical activity?** |
| ☐ | ☐ | **4. Do you lose your balance because of dizziness or do you ever lose consciousness?** |
| ☐ | ☐ | **5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?** |
| ☐ | ☐ | **6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?** |
| ☐ | ☐ | **7. Do you know of any other reason why you should not do physical activity?** |

**If you answered**

## YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

## NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

**DELAY BECOMING MUCH MORE ACTIVE:**

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

**No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.**

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____________________

SIGNATURE ____________________ DATE ____________________

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) ____________________ WITNESS ____________________

**Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.**

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continued on other side...

# 2022 PAR-Q+

## The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

### GENERAL HEALTH QUESTIONS

| **Please read the 7 questions below carefully and answer each one honestly: check YES or NO.** | **YES** | **NO** |
|---|---|---|
| 1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐? | ☐ | ☐ |
| 2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity? | ☐ | ☐ |
| 3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise). | ☐ | ☐ |
| 4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ______ | ☐ | ☐ |
| 5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ______ | ☐ | ☐ |
| 6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ______ | ☐ | ☐ |
| 7) Has your doctor ever said that you should only do medically supervised physical activity? | ☐ | ☐ |

**If you answered NO to all of the questions above, you are cleared for physical activity.**
**Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.**

- Start becoming much more physically active – start slowly and build up gradually.
- Follow Global Physical Activity Guidelines for your age (https://www.who.int/publications/i/item/9789240015128).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

**PARTICIPANT DECLARATION**
If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ______________________ DATE ______________

SIGNATURE ______________________ WITNESS ______________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________

**If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.**

**Delay becoming more active if:**

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

 

# 2022 PAR-Q+

## FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

| | | |
|---|---|---|
| **1.** | **Do you have Arthritis, Osteoporosis, or Back Problems?**<br>If the above condition(s) is/are present, answer questions 1a-1c | If **NO** ☐ go to question 2 |
| 1a. | Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) | YES ☐ NO ☐ |
| 1b. | Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)? | YES ☐ NO ☐ |
| 1c. | Have you had steroid injections or taken steroid tablets regularly for more than 3 months? | YES ☐ NO ☐ |
| **2.** | **Do you currently have Cancer of any kind?**<br>If the above condition(s) is/are present, answer questions 2a-2b | If **NO** ☐ go to question 3 |
| 2a. | Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck? | YES ☐ NO ☐ |
| 2b. | Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)? | YES ☐ NO ☐ |
| **3.** | **Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm**<br>If the above condition(s) is/are present, answer questions 3a-3d | If **NO** ☐ go to question 4 |
| 3a. | Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) | YES ☐ NO ☐ |
| 3b. | Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction) | YES ☐ NO ☐ |
| 3c. | Do you have chronic heart failure? | YES ☐ NO ☐ |
| 3d. | Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months? | YES ☐ NO ☐ |
| **4.** | **Do you currently have High Blood Pressure?**<br>If the above condition(s) is/are present, answer questions 4a-4b | If **NO** ☐ go to question 5 |
| 4a. | Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) | YES ☐ NO ☐ |
| 4b. | Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure) | YES ☐ NO ☐ |
| **5.** | **Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes**<br>If the above condition(s) is/are present, answer questions 5a-5e | If **NO** ☐ go to question 6 |
| 5a. | Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies? | YES ☐ NO ☐ |
| 5b. | Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness. | YES ☐ NO ☐ |
| 5c. | Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet? | YES ☐ NO ☐ |
| 5d. | Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)? | YES ☐ NO ☐ |
| 5e. | Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future? | YES ☐ NO ☐ |

 

# 2022 PAR-Q+

**6. Do you have any Mental Health Problems or Learning Difficulties?** This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome

If the above condition(s) is/are present, answer questions 6a-6b — If **NO** ☐ go to question 7

| | | |
|---|---|---|
| 6a. | Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) | YES ☐ NO ☐ |
| 6b. | Do you have Down Syndrome **AND** back problems affecting nerves or muscles? | YES ☐ NO ☐ |

**7. Do you have a Respiratory Disease?** *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 7a-7d — If **NO** ☐ go to question 8

| | | |
|---|---|---|
| 7a. | Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) | YES ☐ NO ☐ |
| 7b. | Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy? | YES ☐ NO ☐ |
| 7c. | If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week? | YES ☐ NO ☐ |
| 7d. | Has your doctor ever said you have high blood pressure in the blood vessels of your lungs? | YES ☐ NO ☐ |

**8. Do you have a Spinal Cord Injury?** *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 8a-8c — If **NO** ☐ go to question 9

| | | |
|---|---|---|
| 8a. | Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) | YES ☐ NO ☐ |
| 8b. | Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting? | YES ☐ NO ☐ |
| 8c. | Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)? | YES ☐ NO ☐ |

**9. Have you had a Stroke?** *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 9a-9c — If **NO** ☐ go to question 10

| | | |
|---|---|---|
| 9a. | Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) | YES ☐ NO ☐ |
| 9b. | Do you have any impairment in walking or mobility? | YES ☐ NO ☐ |
| 9c. | Have you experienced a stroke or impairment in nerves or muscles in the past 6 months? | YES ☐ NO ☐ |

**10. Do you have any other medical condition not listed above or do you have two or more medical conditions?**

If you have other medical conditions, answer questions 10a-10c — If **NO** ☐ read the Page 4 recommendations

| | | |
|---|---|---|
| 10a. | Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months? | YES ☐ NO ☐ |
| 10b. | Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)? | YES ☐ NO ☐ |
| 10c. | Do you currently live with two or more medical conditions? | YES ☐ NO ☐ |

**PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE:** ______________________

**GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.**

 
01-11-2022

# 2022 PAR-Q+

**If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:**

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:
You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

**Delay becoming more active if:**

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

## PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ______________________ DATE ______________________

SIGNATURE ______________________ WITNESS ______________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________

For more information, please contact
**www.eparmedx.com**
**Email: eparmedx@gmail.com**

**Citation for PAR-Q+**
Warburton DER, Jamnik VK, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health & Fitness Journal of Canada 4(2):3-23, 2011.

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

**Key References**
1. Jamnik VK, Warburton DER, Makarski J, McKenzie DC, Shephard RJ, Stone J, and Gledhill N. Enhancing the effectiveness of clearance for physical activity participation; background and overall process. APNM 36(S1):S3-S13, 2011.
2. Warburton DER, Gledhill N, Jamnik VK, Bredin SSD, McKenzie DC, Stone J, Charlesworth S, and Shephard RJ. Evidence-based risk assessment and recommendations for physical activity clearance; Consensus Document. APNM 36(S1):S266-s298, 2011.
3. Chisholm DM, Collis ML, Kulak LL, Davenport W, and Gruber N. Physical activity readiness. British Columbia Medical Journal. 1975;17:375-378.
4. Thomas S, Reading J, and Shephard RJ. Revision of the Physical Activity Readiness Questionnaire (PAR-Q). Canadian Journal of Sport Science 1992;17:4 338-345.

PRINT FORM RESET FORM

# Appendix C – Information sheet for Participants

The following information sheet was given to the participants to read prior to volunteering to take part in the study.

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# Mechanical and physiological implications of a 3 months mini-trampoline jumping intervention in healthy older adult women

## Information sheet

Thank you for showing an interest in this study. Please read everything below before deciding if you want to take part. This information sheet will tell you a little more about the study.

My name is Anja Fricke and I will be conducting this research project as part of my doctoral degree within the school of Sport and Exercise at Massey University. My supervisors for this study are Dr. Sarah Shultz, Dr. Philip Fink, Dr. Toby Mündel, and Dr. Sally Lark.

### What is the purpose of this research?

This study wants to examine the mechanical and physiological implications of a 3-months mini-trampoline exercise intervention in healthy older post-menopausal women. Specifically this study is going to examine how overall fitness, gait, balance, and muscle strength improve following the exercise programme. Furthermore, this study will examine bone density as well as pelvic floor muscle function following the exercise programme. Overall physical fitness, bone density and pelvic floor muscle functioning tend to decline with increasing age, which can have detrimental effects on overall quality of life. I am hoping to see improvements in all measured aspects following the exercise programme.

### Who can take part in this study?

I am planning to recruit 50 post-menopausal women between the ages of 50-69 years. You are eligible for this study if you are a post-menopausal woman for at least 12 months, agree not to take any bone altering medications or supplements for the duration of this study, and are able to walk independently without any aid. You will not be eligible if you have any of the following conditions: recent bone fracture or knee and hip replacement within the last 12 months, hypertension (resting blood pressure over 140/90mmHg), any cardiovascular diseases, lower extremity arthritis, orthopaedic disease, cognitive impairment, and/or diseases with variable disorders (e.g. neuromuscular conditions such as multiple sclerosis and Parkinson).

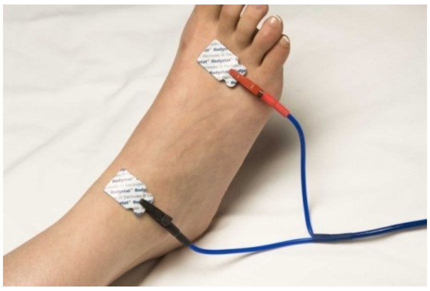
### What is involved in taking part in this study?

If you decide you want to take part in this study you will be randomly assigned to a control or exercising group. If you are in the control group you will only participate in the assessments and will not be part of the exercise intervention. I will provide a few training sessions at the end of the intervention for those who were in the control group and would like to learn some exercises on the mini-trampoline. If you are in the exercising group you participate in all assessments and the exercise intervention.

### *Assessments:*

There will be three key assessments. Assessments will be within one week prior the exercise intervention (or if you are in the control group at any time), within one week after the exercise intervention (or if you are in the control group 3 months after your first initial assessment), and 3 months following your second assessment.

