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**WOMEN IN STRENGTH (WISH STUDY): A MIXED-
METHOD APPROACH TO DEVELOP MUSCLE-
STRENGTHENING EXERCISE INTERVENTION**

by

Nur Dania Rosaini

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THESIS ABSTRACT

Muscle-strengthening exercise (MSE) offers many health benefits, including lower all-cause mortality and non-communicable disease risk, improved metabolic and musculoskeletal health, and enhanced mental health. Despite the global and national Physical Activity Guidelines recommending that adults engage in muscle-strengthening activities for two or more days a week, participation rates remain low, particularly among women. Barriers such as time constraints, a lack of knowledge and confidence in their abilities, and discomfort in the gym continue to constrain women's participation in these activities. Over four sequential studies, this thesis aimed to quantify participation patterns in MSE, understand lived experiences, and co-design and test an intervention to improve participation.

In Study 1 (Chapter 2) 615 participants completed a survey ($n = 144$ males, $n = 471$ females) to identify the types, intensities, frequencies, and durations of participation in muscle-strengthening activities among adults aged 18 to 64 years in the UK. 76% of participants self-reported meeting the guidelines ("Yes" group), with 24% self-reporting not meeting the guidelines ("No" group). However, 95% of the "No" group actually met the guidelines, with the majority meeting this when daily living muscle-strengthening activities (e.g., carrying a shopping bag and climbing stairs) were included. Women in both groups reported doing fewer MSE and daily living muscle-strengthening activities than men. Sex differences were observed in the types of MSE participated in (men: weight machines and resistance exercises, women: holistic exercises). MSE were performed on average 2-3 days a week at moderate intensity, and daily living activities were performed on average 2 days a week at low intensity, with similar session duration for both types of activities.

Study 2 (Chapter 3) used reflexive thematic analysis to explore barriers, facilitators, and strategies to improve women's participation in MSE among women from Study 1 who met the muscle-strengthening guidelines ($n = 24$). Four overarching themes were revealed: (1) reason for participating in MSE (health concerns and sports performance), (2) barriers to MSE participation (perceived time constraint, low motivation, cultural stigma and societal perceptions, confidence in ability and accessibility), (3) facilitators to participating in MSE (resources or information, accountability, social support, ability to choose and positive changes) and (4) strategies to improve women's participation in MSE (what an individual and others can do).

Study 3 (Chapter 4) included 21 women, recruited from participants in Study 1 and the general public, who did not meet the guidelines, to explore barriers and potential facilitators to participation in MSE, and to co-design an MSE intervention informed by the findings of Chapter 3. Challenges and potential facilitators in MSE were classified into five categories: (1) routine and prioritisation, (2) knowledge and self-efficacy, (3) physical and psychosocial, (4) cultural stigma and societal perception, and (5) accessibility and environment. These challenges and potential facilitators were similar to those reported in Chapter 3. The co-designed process identified 3 key elements for inclusion in the intervention, which were: (1) education (strength education session), (2) social (online support group and optional group exercise session), and (3) modalities (access to various modalities and logging the training).

Study 4 (Chapter 5) involved 34 women who did not meet the guidelines, recruited from participants in Study 3 and the general public, to evaluate the feasibility, acceptability, and effectiveness of the co-designed intervention on body composition and muscular strength in a randomised controlled trial. The intervention involved five components, which were: 1) strength education sessions, 2) optional group exercise sessions, 3) an online support group, 4) logging training and 5) access to various modalities (12 weeks gym membership and resistance bands). Participants in the intervention group were asked to participate in MSE of their choice on two days a week. The intervention lasted 12 weeks, followed by a further 24-week follow-up, during which support was removed. The study recruitment (100%) and retention rate, measured by completion of all lab visits (91%), were high. Education sessions (attendance 80–87%) and access to a choice of exercise modalities were highly acceptable. Optional group sessions and the online support group were less utilised. At 12 weeks, no significant time*group interactions were observed. Significant effects of time occurred for muscle thickness ($p = 0.028$), back strength ($p = 0.039$), and knee extensor torque ($p < .001$), but not handgrip strength ($p = 0.118$). From baseline to week 12, changes in muscle thickness were +0.56mm, $p = 0.492$ in control and +0.86mm, $p = 0.054$ in intervention. For back strength, changes were +3kg, $p = 1.000$ in control and +9.8 kg, $p = 0.011$ in intervention. For knee extensor torque, changes were -0.52Nm, $p = 1.000$ in control and +10.89Nm, $p = 0.381$ in intervention. Similar results were observed from baseline to week 24, with effects generally smaller. The co-designed intervention was subsequently mapped to the COM-B model and Behaviour Change Techniques (BCTs) taxonomy to enhance theoretical transparency.

Collectively, this PhD thesis provides a comprehensive investigation of women's participation in MSE by using quantitative, qualitative, and intervention-based approaches. The mixed-method design, combined with a co-design approach, ensured that the intervention and findings were relevant to women's life experiences. The thesis lays the foundation for a scalable intervention to improve women's participation in MSE and their health outcomes by addressing persistent barriers to MSE participation and incorporating participants' insights into the intervention.