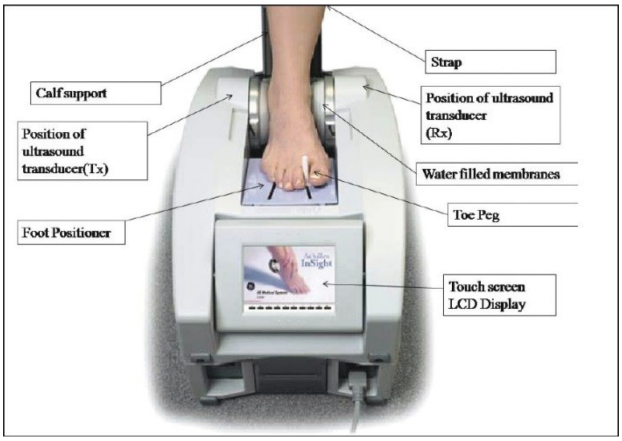
1. Height, weight, waist and hip circumference will be measured. The body mass index will be calculated from measured height and weight.
2. Body composition will also be measured. Small electrodes (sticky gel pads as seen in the picture below) will be attached to your foot and hand, while you lie quietly for 10 minutes. You will not be able to feel anything.



3. Your gait will be assessed with a 10-Meter walk test. You will be asked to walk a distance of 10 meters at your comfortable walking speed on a flat surface for three times. The time it takes to complete each trial will be recorded.
4. I will assess your balance in two different trials. In the first trial you will be asked to stand on a force platform with feet shoulder width apart and shift your weight to the front and back and left and right over a period of 20 seconds. In the second trial you will stand with both feet shoulder width apart for 30 seconds with eyes opened and one trial with eyes closed.
5. To measure how strong your legs are, you will perform a chair-to-stand test. You will be seated on chair and stand up from the seating position for 10 times. I will record the time it takes to complete this task.
6. To measure flexibility, you will be seated on the ground with your feet touching the sit-and-reach box in front of you (see picture below). You will then stretch forward as far as you can

and I will measure the distance of how far you were able to stretch.

7. An ultrasound machine will be used to measure the bone density of the heel of your foot. The sole of the foot of your dominant leg will be thoroughly cleaned using alcohol wipes. You will then place the foot into the ultrasound machine (as seen in picture below). The ultrasound will take a measurement that will last approximately 20 seconds.




8. In order to measure how the pelvic floor musculature functions you will need to insert a small vaginal probe (which inserts just like a tampon) which can measure the muscle activity of your pelvic floor muscles. The probe will be new for each measurement. The muscle activity will be measured while you contract your pelvic floor muscle for 5 seconds and while you perform three maximal effort coughs. If you don't want to do this measure for any reasons, you can opt out of doing this measurement without any negative consequences.
9. The aerobic fitness test consists of a 6-minute walk test. You will be asked to walk at a fast but comfortable speed for 6 minutes and the distance covered during those 6 minutes will be recorded.

## Exercise programme

If you are assigned to the intervention group, you will take part in a 3-months mini-trampoline exercise programme. Training sessions will be 40 minutes long and performed in a group (maximal 6 people) 3 times a week. Exercises are performed on a mini-trampoline with a handle bar you can hold on to at any time (see picture below).

### What will happen to this information?

All of the information that the researcher collect will be kept on a computer. Your details and results will remain confidential, and your name will not be used at any time during the study. Only the researcher (Anja) and her supervisors will have access to the data. We may use the data that we collect in publications or during presentation, but no one will be able to tell which data is yours. You can request to have a results report sent to you, which will give you information about your overall physical fitness, bone density, and pelvic floor muscle functioning.

### What is next step?

If you have any questions, you can ask any member of the research team at any time. If you have read and understood everything and you are happy to take part, please sign the attached 'Consent Form' and complete two questionnaires: one describing your health history and the second one describing your readiness to take part in an exercise programme.

**Participant's Rights**

*Your child is under no obligation to accept this invitation. If you decide to allow your child to participate, your child has the right to:*

- *decline to answer any particular question;*
- *withdraw from the study at any time (if you choose to withdraw you cannot withdraw your data from the analysis after the data collection has been completed);*
- *ask any questions about the study at any time during participation;*
- *provide information on the understanding that your name will not be used unless you give permission to the researcher;*
- *be given access to a summary of the project findings when it is concluded.*
- *request a summary of individual results*

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TE KURA HAUORA TANGATA

**Project Contacts**

Anja Fricke (PhD student researcher) Email: [redacted]

Phone: [redacted]

Dr. Sarah Shultz (Primary supervisor) Email: s.p.shultz@massey.ac.nz

Phone: 04 801 5799 ext 63496

# Appendix D – Consent sheets

The following consent form was used for the participants to provide their own informed consent.

## Mechanical and physiological implications of a 3 months mini-trampoline jumping intervention in healthy older adult women

### CONSENT FORM

**Please circle Y or N for your response below**

| | | |
|---|---|---|
| I have read and I understand the information sheet for volunteers taking part in the study examining the mechanical physiological implications of a 3-months mini-trampoline jumping intervention in healthy older adult women | Y | N |
| I understand that I might be randomly assigned to a control (non-exercising) or exercising group | Y | N |
| By participating I agree not to take any bone altering medication (e.g. calcium, vitamin D, hormone replacement therapy, bisphosphonates) during the duration of the study | Y | N |
| I understand that it is my choice to participate in this study and I can withdraw at any time without giving any reason. | Y | N |
| I understand that my participation in this study is confidential and that no material that could identify me will be used in any reports or presentation in this study. | Y | N |
| I have had time to consider whether I will take part in the study. | Y | N |
| I know who to contact if I have any questions about the study. | Y | N |
| I wish to have my results from the study given to me. | Y | N |

- If you would like your results, please provide your email address:
  ______________________________________

**Consent**

**By signing this form, I give consent to participate in this study**

Signature of Participant: .......................................................... Date:..........................

Full Name (Printed):..........................................................................................

# CONSENT TO PARTICIPATE IN RESEARCH

**TITLE:** Comparing physical and physiological responses to varying exercise modalities in older women

**INVESTIGATOR:** Dr. Sarah Shultz, Kinesiology, Seattle University College of Arts & Sciences

**PURPOSE:** Women are at higher risks of functional disability compared to men; specifically, women are more likely to develop conditions like osteoporosis and urinary incontinence, which can further increase the risk of functional disability. Mini trampoline jumping is a highly beneficial low-impact aerobic exercise capable of improving functional fitness and potentially female specific health risk factors. Our previous research (Fricke, *Int J Prev Med* 2020) has shown that a 12-week mini-trampoline exercise intervention can significantly improve bone health, resting heart rate, aerobic fitness, average walking speed, flexibility, and lower extremity strength. You are being asked to participate in a research project that seeks to investigate the underlying mechanisms driving these benefits by comparing trampoline jumping to exercises more commonly undertaken by postmenopausal women. You will be asked to complete a physical activity readiness questionnaire (PAR-Q) to ensure it is safe for you to perform exercises.

- Once the PAR-Q is completed your height and weight will be recorded. A heart rate monitor will also be secured just under the bra line in order to record heart rate.

- In order to measure resting metabolic rate you will rest on a portable massage table for 20 minutes while resting oxygen uptake will be measured via portable metabolic system (K4b2, Cosmed, Rome, Italy). You will be wearing a soft face mask while breathing normally lying down for 20 minutes. Resting heart rate will also be recorded.

- During and following the resting period, a researcher will place electrodes on the medial gastrocnemius, gluteus maximus, biceps femoris, tibialis anterior, and hip adductors in order to measure surface electromyography (EMG; Delsys Trigno, Natick, MA). Surface electrodes will be placed on your dominant limb. The electrode placement areas will be shaved and thoroughly cleaned using alcoholic wipes.

- You will then be asked to perform three different types of exercises in bouts of 5 minutes with a minimal 10-minute rest periods in between each exercise; the next trial can commence when heart rate returns to within 10% of the recorded resting rate. Exercises will be randomized in order. You will be wearing the face mask and heart monitor during all trials.

- Mini-trampoline exercise: You will perform exercise on the mini-trampoline with handlebar for 5 minutes; these exercises are similar to those used by older women in the previous exercise intervention (Fricke, Int J Prev Med 2020). Exercises that will be performed on the trampoline include:

  - Jogging on the spot (1min)
  - Kneel raises alternating legs (30sec)
  - Heel raises alternating legs (30sec)
  - Jumping jacks (30sec)
  - Scissor jumps (30sec)
  - Left leg bounce (30sec)
  - Right leg bounce (30sec)
  - Jumping with both feet and squeezing ball between knees (1min)

- Walking exercise: You will walk in a comfortable but fast tempo back and forth between cones. You will be asked to walk at a progressive pace that requires some effort to maintain but you should still be able to hold a conversation.

- Home based strength exercise: You will perform a variety of lower leg strength exercises performed on the floor without any additional equipment. Exercises will include:

  - Side steps (30sec)
  - Jogging on the spot (1min)
  - Kneel raises alternating legs (30sec)
  - Heel raises alternating legs (30sec)
  - Jumping jacks (30sec)
  - Calf raises (30sec)
  - Adducting hips with ball between legs (30sec)

- Sit to stand exercises from chair (30sec)

- Glute-bridges (30sec)

- After all exercises are performed, the face mask, heart rate monitor, and electrodes will be removed.

- All tasks should approximately take 1hour to complete from time of arrival.

**SOURCE OF SUPPORT:** None

**RISKS:** There are no known risks associated with this study. However, there is a small risk of fatigue. The researcher will provide ample rest time between each test, ask you about any discomfort throughout the study, and give additional rest periods if needed.

Risk of COVID-19 exposure will be minimized by following Seattle University protocol such as requiring proof of vaccination for all individuals on campus, requiring individuals to fill out a Safe Start Health Check monitoring symptoms prior to arrival on campus, wearing a (K)N95 mask at all times, and sanitizing all equipment between use**.**

**BENEFITS:** Findings from this study further our understanding on how mini-trampoline exercise can benefit postmenopausal women.

**INCENTIVES:** You will receive no gifts/incentives for this study. Participation in the project will require no monetary cost to you.