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LIST OF PRESENTATIONS AND PUBLICATIONS

PRESENTATIONS

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Rosaini N. D., Ryde, G. C., Gray S. R. (2025). Women In Strength: Randomised Controlled Feasibility Testing of a Co-Designed Muscle-Strengthening Intervention for Women. *International Society of Behaviour Nutrition and Physical Activity Annual Congress 2026, Cadiz, Spain, 27th – 30th May 2026*.

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Rosaini, N. D., Digheiri, A., Gray, S. R., Ryde, G. C. (2026). Exploration of Activities People Participate in to Meet the Muscle-Strengthening Physical Activity Guidelines. *In Review*.

Rosaini, N. D., Gray S. R., Oyebola, E., Ryde G. C. (2026). How Women Engage in Muscle-Strengthening Exercises: A Qualitative Study from the WISH Project. *BMC Public Health* 26, 604. <https://doi.org/10.1186/s12889-026-26207-9>

ADDITIONAL PUBLICATIONS

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Connelly, C.D., Gray, S., **Rosaini, N.D.**, Ryde, G. C. (2025). Strength training intervention for hybrid workers: a randomised pilot feasibility trial. *Sci Rep* 15, 41745. <https://doi.org/10.1038/s41598-025-27567-9>

Tumblety, C., Demou, E., **Rosaini, N.D.**, Lu, J., Ryde, G.C. (2026). A systematic review of physical activity and exercise interventions for mental health or wellbeing in workplace settings. *In Review*

Oswald, F., McCrea-Routray, C., **Rosaini, N.D.**, Ryde, G.C. (2026). Exploring the experiences of menstruation in non-elite swimmers. *In Review*

DEDICATION

To my late father, Rosaini bin Tajuddin,

Taken too soon, yet your unwavering belief in me continues to guide every step of my journey. What I have achieved today stands on the foundation of your faith in me.

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I spent a good 30 minutes staring at this page, unsure where to start, since this is the last section I worked on for my thesis. I always hear people say, "A PhD is a lonely journey." But if it's truly lonely, wouldn't the acknowledgement section be short? There were times when I felt alone, but, truthfully, there are a whole lot of people behind me, supporting my every step, and they deserve to be acknowledged.

First and foremost, all praise and thanks to Allah SWT, the Almighty, for the blessings throughout my PhD and for allowing me to successfully complete this chapter of my life.

It is funny whenever I remember how dreadful I felt when I first saw 'Research Project' as the final assessment for my bachelor's degree back in 2021, thinking it would be so hard. As I was doing it during the peak of the pandemic and a quite isolating phase, I decided I wanted to pursue this further, and in October 2021, that was the moment I first got in touch with Dr Stuart Gray. He agreed to take me on as one of his PhD students, and in May 2023, I began my PhD research. Together with Dr Stuart Gray, Dr Gemma Ryde joined the supervisory team, and the three of us shaped the way for this PhD research, though it was mostly the two of them at the start of this journey because I was a clueless 24-year-old back then. Whenever people asked me, "Dania, what advice do you have for people who want to do their PhD?", my answer is always, "A good supervisor is very, very important." In my case, I am blessed to get not one but two excellent supervisors. Under their exceptional mentorship, guidance, and unwavering support, I have gained the confidence I needed to complete this PhD. While I never told them, though now they would know once they read this, their genuine commitment to seeing me succeed has made me strong throughout this journey. There were days when I felt defeated and lost, but they would always offer words of encouragement whenever they could. They have trained me to be the researcher that I am today, and for that, I am truly grateful.

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AUTHOR'S DECLARATION

I declare that, except where explicit reference is made to the contribution of others, the work presented in this thesis is entirely the result of my own. This thesis was carried out under the supervision of Professor Stuart R. Gray and Dr Gemma C. Ryde. This research was supported by the PhD studentship of the Graduate Excellence Programme of Majlis Amanah Rakyat (MARA), Malaysia. The contents of this thesis have not been submitted for any other degree at the University of Glasgow or any other institution.

Nur Dania Rosaini

February, 2026

LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
AHA	American Heart Association
ANOVA	Analysis of Variance
APR	Adjusted Prevalence Ratio
BCT	Behaviour Change Techniques
BHF	British Heart Foundation
BMI	Body Mass Index
BREQ-2	Behaviour Regulation in Exercise Questionnaire-2
CDC	Centers for Disease Control and Prevention
CHERRIES	Checklist for Reporting Results of Internet E-Surveys
CI	Confidence Interval
CMO	Chief Medical Officer
COM-B	Capability, Opportunity, Motivation – Behaviour Model
CONSORT	Consolidated Standard of Reporting Trials
COREQ	Consolidated Criteria for Reporting Qualitative Research
CVD	Cardiovascular Disease
DIY	Do-It-Yourself
EHIS	European Health Interview Survey
EHIS-PAQ	European Health Interview Survey – Physical Activity Questionnaire
GLUT-4	Glucose Transporter Type 4
HbA1c	Hemoglobin A1c
HDL	High Density Lipoprotein
HOMA-IR	Homeostasis Model Assessment of Insulin Resistance
HR-QoL	Health Related Quality of Life
IL-6	Interleukin-6
IMD	Index of Multiple Deprivation
LDL	Low Density Lipoprotein
MD	Mean Difference
METs	Metabolic Equivalent of Task
MRC	Medical Research Council
MSE	Muscle-Strengthening Exercise

MSEQ	Muscle-Strengthening Exercise Questionnaire
MVC	Maximal Voluntary Contraction
MVPA	Moderate Vigorous Physical Activity
NCD	Noncommunicable Disease
NHIS	National Health Interview Survey
NIHR	National Institute for Health and Care Research
OR	Odd Ratio
PAAR	Participatory and Appreciative Action and Reflection
PAR-Q+	Physical Activity and Readiness Questionnaire for Everyone
PRODUCES	Problem, Design, (End)-Users, Co-Creators, Evaluation, Scalability
RCT	Randomised Controlled Trial
RPE	Rate of Perceived Exertion
RR	Relative Risk
SD	Standard Deviation
SF-36	36-Item Short Form Health Survey
SMD	Standardised Mean Differences
SWLS	Satisfaction with Life Scale
T2DM	Type 2 Diabetes Mellitus
TNF-α	Tumour Necrosis Factor-alpha
VO_{2max}	Maximal Oxygen Uptake
WHO	World Health Organization
WISH	Women in Strength

GENERAL DEFINITIONS

This section consists of general definitions of specific terms used in this thesis.

Physical activity: Any bodily movement produced by the skeletal muscle that results in energy expenditure (Caspersen et al., 1985).

Exercise: A subset of physical activity in which the activity is structured and planned, with repetition and purpose, for the improvement or maintenance of physical fitness (Caspersen et al., 1985). There are different categories of exercise, such as aerobic, muscle-strengthening, flexibility and balance.

Aerobic activities: Activities that primarily rely on the aerobic energy system aimed at improving cardiovascular fitness.

Muscle-strengthening activities: Activities performed with the intention to improve muscular strength, endurance or mass. The 2019 UK Physical Activity Guidelines include gardening, climbing stairs, carrying shopping bags, lifting and carrying children, and wheeling a wheelchair as part of daily living muscle-strengthening activities (Department of Health and Social Care, 2019). Muscle-strengthening exercise (MSE) refers to voluntary exercise that uses weight machines or free weights, resistance bands, or body weight (Bennie et al., 2020b).

Frequency: Number of training sessions or number of times certain exercises or muscle groups are performed or trained in a specific time period (e.g., 1 week) (Kraemer and Ratamess, 2004).

Intensity: Referring to how hard the exercise been performed. Can be classified into very light, light, moderate, vigorous and very vigorous intensity activities. For aerobic exercise, intensity can be measured by heart rate (reserve or maximal), metabolic equivalents (METs), and maximal oxygen uptake ($\text{VO}_{2\text{max}}$). For MSE, intensity is the magnitude of loading and is often prescribed by the repetition maximum or rate of perceived exertion (RPE) (American College of Sports Medicine, 2022).

Time: The duration or length of time spent doing an exercise (American College of Sports Medicine, 2022).

Type: The type of exercise performed (American College of Sports Medicine, 2022).

Volume: The total amount of exercise performed. For aerobic exercise, volume is the product of training frequency, intensity and duration. For MSE, exercise volume is the product of sets, repetitions and load performed in a session (American College of Sports Medicine, 2022, Bompa and Buzzichelli, 2019).

Progressive overload: A gradual increase in the demands placed on the body during exercise training. This can be achieved by increasing the load or resistance and repetitions, altering repetition speed (slower or faster), shortening the rest period for muscular endurance or lengthening it for strength and power training, or increasing exercise volume by 2.5 to 5%, or a combination of the above (Kraemer and Ratamess, 2004).

Active: Meeting the current guideline recommendations for aerobic activity (>150 minutes of moderate intensity/>75 minutes of vigorous intensity activity) and muscle-strengthening activity (>2 or more days a week) (Department of Health and Social Care, 2019, World Health Organization, 2020).

Inactive: Not meeting the current guideline recommendations for aerobic activity (<150 minutes of moderate intensity/<75 minutes of vigorous intensity activity) and muscle-strengthening activity (<2 or more days a week) (Department of Health and Social Care, 2019, World Health Organization, 2020)..

Sedentary behaviour: Any waking behaviour while sitting or reclining at low energy expenditure (≤ 1.5 METs), for example, sitting, lying, and reclining (Tremblay et al., 2017).

Moderate to vigorous intensity physical activity (MVPA): Commonly quantified by physical activity performed at an intensity that is above the resting level (1 MET) into the moderate (3-<6 METs) and vigorous level (>6 METs). MVPA is often used for assessing adherence to the aerobic physical activity guideline (≥ 150 minutes of MVPA per week). Example of activities include walking, running, and cycling (World Health Organization, 2020, MacIntosh et al., 2021).

CHAPTER 1 – LITERATURE REVIEW

1.1. PHYSICAL ACTIVITY AND PHYSICAL ACTIVITY GUIDELINES

1.1.1. Physical Activity and Health Outcomes

Over the past decades, research has demonstrated the impact of physical activity on preventing chronic diseases and on the physiological and psychological aspects of well-being. The current section of the thesis will explore the benefits of physical activity for these broad aspects of health. In the following sections, the associations with physical activity are described initially and then specifically for MSE, where available.