**CONFIDENTIALITY:** Your name will be required to complete consent forms. All data collected will be coded with an ID number. A key linking your name and ID number will be stored in case any data need to be recalled. Your name and identifying data will never be used in any public dissemination of these data (publications, presentations, etc.). The consent form and key will be stored in a locked filing cabinet in (CASY 540-01a), which is itself a locked room. All data collected will be stored in a locked filing cabinet and password-protected file on a secure computer in Hunthausen 090, accessible only by the PI, Faculty Advisor, and Lab Supervisor. Human subjects research regulations require that data be kept for a minimum of three (3) years. When the research study ends, any identifying information will be removed from the data, or it will be destroyed. All of the information you provide will be kept confidential.

**RIGHT TO WITHDRAW:** Your participation in this study is *voluntary*. You may withdraw your consent to participate at any time without penalty. Your withdrawal will not influence any other services to which you may be otherwise entitled.

**SUMMARY OF RESULTS:** A summary of the results of this research will be supplied to you, at no cost, upon request. The summary will be available approximately 8 weeks after data collection. If you have any questions about the summary, you can contact the PI, Dr. Sarah Shultz, at 206.398.4112.

**VOLUNTARY CONSENT:** I have read the above statements and understand what is being asked of me. I also understand that my participation is voluntary and that I am free to withdraw my consent at any time, for any reason, without penalty. On these terms, I certify that I am willing to participate in this research project.

I understand that should I have any concerns about my participation in this study, I may call Dr. Sarah Shultz who is asking me to participate, at 206.398.4112**.** If I have any concerns that my rights are being violated, I may contact Dr. Michael Spinetta, Chair of the Seattle University Institutional Review Board at (206) 296-2585.

____________________________________ __________________

Participant's Signature Date

____________________________________ __________________

Investigator's Signature Date

# Appendix E – Recruitment flyers

This appendix presents the final recruitment flyer used to recruit participants.

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COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

THE ENGINE OF THE NEW NEW ZEALAND

## Want to be part in an exciting mini-trampoline exercise programme?

# Volunteers wanted for research

There is currently an exciting opportunity for post-menopausal women to take part in a 3 months mini-trampoline exercise programme! This research is going to examine how a 3-months mini-trampoline exercise programme can improve overall fitness, bone density, and pelvic floor muscle functioning in older healthy women.

We are currently looking for post-menopausal women between the ages of 50-69 years old. The study will be carried out at Massey University on the Wellington campus and locations in Hutt City. It involves three assessments testing physcial fitness, bone density, and pelvic floor muscle functioning (up to 1 hours for each assessment). You will also be able to take part in a 3 month mini-trampoline exercise programme within a group of 6 people.
**Participants will receive up to $100 in travel vouchers for taking part in the study.**

**For more information, or if you are interested in taking part, please contact:**
**Anja Fricke**
**Email: A.fricke@massey.ac.nz**
**And ask about the "Mini-trampoline" study.**

Mini-trampoline jumping exercise programme. Contact: **A.fricke@massey.ac.nz**

Mini-trampoline jumping exercise programme. Contact: **A.fricke@massey.ac.nz**

Mini-trampoline jumping exercise programme. Contact: **A.fricke@massey.ac.nz**

Mini-trampoline jumping exercise programme. Contact: **A.fricke@massey.ac.nz**

Mini-trampoline jumping exercise programme. Contact: **A.fricke@massey.ac.nz**

Mini-trampoline jumping exercise programme. Contact: **A.fricke@massey.ac.nz**

Mini-trampoline jumping exercise programme. Contact: **A.fricke@massey.ac.nz**

SEATTLE UNIVERSITY

# Volunteers wanted for research

There is currently an exciting opportunity for post-menopausal women to take part in a short one-off exercise programme involving mini-trampoline jumping, walking, and strength exercises! This research is going to examine how mini-trampoline exercises can improve overall fitness and pelvic floor muscle functioning in older healthy women.

We are currently looking for post-menopausal women between the ages of 50-69 years old. The study will be carried out at Seattle University Human Performance Lab, Hunthausen 090, 901 12th Ave, Seattle, WA 98122. It involves performing 3 short exercise session of 5 minutes each, while energy expenditure, heart rate, and muscle activity will be recorded. Including set-up the session will take no longer than 1hour.

**For more information, or if you are interested in taking part, please contact:**

**Dr. Sarah Shultz**

**Email:** shultzsarah@seattleu.edu

**And ask about the "Mini-trampoline" study.**

Mini-trampoline exercise
Contact:
**shultzsarah@seattleu.edu**

Mini-trampoline exercise
Contact:
**shultzsarah@seattleu.edu**

Mini-trampoline exercise
Contact:
**shultzsarah@seattleu.edu**

Mini-trampoline exercise
Contact:
**shultzsarah@seattleu.edu**

Mini-trampoline exercise
Contact:
**shultzsarah@seattleu.edu**

Mini-trampoline exercise
Contact:
**shultzsarah@seattleu.edu**

Mini-trampoline exercise
Contact:
**shultzsarah@seattleu.edu**

# Appendix F – The Questionnaire for female Urinary Incontinence Diagnosis (QUID)

This appendix presents the QUID (Questionnaire for female urinary incontinence diagnosis) used for the study as presented in Chapter 4 and 5.

## The Questionnaire for female Urinary Incontinence Diagnosis (QUID)

| | None of the time | Rarely | Once in awhile | Often | Most of the time | All of the time |
|---|---|---|---|---|---|---|
| Do you leak urine (even small drops), wet yourself, or wet your pads or undergarments... | | | | | | |
| 1. when you **cough** or **sneeze**? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2. when you **bend down** or **lift something up**? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3. when you **walk quickly, jog** or **exercise**? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4. while you are **undressing** in order to use the **toilet**? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5. Do you get such a **strong and uncomfortable need** to urinate that you leak urine (even small drops) or wet yourself before reaching the toilet? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6. Do you have to **rush to the bathroom** because you get a **sudden, strong need** to urinate? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Scoring:

Each item scores 0 (None of the time), 1 (Rarely), 2 (Once in awhile), 3 (Often), 4 (Most of the time) or 5 (All of the time). Responses to items 1, 2 and 3 are summed for the Stress score; and responses to items 4, 5, and 6 are summed for the Urge score.

# Appendix G – Statements of Contribution

DRC 16

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND
GRADUATE RESEARCH SCHOOL

**STATEMENT OF CONTRIBUTION**
**DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS**

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

| | |
|---|---|
| Name of candidate: | Anja Fricke |
| Name/title of Primary Supervisor: | Prof. David Rowlands |
| In which chapter is the manuscript /published work: | 2 |

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Fricke, A., Lark, S. D., Fink, P. W., Mundel, T., & Shultz, S. P. (2021). Exercise interventions to improve pelvic floor muscle functioning in older women with urinary incontinence: a systematic review. Journal of Women's Health Physical Therapy, 45(3), 115-125.

( ) The manuscript is currently under review for publication – please indicate:

- The name of the journal:
- The percentage of the manuscript/published work that was contributed by the candidate:
- Describe the contribution that the candidate has made to the manuscript/published work:

( ) It is intended that the manuscript will be published, but it has not yet been submitted to a journal

| | |
|---|---|
| Candidate's Signature: | [signature] |
| Date: | 13-Apr-2023 |
| Primary Supervisor's Signature: | David Rowlands [digital signature] |
| Date: | |

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.

*GRS Version 5 – 13 December 2019*
*DRC 19/09/10*

DRC 16

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TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

# STATEMENT OF CONTRIBUTION
# DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

| | |
|---|---|
| Name of candidate: | Anja Fricke |
| Name/title of Primary Supervisor: | Prof. David Rowlands |
| In which chapter is the manuscript /published work: | 3 |

Please select one of the following three options:

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Fricke A, Fink PW, Mundel T, Lark SD, Shultz SP (2021). Mini-Trampoline Jumping as an Exercise Intervention in Postmenopausal Women to Improve Women Specific Health Risk Factors. Int J Prev Med (12) 1:10.

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Involved in relevant literature review and designing the study; drafted manuscript as first/corresponding author

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- Please provide the full reference of the Research Output:

Fricke, A., Rauff, E., Fink, P.W., Lark S., Rowlands, D. & Shultz, S.P. Perceptions of a 12-week mini trampoline exercise intervention for postmenopausal women. Journal of Sport and Exercise Science. In Press

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- Please provide the full reference of the Research Output:

Fricke, A., Fink, P. W., Shultz, S. P., Rowlands, D. Mini trampoline vs home-based and walking exercise on skeletal muscle activity and energy expenditure

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# Appendix H – Publications

## Published

*Systematic literature review (summarised in Chapter 2):*

Fricke, A., Lark, S.D., Fink, P.W., Mündel, T., & Shultz, S.P. (2021). Exercise interventions to improve pelvic floor muscle functioning in older women with urinary incontinence; a systematic review. *Journal of Women's Health Physical Therapy, 45*(3), 115-125.

*Chapter 4:*

Fricke, A., Fink, P. W., Mündel, T., Lark, S. D., & Shultz, S. P. (2021). Mini-Trampoline jumping as an exercise intervention in postmenopausal women to improve women specific health risk factors. *International Journal of Preventive Medicine*, *12*(1), 10.

*Chapter 5:*

Fricke, A., Fink, P. W., Rowlands, D.S., Lark, S.D., Mündel, T., Shultz, S. P. (2023). Mini trampoline jumping to improve female specific health risk factors in postmenopausal women . Journal of Women's and Pelvic Health Physical Therapy 47 (1): 19-25

*Chapter 7:*

Fricke, A., Rauff, E., Fink, P.W., Lark S., Rowlands, D. & Shultz, S.P. Perceptions of a 12-week mini trampoline exercise intervention for postmenopausal women. Journal of Sport and Exercise Science 7 (1): 53-59.

*Chapter 8:*

Fricke, A., Fink, P.W., Lark, S.D., Mündel, T., & Shultz, S.P. (2021). Mini-trampoline jumping as an exercise intervention for post-menopausal women who experienced a stroke – A case report. Journal of Women's Health Physical Therapy, *45*(4), 201-208.

Systematic Review

# Exercise Interventions to Improve Pelvic Floor Muscle Functioning in Older Women With Urinary Incontinence: A Systematic Review

Anja Fricke, MSc[1]
Sally D. Lark, PhD[1]
Philip W. Fink, PhD[2]
Toby Mundel, PhD[2]
Sarah P. Shultz, PhD[1,3]

## ABSTRACT

**Background:** An estimated 200 million people worldwide live with urinary incontinence, and women are more affected than men. The World Health Organization and the International Continence Society recommend pelvic floor muscle training to treat urinary incontinence in women.
**Objective:** The purpose of this systematic review was to examine pelvic floor muscle function and understand its impact on urinary incontinence in women older than 50 years.
**Methods:** Medline, PsycINFO, Webscience, CINAHL, and Scopus were searched for articles from 1988 to May 2019. Included studies had a comparison or control group, exercise intervention aimed to train the pelvic floor musculature, women 50 years and older, and had been published in peer-reviewed journals.
**Results:** Eight studies were included in this review. Exercise interventions included home-based as well as supervised pelvic floor muscle-strengthening, and indirect pelvic floor muscle-strengthening exercises via co-contraction of surrounding muscles. All interventions were able to improve pelvic floor muscle strength as well as urinary incontinence symptoms, with bigger improvements found in supervised interventions.
**Conclusion:** This review has shown that exercise interventions targeting the pelvic floor muscles may be effective in improving pelvic floor muscle strength, urinary incontinence symptoms, and even quality of life measures. Exercise interventions that were supervised or included some type of biofeedback device showed greater and faster improvements than interventions without additional assistance.
**Key Words:** exercise, pelvic floor muscle, urinary incontinence

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*The authors declare no conflicts of interest.*

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## INTRODUCTION

Urinary incontinence, as defined by the International Continence Society (ICS), is a complaint of any involuntary urinary leakage.[1–4] The World Health Organization (WHO) acknowledges incontinence as a set of diseases, while the International Classification of Functionality recognizes the associated severe disabilities.[5] Global demographic trends indicate that the incidence of urinary incontinence will rise in the coming years, adding a significant health and social burden as well as increased economic costs.[1] It is estimated that, worldwide, more than 200 million people live with urinary incontinence, and women are more affected than men.[2,6] The incidence of incontinence increases from middle age onward and is associated with a reduced quality of life.[2] In about 25% of people living with urinary incontinence, the health issue is considered to be severe; yet half the people living with incontinence do not discuss their problems with a health care professional or even family members or friends out of embarrassment.[2,7]

Chronic incontinence can be classified into 5 different types: overflow, functional, stress, urgency, and mixed incontinence.[2,3,8] Stress urinary incontinence is considered to be the most common type of incontinence in older women.[3,6,9–11] Stress urinary incontinence is defined as an involuntary loss of urine during activities that increase the intra-abdominal pressure such as sneezing or coughing.[9,12] Urgency

  

Original Article

# Mini-Trampoline Jumping as an Exercise Intervention in Postmenopausal Women to Improve Women Specific Health Risk Factors

**Anja Fricke[1], Philip W. Fink[2], Toby Mundel[2], Sally D. Lark[1], Sarah P. Shultz[1,3]**

[1]School of Sport Exercise and Nutrition, Massey University, Wallace Street, Wellington, New Zealand, [2]School of Sport Exercise and Nutrition, Massey University, Massey University Ave and Albany Drive Palmerston-North, New Zealand, [3]Kinesiology Department, Seattle University, 901 12th Avenue, Seattle, WA, USA

## Abstract

**Background:** Women tend to outlive men and are at higher risks of functional disability compared to men. Specifically, women are more likely to develop conditions like osteoporosis and stress urinary incontinence which can further increase the risk of functional disability. Regular physical activity and/or exercise programs can minimize the physiological decline that occurs during aging and can improve overall physical fitness, bone health, and pelvic floor muscle function; however, exercise programs tend to focus on only one parameter. Mini-trampoline jumping is a highly beneficial low-impact aerobic exercise capable of improving aerobic fitness, balance, muscle strength, and potentially bone health as well as pelvic floor muscle functioning. The aim of the proposed research project is to examine the benefits of a 3-month mini-trampoline exercise intervention on physical fitness, bone health, and pelvic floor muscle functioning in postmenopausal women. **Methods:** Fifty postmenopausal healthy women aged 50–69 years will be recruited. Assessments on physical fitness (aerobic fitness, walking speed, balance, lower extremity strength, flexibility), bone health, and pelvic floor muscle functioning will occur within 1 week before and after the exercise intervention, including a 3-month follow-up assessment. The exercise intervention will last 12 weeks, with three sessions of 40 min each per week. **Conclusions:** The proposed research has the potential to improve functional ability and women-specific risk factors in older women with an innovative and fun exercise program.

**Keywords:** *Osteoporosis, pelvic floor, physical fitness, postmenopause*

## Introduction

Physical functional ability is key to elderly individuals maintaining an independent lifestyle.[1] Any deficits in muscle strength, mass, power, and endurance can limit mobility and activity, especially for women.[2] Older women are at higher risk of functional disability compared to older men, as older women are also more likely to develop conditions like osteoporosis and urinary incontinence, which can both decrease overall activities of daily living.[3,4] Menopause is known to have the single greatest effect on overall bone mass loss and osteoporosis,[4] which affects four times as many women as men. Importantly, decreased bone mass significantly increases the risk of fractures, disability, and chronic pain.[3]

Stress urinary incontinence is considered to be the most prevalent form of urinary incontinence[5] and commonly occurs during some form of physical exertion or during sneezing and coughing.[6] Urinary incontinence can create serious medical conditions (e.g., urinary tract infections) but also to social problems (e.g., embarrassment), reducing social interactions and physical activity.[7] Women are specifically susceptible to stress urinary incontinence because the pelvic floor musculature in women weakens with older age due to sarcopenia, childbirth trauma, and/or menopause.[6]

Regular physical activity can minimize the physiological decline that occurs during aging and improve overall physical fitness, bone health, and pelvic floor muscle function; however, exercise programs tend to focus on only one parameter.[6,7] Several studies have shown that sedentary adults are at a larger risk of functional decline compared to adults who exercise regularly and exercise is highly recommended to reduce these risks.[1] Although studies have shown significant improvements for overall physical performance when participating in an exercise intervention, no study



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to date also included other functional ability measures that specifically focus on health risks associated with postmenopausal women.

The ability to remain functionally independent is reliant on several physical abilities and, thus, it is important that exercise interventions do not rely on a single measure to improve general function. Furthermore, research on exercise programs that could improve pelvic floor muscle functioning is sparse, with no clear exercise intervention identified. Mini-trampoline jumping, also known as rebounding, is a highly beneficial low-impact aerobic exercise capable of improving aerobic fitness, balance, muscle strength, and postural control in young as well as older adults.[8-10] Mini-trampoline exercises incorporate a multicomponent approach, which affects many physical factors including strength, body stability, muscle coordinative responses, joint movement amplitudes, and spatial integration.[8] Yet no research has examined the effects of a mini-trampoline exercise intervention on older women's health.

Therefore, the aims of this intervention study are to understand the benefits of a 3-month mini-trampoline exercise intervention on i) physical fitness, ii) bone health, and iii) pelvic floor muscle functioning in postmenopausal women.

## Methods

### Study design

This is a randomized exercise intervention study with pre-, post-, and follow-up measures. Figure 1 represents a schematic timeline of the study design following the initial recruitment. The study has gained ethical approval from the Massey University Ethics Committee (Southern A 18/52).

### Participants

Fifty postmenopausal healthy women aged 50–69 years will be recruited. It is believed that this aged cohort would benefit the most from the mini-trampoline exercise intervention: physical function has started to decline but women would still be able to safely perform the exercises.[11] Eligible participants will undergo prescreening for inclusion and exclusion criteria [Table 1]. A health history questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q) will be used to determine eligibility and readiness to participate in exercise. Participants will be recruited from the Wellington region via flyers and advertisements. Regional companies and sports clubs will be contacted directly via e-mail and phone to increase engagement with external stakeholders.

Ten of the recruited women will be assigned to a control group while 40 will be assigned to an exercise group. The sample size was calculated based on a study examining the effects of a mini-trampoline exercise intervention on balance and strength improvements in older adults.[8] Based on the means and standard deviations provided in that study, the sample size required to achieve a power of 0.8 and 95% CI is $n = 33$ for changes in balance and $n = 36$ for changes in lower extremity muscle strength. Accounting for 10% attrition, a total of 40 participants will be necessary to see appropriate changes in physical function after the 3-months exercise intervention. Very little change is expected in the control group; thus, the relatively small amount of variability reduces the sample size required for the control group.

### Assessments

The primary outcome measures for this study are indicators of physical fitness, sub-categorized as aerobic fitness, gait, balance, lower extremity muscular strength, lower extremity flexibility. Secondary outcome measures include bone health of the calcaneus and pelvic floor muscle functioning. All parameters will be measured within one week prior to commencing the exercise intervention, within 1 week following the exercise intervention and 3 months following the exercise intervention.