1.1.1.1. Physical activity effects on cardiovascular and all-cause mortality

A 2022 systematic review and meta-analysis of 184 studies examined the association between physical activity, sedentary behaviour and cardiovascular disease (CVD) risk (Liang et al., 2022). The review included 148 randomised controlled trials (intervention duration range: 8 weeks to 24 months) that evaluated the effect of physical activity and CVD risk factors, and 36 longitudinal studies (mean follow-up time: 11.4 years) to examine the association of sedentary behaviour and physical activity on CVD incidence and mortality among healthy adults. Evidence from the longitudinal studies indicated that the risk of developing CVD increases among healthy adults who are sedentary (HR= 1.34, 95% CI = 1.26 to 1.43), whereas long-term participation in physical activity was associated with a lower risk of CVD (HR= 0.71, 95% CI = 0.66 to 0.77) and several other CVD risk indicators (Liang et al., 2022).

Another systematic review and meta-analysis in 2022 of 16 observational studies with a minimum follow-up period of 2 years by Momma et al. (2022) examined the association between muscle-strengthening activities and risk of all-cause mortality and noncommunicable diseases (NCDs), such as CVD, cancer, and diabetes, among adults (age range 18 to 97.8 years). Muscle-strengthening activities were associated with a 15% risk reduction of all-cause mortality (RR 0.85; 95% CI = 0.79 to 0.93; $p < .001$), 17% risk reduction of CVD (RR 0.83; 95% CI = 0.73 to 0.93; $p = 0.002$), and 12% risk reduction of total cancer (RR 0.88; 95% CI = 0.80 to 0.97, $p = 0.008$) (Momma et al., 2022). Figure 1.1

shows the non-linear dose-response relationships observed, where the lowest relative risk (RR) was seen at 40 minutes per week for all-cause mortality (RR 0.83; 95% CI 0.76 to 0.86), 60 minutes per week for CVD (RR 0.83; 95% CI = 0.76 to 0.90), and 30 minutes per week for cancer (RR 0.91; 95% CI 0.85 to 0.97)(Momma et al., 2022). The joint benefits of aerobic and muscle-strengthening activities were examined in a subset of studies ($n = 3$). In these studies, muscle-strengthening activities were categorised as ‘none vs any’, or ‘ ≥ 2 vs < 2 times per week’, while aerobic activity was categorised as ‘ ≥ 150 vs < 150 minutes per week’ or ‘low vs high’. Combined participation in aerobic and muscle-strengthening activities (vs none) was associated with 40% risk reductions for all-cause mortality, 46% for CVD, and 28% for cancer mortality (28%)(Momma et al., 2022). These findings highlight that MSE is essential for reducing the risk of all-cause mortality and NCDs, and including aerobic activities alongside MSE can provide additional benefits.

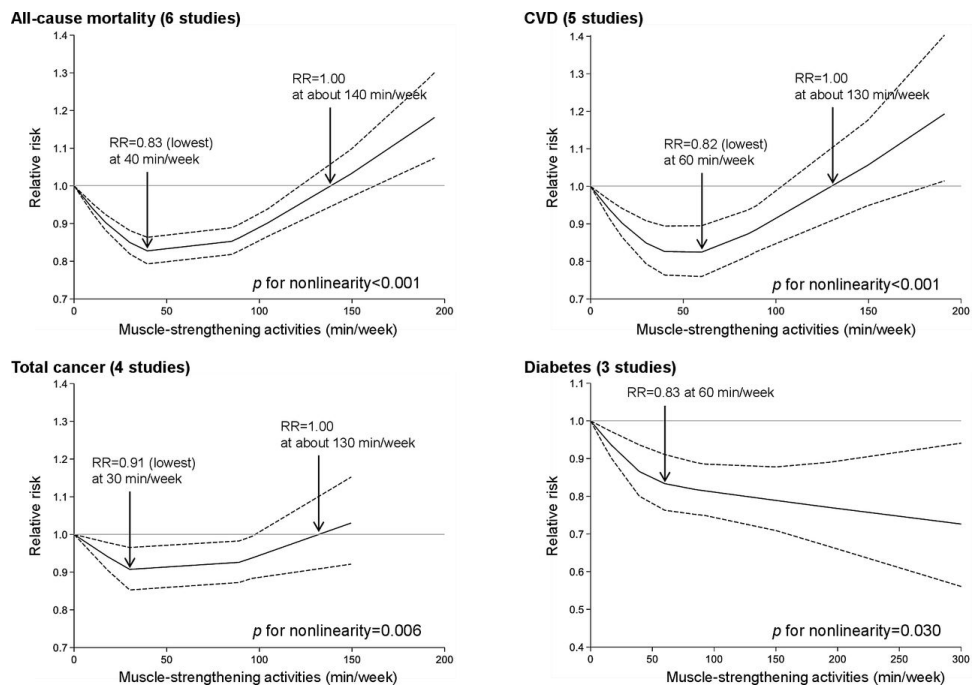


Figure 1.1: Non-linear dose-response relationship of the association between muscle-strengthening activities, all-cause mortality, CVD, total cancer and diabetes, adapted from Momma et al. (2022).

1.1.1.2. *Physical activity effects on metabolic health*

With the increasing prevalence of metabolic disorders such as type 2 diabetes mellitus (T2DM) and CVD, epidemiological and intervention studies have examined the role of physical activity in glucose regulation, insulin sensitivity, blood pressure, and lipid metabolism among adults. In the EPIC-InterAct case-cohort study, comparing inactive (36

kJ/kg daily) and moderately inactive (41 kJ/kg daily) persons, there was a 13% relative risk reduction in men and a 7% relative risk reduction in women for the incidence of T2DM for those who were moderately inactive (InterAct et al., 2012). This supports earlier findings that report the positive effect of physical activity on lowering the risk of T2DM in men and women (Hu et al., 2001, Hu et al., 2003).

Besides the effects of physical activity on T2DM, numerous studies have also examined the impact of physical activity and glucose metabolism, including fasting glucose, HbA1c, insulin sensitivity, as well as blood pressure and lipid profile. In 2017, Boniol et al. (2017) did a systematic review and meta-analysis of 125 studies to evaluate the impact of physical activity on fasting blood glucose and HbA1c. In 105 studies reporting changes in fasting blood glucose, an increase of 100 minutes of physical activity was associated with a reduction of 2.75 mg/dL (95% CI = -3.96 to -1.55). In 56 of those studies, T2DM patients had a greater reduction in fasting blood glucose (-4.71 mg/dl; 95% CI = -7.42 to -2.01). Similar to fasting blood glucose, in 76 studies that reported the changes in HbA1c, an increase of 100 minutes of physical activity resulted in a reduction of 0.14% (95% CI = -0.18 to -0.09) in HbA1c, with a greater decrease among those with T2DM (-0.16%; 95% CI -0.21 to -0.11) as shown in 60 studies. However, there is a high degree of heterogeneity in the main analysis of both results (83.5% for fasting blood glucose and 73% for HbA1c). Recent findings by Momma et al (2022) showed that muscle-strengthening activities were associated with a 17% reduction in the incidence of diabetes (RR 0.83; 95% CI = 0.77 to 0.89; $p < .001$), with every increase of 10 minutes of activities per week inversely associated with decreased diabetes risk, with further risk reduction up to 60 minutes a week (Figure 1.3).

Numerous studies have also examined the impact of physical activity on insulin sensitivity. Insulin plays an integral role in skeletal muscle for glucose uptake and regulation, in the liver for glycogen synthesis, lipogenic gene expression, and reduced gluconeogenic gene expression, and in white adipocytes for lipolysis suppression, glucose transport, and lipogenesis (Malkowska, 2024). Glucose regulation is impaired when the body's response to insulin is impaired. This condition, also known as insulin resistance, is often associated with other conditions, including obesity, T2DM, cancers, and CVD (Zhao et al., 2023). In a 12-week walking intervention involving 20 obese women, significant reductions in blood glucose ($p = 0.008$) and insulin resistance (HOMA-IR) ($p = 0.029$) were observed in the

intervention group compared with the control group (Hong et al., 2014). Significant improvements were also seen in systolic blood pressure ($p = 0.037$), subcutaneous ($p < .001$) and visceral ($p = 0.011$) abdominal fat, serum cytokine TNF- α ($p = 0.027$), IL-6 ($p = 0.048$) and adiponectin ($p = 0.002$) (Hong et al., 2014).

Similar to aerobic exercise, MSE has been shown to improve blood pressure and glycaemic control. A systematic review and meta-analysis of 173 trials ($n = 6169$) by Ashton et al. (2020) examined the effects of different durations of resistance exercise (short ≤ 6 weeks, medium 7-23 weeks, and long ≥ 24 weeks) on cardiometabolic health. It was found that medium-term resistance exercise reduced systolic blood pressure by 4.02 mmHg ($p < 0.0001$) and diastolic blood pressure by 1.73 mmHg ($p = 0.003$) (Ashton et al., 2020). A larger reduction was observed in long-term resistance exercise, where systolic blood pressure decreased by 5.08 mmHg ($p = 0.04$) and diastolic blood pressure decreased by 4.93 mmHg ($p = 0.008$) (Ashton et al., 2020). Medium-term resistance exercises have also shown a significant reduction in fasting insulin ($-0.59 \mu\text{U/mL}$; $p = 0.002$), HOMA-IR (-1.22 ; $p = 0.02$), and fasting glucose (-2.93 mg/dL ; $p = 0.02$), but not in short-term or long-term resistance exercise (Ashton et al., 2020). Several other studies have also reported significant improvement in glucose metabolism, including HbA1c (Jansson et al., 2022, Bacchi et al., 2012, Lee et al., 2017), insulin sensitivity (Bacchi et al., 2012, Di Meo et al., 2017, Ismail et al., 2019), and in total skeletal muscle GLUT-4 protein concentration (Di Meo et al., 2017) following MSE.

Regarding the lipid profile, there is mixed evidence on the effect of MSE on triglyceride and cholesterol levels. In a randomised controlled trial by Bacchi et al. (2012), 60 minutes of resistance exercise three times per week for four months resulted in a significant improvement in high-density lipoprotein cholesterol (HDL) ($+1.3 \text{ mg/dL}$) and triglycerides (-23.9 mg/dL). However, in the systematic review and meta-analysis by Ashton et al. (2020) described above, there was no significant effect on the lipid profile (total cholesterol, HDL, LDL, and triglycerides) in short, medium, or long-term resistance exercises.