### Primary outcome measures

The primary outcome measure for this intervention is functional fitness, which comprises aerobic fitness, walking ability, balance, strength, and flexibility. As all of these components are known to decline in function with increasing age, they are directly targeted in the exercise intervention.[11] A mini-trampoline exercise program has the potential to improve overall functional fitness with its multi-component approach.[8]

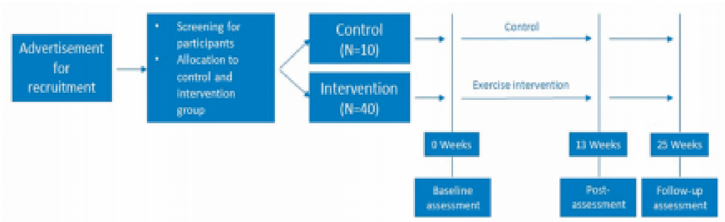


**Figure 1: Schematic timeline of the proposed study**

**Table 1: Inclusion and exclusion criteria**

| | |
|---|---|
| Inclusion criteria | Female aged 50-69 years |
| | Postmenopausal for at least 12 months |
| | Able to walk independently without any aid |
| | Agree not to take bone altering medication and supplements |
| | Able to travel independently to research and exercise sites |
| Exclusion criteria | Neuromuscular conditions such as multiple sclerosis and Parkinson's |
| | Lower extremity bone fractures or knee and hip replacements within the last 12 months |
| | Uncontrolled hypertension |
| | Uncontrolled cardiovascular diseases |
| | Severe lower extremities arthritis |
| | Severe lower orthopedic diseases |

#### *Aerobic fitness*

Aerobic fitness will be assessed with the 6-min walk test. The test will be performed indoors on a flat surface in a rectangular course (5 m in length and 1 m in width). Participants will walk as fast as they comfortably can for 6 min and the total distance covered at the end of the 6 min will be measured. The 6-min walk test has previously demonstrated to produce good test-retest reliability in measuring aerobic fitness in older adults.[12]

#### *Walking speed*

Walking speed and lower extremity strength will be assessed during a 10-m walking test. Participants will walk a total of 20 m (with 5 m provided at the beginning and the end for acceleration and deceleration, respectively) at their comfortable walking speed on a flat and straight surface. Timing gates at the start and end of the 10 m will record the time. Participants will perform three trials with 1-min rest breaks between each trial. This test has previously been validated to measure lower leg strength and walking speed for older adults.[13]

#### *Balance*

#### Dynamic balance

The dynamic balance will be assessed with participants standing on a force platform (AMTI, Watertown, MA, USA) with feet shoulder-width apart and arms stabilized at the hip. Participants will be asked to shift their weight anteriorly and posteriorly, and then laterally to the right and left sides as far as possible while retaining their balance. The tasks will be performed repeatedly over a period of 20 s, whereby participants shift their weight in all directions during that time period. The total path length, path length along the medial-lateral as well as anterior-posterior axis, maximal range of sway in the anterior-posterior as well as medial-lateral direction, and velocity along the medial-lateral as well as anterior-posterior axis will be assessed. The center of pressure measurements has been deemed valid and reliable in testing balance in older adults.[14]

#### Static balance

The static balance will be measured during a two-legged stance with participants standing on the force platform shoulder-width apart with eyes closed for 30 s. Participants will also perform a one-legged stance with eyes open for 30 s. Three trials for each condition will be performed and the center of pressure will be recorded. To understand the pattern of movement, movement range and length of path will be analyzed and a multifractal analysis will be performed.[15]

#### *Lower extremity strength*

Lower extremity muscle strength will be further assessed with the chair based sit-to-stand-test. Participants will be seated on a standardized 40 cm high chair and stand up from the seated position for 10 times as fast as possible. The time it takes to sit and stand 10 times will be recorded. The chair-to-stand test provided good test-retest reliability and good criterion-related validity in measuring lower limb strength in older adults.[16]

#### *Flexibility*

Hamstring flexibility will be assessed with the sit-and-reach test. Participants will place the soles of their feet against the sit-and-reach box. Participants will slowly reach forward with both hands as far as possible to a position that can be maintained for 2 s. Hands have to be in a parallel position to each other and fingertips should be in contact with the measuring tape of the sit-and-reach box. The score that is the most distant point reached with fingertips and held for 2 s will be recorded in cm. Three trials will be performed, while the best out of three trials will be recorded. The sit-and-reach test has been validated to be a good predictor of hamstring flexibility.[17]

### Secondary outcome measures

Secondary outcome measures include bone health and pelvic floor muscle functioning. Both outcome measures are specific health risks for aging women, which are known to decline in functioning in postmenopausal women.[4,5] Based on previous research, a mini-trampoline exercise intervention might have the potential to improve bone health in the calcaneus as well as pelvic floor muscle functioning.[8-10] Bone health in the calcaneus might be improved through the mechanical loads that will be applied through contact with the base of the mini-trampoline. Any tension, compression and torsion at the tendon and bone complex create electrical signals that stimulate bone metabolism and possibly inhibit bone reabsorption.[18] The pelvic floor muscles are believed to be highly active during trampoline exercises and thus might be strengthened following an exercise program.

*Bone health*

The bone health of the calcaneus will be assessed via a qualitative ultrasound measure. The ultrasound parameters taken from the calcaneus have shown high correlations with bone mineral density in the hips of older women. A qualitative ultrasound measure is therefore recommended as an inexpensive tool to screen for bone health in older women.[19] Participants will be seated comfortably on a chair while ultrasound gel is applied to the pads of the ultrasound machine. The thoroughly cleaned right foot of participants will be placed on the ultrasound machine with the lining of the machine placed between the hallux and second phalanx. The foot will be kept stable with a brace during measurements.

*Urinary incontinence and pelvic floor muscle functioning*

The degree of urinary incontinence will be assessed with the female urinary incontinence diagnosis questionnaire. This short 6-item urinary incontinence symptom questionnaire has previously been validated to be used as an outcome measure in clinical trials.[20] The functioning of the pelvic floor musculature will be examined via surface electromyography (EMG) (Noraxon, Arizona, USA). During the initial meeting prior to the first testing session, participants will be taught the structure and anatomy of the pelvic floor muscle to help create awareness of this muscle group, its location and function. Participants will be instructed to try and stop voiding during micturition on only a couple of occasions to feel the pelvic floor muscles. This protocol has been used in previous studies in order for participants to contract the correct muscle group during testing.[21] Participants will void their bladder immediately prior to testing in order to standardize bladder volume. Participants are provided with verbal instructions to insert a vaginal probe as they would do when inserting a tampon; the two conducting plates must be placed laterally (with one plate facing their right side of the body and the other plate facing the left side of the body). Participants will be instructed to perform maximum voluntary contractions of the pelvic floor muscle while in a standing positing and hold this contraction for 10 s. Following the 1-min rest period, participants will then perform three maximal effort coughs. Testing will be repeated three times with 1-min rest breaks in between each trial. This protocol aligns with previously validated and reliable protocols.[22,23]

## Exercise intervention

Forty of the 50 recruited participants will be assigned to the intervention group and 10 participants will be assigned to the control group. The control group will only attend the pre-, post-, and follow-up assessments and will be instructed to continue with their daily routines for the 12 week period between assessments. Participants in the intervention group will partake in a mini-trampoline exercise program for 12 weeks, with 40-min sessions occurring three times a week. Mini-trampoline exercises will concentrate on movements to improve aerobic fitness, flexibility, lower extremity strength and balance, as well as pelvic floor muscle activation. Exercises were chosen for their ability to scaffold in progression throughout the program. Specifically, exercises will start with simple and basic movements and progress to more challenging and interactive tasks throughout the 12 weeks.

Exercises will be performed on a mini-trampoline with handlebars. During the course of the exercise program, participants will be encouraged to perform exercises without holding onto the handlebar; however, this is dependent on individual ability, progress and confidence. The researcher will conduct each training session in a small group with a maximum of six participants. Exercise sessions will be performed at Massey University in Wellington or at community locations to minimize the burden on participants. In addition to the primary researcher, each exercise session will also be attended by a research assistant who will ensure that participants are performing exercises safely and correctly. Each participant will be provided with a heart rate monitor during the exercise sessions. For the exercise to be effective the heart rate should continuously be between 40 and 75% of the age-predicted maximum heart rate (HRmax = 208 − 0.7 × age). If the heart rate reaches near-maximal values (80% HRmax), participants can reduce the intensity or take short rest breaks.

## Adherence

A potential challenge to this intervention study could be adherence to the exercise program. The most commonly reported motivators to exercise were those that are linked to health and fitness benefits in older adults.[24] The potential health benefits of this intervention study are vast which should enhance adherence to this exercise program. Furthermore, exercise sessions of our study will be performed in small groups of six people, allowing for social interactions. It has been well documented that individuals' compliance to exercise program are greatly increased if social interactions and social integration are well maintained during the exercise program.[25] The intended participants for this intervention study are aged 50–69 years, therefore it can be expected that the majority of participants are still in the workforce. For individuals who work full-time, time might be a compliance issue. However, this study will offer the opportunity for testing and exercise sessions to occur within the premises of participating companies if a suitable room can be provided, allowing participants to partake in the intervention study without having to travel. Furthermore, exercise sessions are only 40 min long and could, therefore, occur during lunchtime hours.

### Statistical analysis

To address the primary and secondary aims, a series of 2 (Group: Control vs Intervention) ×3 (Test: baseline, post-assessment, follow-up) repeated measures ANOVA will be utilized. Dependent variables will include the aforementioned measures of physical fitness, bone density, and pelvic floor musculature. The relationship between dependent variables and potential confounding factors (i.e., age, natural childbirth) will be assessed using Pearson's correlation. When relationships exist between confounding factors and dependent variables that are considered moderate or strong ($R > 0.6$), the factor will be added as a covariate to the appropriate ANOVA.

## Discussion

With the increasing aging population, the ability to live independently becomes increasingly important in modern society. New Zealand district health boards spent over $900 million on support services, and specifically residential care, for older people in 2014/2015 alone.[26] It is not just a financial burden on the government but more importantly has detrimental health impacts on the individual and reduces the overall quality of life. People who live in retirement villages and residential care are often away from their former homes and neighborhoods as well as separated from their extended families. It is, therefore, not uncommon for residents to become lonely, which often directly contributes to depression and a reduction in quality of life.[27] Furthermore, a decline in functional fitness has been associated with a decline in overall quality of life.[28] Thus, functional ability is a key factor for older individuals to both maintain independent living and participate in family and community services.[1]

This proposed study aims to improve functional ability in older adults with an innovative and fun exercise program that is new to most people and thus has the potential to increase adherence. The mini-trampoline exercise program has the potential to not only improve physical fitness but also improve specific risk factors in aging women, which include bone health and pelvic floor muscle functioning. Improving any or all of these functions could, in turn, improve the overall quality of life and help to maintain an independent living situation in the older population. The results of this study could help guide the development of exercise intervention for older adults and particularly for older women with specific health risks.