1.1.1.3. Physical activity effects on sarcopenia

Physical activity plays a vital role in reducing the risk of sarcopenia, a condition characterised by an age-related decline in muscle mass, strength, and function. In a cross-

sectional analysis of older adults (>65 years), Sanchez-Sanchez et al. (2019) reported that an additional 15 minutes per day of MVPA (≥ 3 METs) was associated with a 15% lower prevalence of sarcopenia, while an additional hour per day was associated with a 50% lower prevalence. As the results were from a cross-sectional analysis, causal relationships cannot be inferred. While a higher level of MVPA may contribute to delaying or reducing the impact of sarcopenia, evidence from intervention studies indicates that MSE remain the most effective approach for muscle strength, mass and performance (Grgic et al., 2020, Liu and Latham, 2009). In a recent systematic review and meta-analysis of 28 studies ($n = 2582$) by Sanchez et al. (2025) on different types of exercise intervention in sarcopenia, it was reported that resistance training (vs. usual care) was the most effective intervention to improve physical performance, with secondary analysis shown significant improvement in gait speed ($+0.11$ m/s; 95% CrI: 0.01 to 9.21), while other types of intervention, such as aerobic and power interventions, did not produce significant effects. Although Sanchez et al. (2025) did not detect any significant effects on handgrip strength, a proxy for overall muscular strength, a systematic review and network meta-analysis by Shen et al. (2023) reported that resistance training alone significantly improved handgrip strength (MD 2.69 kg; 95% CI = 1.78 to 3.61), with additional improvement seen when resistance training was combined with aerobic exercises (MD 3.02 kg; 95% CI 1.64 to 4.4). Shen et al. (2023) further reported that intervention involving resistance training, alongside aerobic and balance exercises, significantly improves physical performance (gait speed, time up and go, chair stand test) and quality of life for older adults with sarcopenia. These adaptations are particularly important for women, who experience earlier decline in muscle mass and bone density during and after menopause (Calmels et al., 1995, Phillips et al., 1993, Montero-Fernandez and Serra-Rexach, 2013).

1.1.1.4. Physical activity effects on mental health

More studies are emerging on the effects of physical activity and mental health. Physical activity participation can lower the incidence of depression and anxiety (Schuch et al., 2018, Schuch et al., 2019, Rahmati et al., 2024). In a recent umbrella review of 7 prospective cohort studies by Rahmati et al. (2024) reported that a high level of physical activity reduces the risk of depression incidence (OR= 0.77; 95% CI = 0.72 to 0.82, $p < .00001$) and risk of anxiety incidence (OR= 0.75; 95% CI = 0.63 to 0.89; $p = 0.001$). Regarding the amount of physical activity requirement for such benefits, in a systematic review and meta-analysis of 15 prospective studies ($n = 11930$; 64% women), Pearce et al. (2022) reported that those who met half of the recommended amount of physical activity (4.4 mMET hours/week or

~75 minutes/week) had an 18% lower risk of depression, and those who met the full recommended amount (8.8 mMET hours/week or ~150 minutes/week) had a 25% lower risk of depression.

MSE specifically also improves depression and anxiety conditions. In a meta-analysis of 33 randomised controlled trials ($n = 1877$), Gordon et al. (2018) reported that resistance training interventions, typically lasting 16 weeks (range 6-52 weeks), with a common session frequency of 3 days a week (range 2 to 7 days) has a moderate effect in reducing depression symptoms ($\Delta = 0.66$; 95% CI = 0.48 to 0.83; $p < .001$). A recent systematic review and meta-analysis of 21 randomised controlled trials by Cunha et al. (2024), comparing traditional resistance training (i.e., weight training) with alternative resistance training (i.e., elastic bands, bodyweight, and home-based exercise) reported that both types of resistance training were effective in improving symptoms of depression and anxiety. However, greater mental health benefits were observed with traditional exercises (vs alternatives), 3 days per week (vs 2 days), 3 sets (vs 2 or fewer), and up to 6 exercises (vs 7 or more) (Cunha et al., 2024). While both aerobic and MSE improve depression and anxiety incidence, there is limited evidence on their effects on more severe mental health outcomes such as psychosis and schizophrenia. In two studies reviewed by Rahmati et al. (2024), it was reported that a high level of physical activity lowers the incidence risk of these conditions (OR = 0.73; 95% CI = 0.53 to 0.99, $p = 0.047$), but further research is needed on the effects of different modalities of physical activity.

Collectively, the literature demonstrates that physical activities, both aerobic and MSE, are beneficial for a broad spectrum of outcomes, including reducing cardiovascular and mortality risks, improving metabolic regulation, preserving skeletal function, and supporting mental health, across a wide age range. Engaging in both types of activity is important, as each offers unique benefits, and when MSE is combined with aerobic activity, these benefits appear to be heightened. This highlights physical activity as a cornerstone of health promotion across the lifespan and the importance of including MSE within this.

1.1.2. History of Physical Activity Guidelines

Given the extensive benefits of physical activity, there are guidelines across the world which set out recommended amounts of physical activity people should aim to engage in. The

earliest physical activity guidelines published by the American College of Sports Medicine (ACSM) date to 1978, when the focus was only on participation in aerobic activity (American College of Sports Medicine, 1990). It was recommended that adults perform aerobic activities for 3 to 5 days a week, for 20 to 60 minutes/day continuously at 60% to 90% of their maximal heart rate, to develop and maintain cardiorespiratory and muscular fitness (American College of Sports Medicine, 1990). Following this, in 1995, the Centres for Disease Control and Prevention (CDC) and ACSM published updated recommendations which stated that adults should accumulate 30 minutes or more of moderate intensity physical activity, most or preferably all days of the week (Pate et al., 1995). Since significant improvements in maximal oxygen uptake ($\text{VO}_{2\text{max}}$) can still be achieved from accumulated bouts (from 32.1 ± 4.6 to 34.5 ± 4.5 ml/kg/min), the guidelines shifted from continuous activity to accumulated bouts as this was thought to be more achievable for individuals with busy schedules (DeBusk et al., 1990).

It was not until 2007 that the updated recommendation by ACSM and the American Heart Association (AHA) specifically included muscle-strengthening activity twice per week in the guidelines, along with aerobic activity recommendations (Haskell et al., 2007). The muscle-strengthening activity recommendations were to perform 8 to 10 exercises, twice per week, targeting the major muscle groups (Haskell et al., 2007). In 2010, the World Health Organisation (WHO) published its first Global Recommendations on Physical Activity for Health, providing age-specific guidance for children, adults and older adults (World Health Organization, 2010). For adults aged 18 to 64 years old, the WHO recommends at least 150 minutes of moderate intensity aerobic activity, or 75 minutes of vigorous intensity aerobic activity per week, accumulated in bouts of at least 10 minutes, and to increase to 300 minutes of moderate intensity or 150 minutes of vigorous intensity aerobic activity for additional health benefits (World Health Organization, 2010). The guidelines also included the recommendation for muscle-strengthening activities, where they should be done for two or more days a week involving a major muscle group (World Health Organization, 2010). The first UK Chief Medical Officer (CMO) physical activity guidelines, jointly issued by the four home countries (England, Scotland, Wales, and Northern Ireland), were published in 2011 (Department of Health and Social Care, 2011). This guideline was based on the 2009 Annual CMO Report, which recommended that adults engage in moderate-intensity activity for 30 minutes, five days per week, in England, Wales, and Northern Ireland, and on 'most days' of the week in Scotland (Department of Health, 2010). The variation in wording across the home countries, along with a lack of clarity about the intensity and type of activities,

highlighted the need for updated, more consistent guidelines (Bull and the Expert Working Groups, 2010). The 2011 UK CMO physical activity guidelines align with the 2010 WHO recommendations but also include age-specific recommendations and an emphasis on the benefits of regular movement and on minimising sedentary time (Department of Health and Social Care, 2011).

1.1.3. Current Guidelines

The most recent physical activity guidelines in the UK are the 2019 UK CMO physical activity guideline (Department of Health and Social Care, 2019) and the 2020 WHO physical activity guideline (Bull et al., 2020, World Health Organization, 2020). Similar, but not identical guidelines and recommendations are also available worldwide, such as in the United States (US Department of Health and Human Services, 2018), Canada (Canadian Society for Exercise Physiology, 2020), Australia (Department of Health Disability and Ageing, 2021), and New Zealand (Ministry of Health, 2020). To illustrate the consistency and variability in the physical activity guidelines, Table 1.1 describes the recommendations for adults across major domains (aerobic activity, muscle-strengthening activity, sedentary behaviour and general principles) in several areas of the world.

Table 1.1: Summary of Global and Country-Specific Physical Activity Guidelines Recommendations for adults aged 18 to 64 years old. Adapted from Bull et al. (2020), World Health Organization (2020), Department of Health and Social Care (2019), US Department of Health and Human Services (2018), Canadian Society for Exercise Physiology (2020), Department of Health Disability and Ageing (2021), Ministry of Health (2020).

Year and Report	Country	Aerobic	Muscle-Strengthening Activities	Sedentary Time	General Principle
2020 WHO Physical Activity Guidelines (Bull et al., 2020, World Health Organization, 2020)	Global	150 – 300 minutes (moderate intensity) or 75 – 150 minutes of (vigorous intensity) for aerobic physical activity. - More than 300 minutes (moderate intensity) or more than 150 minutes (vigorous intensity) for additional health benefits.	2 or more days a week, at moderate intensity, targeting the major muscle groups.	Limit time spent sedentary by replacing it with any intensity of activity, including light intensity.	- All adults should do regular physical activity. - Some activity is better than none.
2019 UK CMO Physical Activity Guidelines (Department of Health and Social Care, 2019)	United Kingdom	150 minutes (moderate intensity) or 75 minutes (vigorous intensity) or even shorter duration of vigorous	At least 2 or more days a week, targeting major muscle group.	Minimise time spent sedentary and break up long period of sedentary time	- Be physically active every day. - Any activity is better than none, and more is better.