### Implications

This study addresses the health and wellbeing of healthy postmenopausal women, aiming to improve physical functioning and women-specific health risk factors. Extending the knowledge of a mini-trampoline exercise intervention in this population group could potentially improve health benefits in postmenopausal women, increasing their physical function and overall quality of life and decreasing the effects of age-related functional decline.

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### Conflicts of interest

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Case Report

# Mini-Trampoline Jumping as an Exercise Intervention for Postmenopausal Women Who Experienced a Stroke: A Case Report

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Toby Mundel, PhD[2]
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## ABSTRACT

**Introduction:** This case report details a mini-trampoline exercise intervention for a 56-year-old postmenopausal woman who experienced a stroke 7 years ago, which has not previously been reported in medical literature.
**Case Description:** The patient was diagnosed with a cerebral infarction on the left hemisphere following 3 aneurysms at 49 years of age. The patient underwent extensive physical rehabilitation for 6 years, which included physiotherapy, swimming, walking, and attending a cardiac exercise clinic. Although she is able to walk unaided, she still experiences a right-sided hemiparetic gait.
**Outcomes:** The patient showed great improvements in walking speed, lower leg strength, flexibility, pelvic floor muscle strength, bone health, and some aspects of balance following a supervised 12-week mini-trampoline exercise intervention and 12-week follow up.
**Discussion:** This article represents a case in which a mini-trampoline exercise intervention improved physical function and female-specific health risk factors in a postmenopausal woman who experienced a stroke 7 years ago.
**Key Words:** female-specific, mini-trampoline, postmenopausal, stroke

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## INTRODUCTION

A stroke, commonly caused by a disturbance of cerebral perfusion, results in a sudden loss of neurological function. The degree of disability caused by a stroke varies depending on the size and area of the damage.[1] Most people who experience strokes continue to live with physical impairments, such as decreased muscular function, impaired balance, decreased joint range of motion, reduced motor control (commonly associated with hemiplegia), and urinary incontinence.[2-4] A decrease of muscle function following a stroke is commonly a result of a loss in muscle strength, muscle power, and muscle contraction velocity.[5] The ability to remain functionally independent is highly reliant on lower limb function, as it allows an individual to stand up, maintain balance and control, and ensure an efficient gait.[5] Falls frequently occur during circumstances with increased environmental demands, which require sufficient velocity and force generated by the lower limb muscles.[3] Because muscle power is a product of muscle strength and contraction velocity,[3] decreased muscle power is often related to a higher occurrence of falls. Furthermore, a hemiplegic gait results in decreased loading of the hemiparetic leg, which in turn can lead to a decline of bone mineral density at the hip.[6] With a decreased bone mineral density and a higher risk of falls due to poor balance and motor control, people who have experienced strokes are also at higher risk of fractures.[6,7] Postmenopausal women who have experienced a stroke are also at higher risk of developing urinary incontinence and fractures compared with men.[8,9] A common secondary complication observed after a stroke is poor general cardiorespiratory fitness, which is associated with poor functional performance and further increases the risk of strokes and cardiovascular diseases.[6]

Research Report

# Mini-Trampoline Jumping as an Exercise Intervention for Postmenopausal Women

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## ABSTRACT

**Background:** Mini-trampoline jumping is a highly beneficial low-impact aerobic exercise capable of potentially improving female specific health risk factors.
**Objectives:** The aim of this research was to examine the benefits of a 3-month mini-trampoline exercise intervention on bone health and pelvic floor muscles functioning in postmenopausal women.
**Methods:** Thirty-seven healthy postmenopausal women were recruited and participated in the 12-week mini-trampoline exercise intervention. Baseline, postintervention, and 3-month follow-up assessments included bone health, pelvic floor muscles functioning, and urinary incontinence.
**Results:** Bone mineral density increased significantly at postintervention compared with the control group. The exercise group demonstrated decreased stress urinary incontinence scores at postintervention, with the difference being statistically significant at follow-up. No significant differences were found for the cough assessment or urge urinary incontinence scores.
**Conclusion:** A mini-trampoline exercise intervention has the potential to improve female specific health risk factors in postmenopausal women.
**Key Words:** bone density, exercise, menopause, pelvic floor, urinary incontinence

## INTRODUCTION

The health status of women is major public health concern. Although women are expected to live longer, women are generally in worse health than men.[1] Compared with men, postmenopausal women report greater levels of depression, physical disability, and physical performance.[2] Postmenopausal women are at a higher risk of functional disability than men, as women are more likely to develop conditions such as osteoporosis and urinary incontinence, which can decrease overall activities of daily living.[2,3,4] Menopause, which occurs at an average age of 51 years,[5] greatly affects overall bone mass loss[3] and osteoporosis. With a loss of bone mass the risk of fractures, disability, and chronic pain significantly increases. Importantly, decreased bone mass significantly increases the risk of fractures, disability, and chronic pain.[2]

Urinary incontinence is often further classified into stress urinary incontinence (SUI), urge urinary incontinence (UUI), and overflow urinary incontinence.[6] The most common form of urinary incontinence is SUI, which is more commonly seen in women than in men.[6] Stress urinary incontinence can be defined as an involuntary loss of urine that commonly occurs during some form of physical exertion and effort or during sneezing and coughing.[7] Stress urinary incontinence can lead not only to serious medical conditions such as urinary tract infections and perineal rash but

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# Chapter 7 – Fricke et al. (2023)

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## Perceptions of a 12-week mini-trampoline exercise intervention for postmenopausal women

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ABSTRACT

*The aim of this study was to examine the views and attitudes of postmenopausal women who participated in a mini-trampoline exercise intervention to improve female specific health risk factors. Twenty-nine postmenopausal healthy women aged 59.34 ± 5.82 years completed an open-ended and anonymous questionnaire consisting of 13 questions about their current activity levels, their perceptions of the mini-trampoline exercise intervention, and their future exercise plans. Principles of thematic analysis were utilized to analyse survey responses whereby each response was coded and categorized into a higher order theme. Adherence to the mini-trampoline exercise intervention was high (89.3%) and general attitudes were positive. Most responses (89%) suggested it was easy to participate. The most salient barriers to participation included work (24%) and personal commitments (20%). Women's responses (43%) suggested they would participate in a similar exercise intervention if it were offered at a gym. The highest-responding frequency and duration of the programme was reported to be 3 times per week (59%) and 40 minutes per session (31%). Local gyms could consider implementing a flexible scheduled, group-based mini-trampoline exercise programme that occurs at least three times per week for 40 minutes as these programme characteristics appear to be key for increased adherence to exercise in postmenopausal women.*

### 1. Introduction

Older women are more likely than older men to develop conditions such as osteoporosis and urinary incontinence, which can decrease overall activities of daily living (MacLean et al., 2008; McGarry & Kiel, 2000). Regular exercise has long been recommended to reduce postmenopausal symptoms and increase physical functioning as well as quality of life (Shangold, Sherman, & DiNubile, 1998; Tolar, Teitelbaum, & Orchard, 2004). Yet older women have lower physical activity levels than men; just 27% of women over the age of 65 years meet daily recommended activity goals (Findorff, Wyman, & Gross, 2009). Older women and men alike have difficulties adhering to exercise programmes (Moore et al., 2020; Tak, van Uffelen, Paw, van Mechelen, & Hopman-Rock, 2012) such that 10 – 15% of older adults who start a structured exercise programme are known to drop out during the first six months (Tak, van Hespen, van Dommelen, & Hopman-Rock, 2012). Future exercise programmes that target older women should focus on known facilitators (e.g., enjoyment, duration, setting, level of self-efficacy, programme tailoring) (White, Randsdell, Vener, & Flohr, 2005) and strategies that allow women to overcome barriers (e.g., lack of time, money, social support, transportation, exercise experience) and increase their adherence to exercise (Forkan et al., 2006; Moore et al., 2020; Tak, van Uffelen, et al., 2012).

Mini-trampolines solve many of the challenges that prevent women from exercising. They are relatively inexpensive, small, portable, and offer all the benefits of a low impact exercise, while being performed in small, confined spaces, including at home

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(Weston, 2001). The level of effort exerted by an individual on a mini-trampoline exercises is easily self-adjustable, thus allowing for an effective workout for different women with different fitness levels (Aragão et al., 2011). Mini trampoline exercise programmes can improve physical fitness and also female-specific health risk factors, such as osteoporosis (Aragão et al., 2011; Bunyaratavej et al., 2015; Cunha et al., 2016). However, most research-based exercise interventions measure success solely on improved physical outcomes; no published research has examined the views and attitudes of women who participated in a mini-trampoline exercise intervention. Yet, it is important to consider participant perceptions of an exercise programme to examine its acceptability and sustainability as well as its effectiveness, particularly in older women who have specific motivators and barriers to exercise. Therefore, the purpose of this study was to examine the current views and attitudes of the programme from participants who completed a mini-trampoline exercise intervention study.

## 2. Methods

Participants were involved in a larger mini-trampoline exercise intervention (Fricke et al., 2021) to improve functional fitness and female-specific health risk factors in older women. The 12-week exercise intervention comprised of three 40-minute sessions held each week for 12 weeks, with pre- and post-tests as well as a 3-month follow-up. The research gained ethical approval from the Massey University Ethics Committee (Southern A 18/52). All women who participated in the intervention group of the exercise intervention study were contacted via email after completing the intervention and follow-up assessment. Each e-mail included a link to an online, anonymous questionnaire developed by two authors (AF, SS) within Google Forms. Survey questions asked participants to discuss their current physical activity levels, their perceptions of various components of the mini-trampoline, exercise intervention, and their future physical activity plans. All 13 questions were open-ended, and participants were able to provide more than one answer for each question. One hundred percent of participants (n = 29) who completed the intervention also completed the questionnaire.

Participants' open-ended responses were managed in Excel (Microsoft, Version 2002) and analysed using principles of thematic analysis (Green & Thorogood, 2005). Answers for each question were independently coded by the first author and a second researcher (ER) into higher order themes using a thematic framework. The two coders discussed the thematic coding for every individual response to each question until 100% agreement was achieved. Each question resulted in a varying number of themes. To determine the percentage in which a theme emerged, the following calculation was used:

$$\frac{N\text{theme}}{N\text{responses}} \times 100$$

where $N$theme is the number of times a particular theme was mentioned and $N$responses is the total number of responses for that question. $N$responses varied between questions depending on the number of total responses provided.

## 3. Results

The completion rate for this intervention was 97% (n = 29; age = 59.34 ± 5.82 years; BMI = 27.62 ± 7.85 kg/m$^2$). The average attendance rate of women in this study was 89% (range: 80.5% – 100%). All (n = 29) participants who completed the exercise intervention completed the questionnaire; 97% (n = 28) reported to have participated in regular exercise prior to participating in the mini-trampoline intervention. Prior to this exercise intervention, 24% of total participants (n = 7) reported that nothing has ever stopped them from exercising. In contrast 28% (n = 8) reported that injury has previously stopped them from participating in exercise, 14% (n = 4) reported other health issues, another 14% (n = 4) mentioned a lack of motivation, while 10% (n = 3) reported pain or soreness throughout the body as a barrier to previously participating in exercise.

A detailed description of the five most salient higher order themes along with illustrative quotes for all survey questions can be found in the Supplementary material. Three questions focused on motivation to participate in a mini-trampoline exercise programme (Supplementary Table 1). Participants reported that social interaction was the most enjoyable programme characteristic and contribution to research was a primary motivator to participate. Similarly, three questions focused on barriers to participating in the programme. Participants (60%) found the exercises easy to complete and most commonly reported nothing unenjoyable about the programme. Work commitments were cited as being the primary barrier to participating in the programme.

Individual programme tailoring is a known facilitator for women's adherence to exercise (White et al., 2005). Participants provided feedback on optimal mini-trampoline exercise prescription (Figure 1). Most participants reported that no changes needed to be made to the format of the programme, and many agreed that the programme should include three 30-minute sessions per week.

## 4. Discussion

This study examined the current views and attitudes from older women who participated in a mini-trampoline exercise intervention to improve female specific health risk factors. The most enjoyable characteristics of this mini trampoline intervention were the social aspects of exercising in a group, the short duration bursts of exercise as well the instructor. Conversely, the most common barriers to participation included work, personal commitments, and transportation to sessions. Our mini-trampoline exercise programme aimed to address some of these barriers by providing the exercises for free, offering different locations and times and allowing women to participate in a different exercise session if they were unable to attend their usual session.

According to Pisters et al. (2010) an adherence level of at least 80% – 85% is recommended if the results of an intervention are to be satisfactory and if the intervention is to have therapeutic value. The higher adherence rate (89%) in this study is likely reflected in the overall positive views of participants about the mini-trampoline intervention. Research has shown that exercise interventions that involve socialization, support, and a sense of

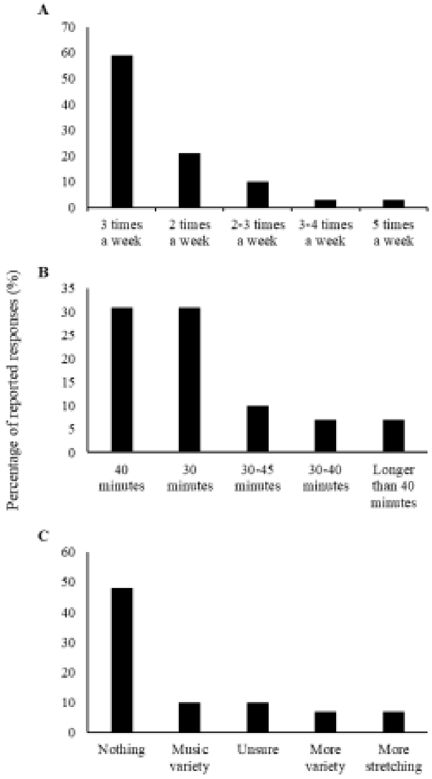


Figure 1: Salient higher order themes for preferred programme; (A) frequency, (B) duration, and (C) formatting.

group cohesion promote adherence to the programme (Caserta & Gillett, 1998). This mini-trampoline intervention only included women who were of similar age and postmenopausal. The similarities shared between participants potentially enhanced the opportunities for participants to bond and feel more confident about participating in the programme (White et al., 2005). Older women prefer to follow supervised exercise programmes (Jordan et al., 2010; Picorelli et al., 2014) and adherence to exercise programmes can be improved by having a knowledgeable instructor who can provide feedback and be seen as a peer (Caserta & Gillett, 1998). The preference for supervised exercise was supported by the current results, as participants mentioned the instructor as one of the most enjoyable characteristics in this intervention. Previous research has shown that women had higher adherence rates to exercise interventions that were scheduled, as is typical for supervised exercise sessions, and women might not make time for exercise unless they have a specific class to go to (Caserta & Gillett, 1998). The duration of exercise sessions in an exercise programme is also an important determinant for improving adherence (White et al., 2005). The short duration of each exercise session and the scheduled exercise times (with flexibility to shift times and days when needed) were important characteristics of this intervention's effectiveness.

The majority of women in our intervention (89%) said it was easy to participate; however, there were some barriers for participants to overcome. The most common barriers reported for participation included work, personal commitments, and transportation to sessions. Participants enjoyed being able to make up for missed sessions by joining one of the other classes that were offered. Thus, to increase adherence for an exercise programme tailored to older women, a mixture of supervised scheduled sessions and home-based sessions might be ideal, as it includes some structure but still offers flexibility by exercising at home anytime as well. Furthermore, offering a mixture of supervised scheduled sessions and home-based sessions would reduce barriers around transportation and other commitments since an at home workout can be completed at any time.

Responses regarding the difficulty of mini-trampoline exercises varied slightly, although most women considered the exercises to be easy and did not feel any fatigue. Evidence from other research suggests that adherence to an exercise programme is increased at lower perceived intensity levels (White et al., 2005). Exercise intensities that are perceived to be low may increase adherence as women will not sweat, have to change clothes, or anticipate soreness that comes with higher perceived intensities (White et al., 2005). Furthermore, studies have reported significantly higher injury and drop-out rates for higher intensity exercises compared to moderate or lower intensity exercises (Cox et al., 2003; Perri et al., 2002). Lower intensity exercises may also lead to greater adherence rates due to increased self-efficacy (Woodgate, Brawley, & Weston, 2005).

The majority of women reported interest in purchasing a mini-trampoline and/or would participate in a similar programme if offered at the gym, depending on the cost. Optimal exercise prescription included three 30-minute sessions per week with revised formatting that included a larger variety of music and exercises, as well as more stretching exercises at the end of a session. Although the exercise was well-received, the intervention was only three months long. Attendance rates of exercise programmes tend to be higher at the start of the programme, but can decrease quickly and significantly after six months (Caserta & Gillett, 1998; White et al., 2005) Further research is needed to determine if post-menopausal women can maintain adherence to a mini-trampoline exercise intervention after the 6-month threshold.

## Conflict of Interest

The authors declare no conflict of interests.

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**Supplementary material**

Supplementary Table 1: Full description of top 5 salient themes for all survey questions.

| Theme | Theme in response n (%) | Example quotation |
|---|---|---|
| **Question 1: List three things you like about this programme.** | | |
| Social interaction | 22 (24) | "Doing exercise with other likeminded and same age group. Doing exercise that was achievable in short burst. Doing exercise with women only." |
| Duration of session | 9 (10) | "Music, socialisation, duration, intense but shortish" |
| Instructor | 9 (10) | "Fabulous teacher, great social event, fitness level increased" |
| Music | 6 (7) | "Music, social support, leadership" |
| Fun/enjoyment | 6 (7) | "Trainer, I saw fast results, fun" |
| **Question 2: List three things you didn't like about the programme.** | | |
| There was nothing that was unenjoyable | 14 (41) | "None" |
| Travel to sessions | 6 (18) | "Travel to and from class" |
| Missing sessions | 2 (6) | "Having to miss sessions, jumping with the ball between your legs" |
| Specific movement of exercises | 2 (6) | "Just that one exercise (2 kg weights while running and arms to front!)" |
| Music | 2 (6) | "Distance travelled, some of the music" |
| **Question 3: Why did you take part in this intervention?** | | |
| Contribute to research | 12 (23) | "Thought it was a really interesting research programme" |
| Potential health benefits | 11 (21) | "Good for me and needed improve health and fitness. Commitment to attend easier knowing it was helping research. Timing workable for me" |
| Novel exercise | 5 (10) | "Its's a novel form of exercise" |
| Fun exercise | 5 (10) | "Sounded like fun" |
| Free exercise | 4 (8) [a] | "No cost to me. Regular, healthy exercise. To help out." |
| **Question 4: What barriers did you need to overcome to participate in this exercise intervention?** | | |
| Work commitments | 6 (24) | "It was a bit tricky balancing it with work" |
| Personal commitments | 5 (20) | "It was easy except missing once for other commitments/appointments" |
| Transportation to sessions | 4 (16) | "Just a long way to travel" |
| Poor weather | 3 (12) | "Cold, rain, winter" |
| Organisation | 2 (8) | "Organising my time to make it every week" |
| **Question 5: How hard did you find the mini-trampoline sessions?** | | |
| Easy | 9 (36) | "Not hard at all. I looked forward to each session" |
| Easier as programme progressed | 6 (24) | "After a few weeks it was easy even though we 'knew' the sessions were increasingly more energetic and longer" |
| Required reasonable effort | 5 (20) | "Had to push myself. I felt tired afterwards, especially for the first month" |
| Somewhat hard | 1 (4) | "It was tiring but achievable" |
| Certain exercises were hard | 1 (4) [b] | "The weights were the toughest – when we started using them a lot. My arms would ache for a few days" |

| | | |
|---|---|---|
| **Question 6: Were you fatigued for days after?** | | |
| No fatigue | 9 (56) | "No issues with fatigue" |
| Fatigue that dissipated | 2 (13) | "Didn't find them hard. Tried to keep up reasonable pace so good workout. First week or two tiring" |
| Experienced some soreness | 1 (6) | "Not till the last couple of weeks, not so fatigued but very sore and stiff" |
| It was fatiguing | 1 (6) | "It was exhausting and tiring but I knew it was good for me so I just did the best I could" |
| Experienced some fatigue | 1 (6) [c] | "First session was really hard and I was sore afterwards but then got better. Exhausting and tiring but knew it was good" |
| **Question 7: If the same programme was run at a gym/community centre, would you take part?** | | |
| Yes | 13 (43) | "Yes, most definitely" |
| Yes, depending on affordability | 5 (17) | "Yes, provided it was not too expensive" |
| Maybe | 4 (13) | "Quite possibly" |
| No | 3 (10) | "No" |
| Yes, depending on location | 2 (7) | "Yes, I think so. Dependent on closeness of venue" |
| **Question 8: How do you view sport and exercise now?** | | |
| No changes in attitude towards exercise | 5 (16) | "No different than before as I already exercise regularly. I look forward to exercise" |
| Enjoys group exercise | 4 (13) | "It is a chore mostly but it has made me think of the group class style being easier rather than individual." |
| Enjoys exercise | 4 (13) | "I enjoy exercise, I'm going to find something else to fill the gap." |
| Enjoys exercise but lack of time to do it | 2 (6) | "I have never minded exercise, but the time to do is not always available" |
| Motivation for exercise can be hard | 2 (6) | "I never look forward to exercise but I know I have to do it so that I don't cease up later in life." |
| **Question 9: What would you like to see added to this programme?** | | |
| Nothing | 14 (48) | "Nothing" |
| More variety in music | 3 (10) | "More variation in steps and music to maintain interest." |
| Don't know | 3 (10) | "Don't know" |
| More variety | 2 (7) | "Perhaps more variation but not sure what that would consist of" |
| More stretching | 2 (7) | "More stretching afterwards" |
| **Question 10: How many times a week do you think this programme should take place?** | | |
| 3 times a week | 17 (59) | "3 times a week was good. 12 times a month." |
| 2 times a week | 6 (21) | "Twice a week" |
| 2-3 times a week | 3 (10) | "2 – 3 times a week" |
| 3-4 times a week | 1 (3) | "3 – 4 times a week" |
| 5 times a week | 1 (3) [d] | "5 times a week" |
| **Question 11: How long should each session last?** | | |
| 40 minutes | 9 (31) | "40 minutes was good for me." |
| 30 minutes | 9 (31) | "30 minutes is great" |
| 30-45 minutes | 3 (10) | "30-45 minutes" |
| 30-40 minutes | 2 (7) | "30-40 minutes is good" |
| Longer than 40 minutes | 2 (7) | "I found the exercise sessions were a little short especially as I gained fitness and expertise" |

| | | |
|---|---|---|
| **Question 12: Do you have activity plans for the future?** | | |
| Back to original activities | 10 (34) | "Back to yoga and beginning swimming" |
| Continue trampoline exercises at home | 6 (21) | "I hope to keep jumping at home" |
| Yes | 3 (10) | "Yes" |
| Back to original activities and looking for something new | 2 (7) | "I will continue to walk, participate in zumba and stretch. I am looking at arthritis exercises for seniors." |
| Back to original activities and continue trampoline at home | 2 (7) [e] | "I will continue with pilates, Mt Kaukau walks and commuter cycling and get back into my garden, but I also hope to continue using the mini tramp 3 times per week." |
| **Question 13: Are you considering buying a mini-trampoline or have already bought one?** | | |
| Yes, considering buying one | 10 (34) | "Yes, I am considering it" |
| Yes, already bought one | 4 (14) | "I have bought one. I'm enjoying it." |
| Was given a trampoline from the intervention | 3 (10) | "I was lucky enough to win one" |
| Had one prior the intervention | 2 (7) | "Already had one which is also why I was keen to participate" |
| Yes, planning to buy one | 2 (7) | "I was hoping to win one but I didn't! I now have it on a watchlist on trademe". |

*Note:* [a] equal number of responses with "regular exercise"; [b] equal number of responses with "easy if sessions were not missed", "coordination was difficult but exercise easy", "difficulty level was progressive"; [c] equal number of responses with "experienced soreness towards end of the programme" and "experienced tired muscles but not fatigued"; [d] equal number of responses with "3 times a week with a weekend option"; [e] equal number of responses with "Nothing planned but need to make plans"

# Appendix I – Conference Abstract

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# Mini-trampoline jumping as an exercise intervention in post-menopausal women to improve bone health and fitness

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## Introduction

Women tend to outlive men and are at higher risks of functional disability compared to men. Specifically, women are more likely to develop conditions like osteoporosis which can further increase the risk of functional disability[1]. Mini-trampoline jumping is a beneficial low-impact aerobic exercise capable of improving aerobic fitness, balance, muscle strength and potentially bone health in older people[2]. The aim of the proposed research project was to examine the benefits of a 3-month mini-trampoline exercise intervention on physical fitness and bone health in post-menopausal women.

## Methods

38 post-menopausal healthy women (control=8 & intervention=30; Age=59 ± 6 years; Height=164 ± 0.1 cm; Weight=77 ± 19 kg; BMI=28.6± 6.3 kg/m²) participated in this intervention study. The exercise intervention lasted 12 weeks, with three 40-minute sessions per week. Assessments were performed within one week before (baseline), one week after (post-intervention), and 3-month after (follow-up) the exercise intervention. A 6-minute walk test, 6-meter walk test, sit-to-stand test, and sit-to-reach test were used to assess aerobic fitness, walking speed, lower extremity strength, and flexibility respectively. Bone health was measured via a qualitative ultrasound at the right calcaneus.

## Results

Compared to baseline values, women in the intervention group showed significant improvements at the post-intervention assessment in resting HR ($p<0.01$), aerobic fitness ($p<0.01$), lower extremity strength ($p<0.01$), walking speed ($p=0.02$), flexibility ($p<0.01$), and bone health ($p=0.05$) (Table 1). The follow-up assessment showed a significant decline from post-intervention in aerobic fitness ($p<0.01$), bone health ($p<0.01$), as well as a significant increase of resting HR ($p<0.01$).

| | | Baseline | Post-intervention | Follow-up |
|---|---|---|---|---|
| BMI (kg/m²) | Intervention | 28.7 ± 1.1 | 28.5 ± 1.1 | 28.6 ± 1.1 |
| | Control | 27.6 ± 1.9 | 27.6 ± 2.0 | 27.8 ± 2.0 |
| Resting HR (bpm) | Intervention | 69.2 ± 1.7* | 64.1 ± 1.7* | 71.7 ± 2.2^ |
| | Control | 66.4 ± 3.1 | 71.1 ± 4.4 | 75.9 ± 4.1^ |
| 6-minute walk test (m) | Intervention | 354.3 ± 8.5 | 398.1 ± 8.3 | 378.7 ± 8.7^# |
| | Control | 312.6 ± 21.3 | 355.5 ± 22.4# | 390.8 ± 8.0 |
| 6 meters walk test (kph) | Intervention | 5.9 ± 0.2 | 6.3 ± 0.2* | 6.5 ± 0.2# |
| | Control | 6.2 ± 0.2 | 6.1 ± 0.2 | 6.3 ± 0.2 |
| Sit-to-stand test (sec) | Intervention | 24.2 ± 0.9 | 19.4 ± 0.9* | 19.2 ± 0.8# |
| | Control | 20.4 ± 2.2 | 17.9 ± 1.3 | 17.6 ± 1.5# |
| Sit-to-reach test (cm) | Intervention | 19.4 ± 1.6 | 22.75 ± 1.6* | 22.17 ± 1.5# |
| | Control | 16.4 ± 4.5 | 13.6 ± 4.7 | 13.1 ± 4.6 |
| Bone mineral density (g/cm²) | Intervention | 0.498 ± 0.109* | 0.534 ± 0.116* | 0.510 ± 0.111^ |
| | Control | 0.576 ± 0.188 | 0.540 ± 0.122 | 0.563 ± 0.185 |

Table 1. Results at baseline, post-intervention, and follow-up. Significant differences are shown between:
* Baseline and post-intervention ^ Post-intervention and follow-up # Baseline and follow-up

## Discussion

Although the exercise intervention did not improve BMI, significant improvements were found in all of the other assessments. Specifically, bone health results indicate that a mini-trampoline exercise programme may improve sex specific risk factors in older women. The follow-up assessment indicated that in order to specifically maintain aerobic fitness, resting HR, and bone health, continuation of the exercise intervention might be necessary. In contrast, improvements seen after the intervention in lower extremity strength, walking speed, and flexibility did not dissipate in the three months following programme completion. Thus, mini-trampoline exercise has the potential to significantly improve physical fitness and bone health in post-menopausal women; however continuation of exercise might be necessary to maintain certain improvements.

*References:*
1 McGarry, K.A. and D.P. Kiel, *Postmenopausal osteoporosis.* Postgraduate Medicine, 2000. **108**(3): p. 79-91.
2 Aragão, F.A., et al., *Mini-trampoline exercise related to mechanisms of dynamic stability improves the ability to regain balance in elderly.* Journal of Electromyography and Kinesiology, 2011. **21**(3): p. 512-518.