		intensity, or combination of all three.	Some strengthening activity is better than none.	with at least light physical activity.	
2018 Physical Activity Guidelines for American (US Department of Health and Human Services, 2018)	United States of America	- At least 150-300 minutes (moderate intensity) or at least 75 – 150 minutes (vigorous intensity) or combination of both. - For additional health benefits, aim to do more than the recommended level.	2 or more days a week at moderate to greater intensity involving all major muscle group.	Limit the time spent sedentary by replacing it with any intensity of activity, including light intensity.	Adults should do regular physical activity.
2020 Canadian 24-Hour Movement Guidelines for Adults (Canadian Society for Exercise Physiology, 2020)	Canada	- At least 150 minutes of MVPA. - Do several hours of light physical activity.	At least 2 days a week of muscle-strengthening activities.	- Limit sedentary time to no more than 8 hours per day. - Limit recreational screen time less than 3 hours per day - Break up long period of sedentary time.	Adults should be physically active every day, limit sedentary time and get sufficient sleep (7 – 9 hours).

2021 Physical Activity and Exercise Guidelines for all Australian (Department of Health Disability and Ageing, 2021)	Australia	• 2.5 to 5 hours (moderate intensity) or 1.25 to 2.5 hours (vigorous intensity) or combination of both.	• At least 2 days each week.	• Reduce sedentary time and break up long period of sitting.	• Adults should be active most day, preferable every day. • Some activity is better than none. Start by doing some then slowly build up to the recommended amount.
2020 Eating and Activity Guidelines for New Zealand Adults (Ministry of Health, 2020)	New Zealand	• 2 ½ hours (moderate intensity) or 1 ¼ hours (vigorous intensity) activities throughout the week. • For additional benefits, aim for 5 hours (moderate intensity) or 2 ½ hours (vigorous intensity).	• At least 2 days each week.	• Reduce sedentary time by sitting less, move more and break up long period of sitting.	• Some physical activity is better than none.

MVPA: moderate-to-vigorous physical activity.

Overall, in the global and country-specific guidelines, the general recommendations are broadly similar across each category. Aerobic activities are recommended for 150 to 300 minutes of moderate intensity and 75 to 150 minutes of vigorous intensity, with more health benefits obtained by engaging in more activity. Muscle-strengthening activities are recommended for at least two days a week and target the major muscle groups. Adults were asked to limit the time spent sedentary, and some physical activity is better than none.

As this thesis is situated within a UK adult population, the 2019 UK CMO physical activity guidelines (Department of Health and Social Care, 2019) provide the most relevant national recommendations. These guidelines offer more detailed recommendations for the muscle-strengthening activities compared to other countries, which are:

- Activities should use the major muscle groups in both the upper and lower body and be performed until voluntary failure.
- Examples of activities include MSE such as machine-based, free weights, bodyweight, and resistance bands exercises, as well as daily living muscle-strengthening activities such as gardening, climbing stairs, carrying shopping bags, lifting and carrying children, and wheeling a wheelchair.

The addition of daily living muscle-strengthening activities was described in detail only in the UK guidelines, not in other guidelines. As for aerobic activities, the guidelines provide examples of intensity-specific activities: brisk walking or cycling were suggested for moderate intensity, running for vigorous intensity, and sprinting or stair climbing for shorter duration for very vigorous intensity activity (Department of Health and Social Care, 2019). Taken together, these guidelines (both aerobic and muscle-strengthening activities) establish a clear benchmark for the levels and types of activities adults should be doing to obtain the health benefits. They provide a reference point for understanding current levels of physical activity participation and combined with the history of the guidelines, suggest that MSE is a ‘newer’ addition with regard to public health promotion.

1.2. PHYSICAL ACTIVITY PARTICIPATION PATTERNS

Despite the well-established health benefits of physical activity and the long-standing availability of the physical activity guidelines, global physical inactivity remains high.

Approximately 31% of the world's adult population does not meet the recommended physical activity guidelines, and this figure is projected to rise to 35% by 2030 if current trends continue (Strain et al., 2024). Physical inactivity is one of the leading modifiable risk factors contributing to the global burden of NCDs (Lee et al., 2012, Lavie et al., 2019). In 2021, it was reported that an estimated 43.8 million (95% UI 41.8 – 45.9 million) deaths worldwide were from NCDs (Li et al., 2025). Increasing the participation rate in physical activity is one of the key public health strategies to reduce the prevalence and mortality associated with NCDs. In the UK, adherence to the aerobic and muscle-strengthening activity recommendations is measured using national surveillance, such as the Health Survey for England, the Scottish Health Survey, the Health Survey for Northern Ireland, and the National Survey for Wales. These surveillance data also enable comparison between adherence to aerobic and muscle-strengthening activity guidelines, emphasising the differences in participation.

1.2.1. Comparison of Aerobic and Muscle-Strengthening Activity Guidelines Adherence

Despite being a key part of the guidelines, the adherence to muscle-strengthening activity in the UK remains lower than adherence to aerobic activity, with consistently lower participation observed among women. In England, the 2021 Health Survey for England ($n = 5880$) reported that 64% of adults aged 16 and above met the aerobic activity guidelines, with higher adherence among men (70%) than women (59%). In contrast, only 2% of adults met the muscle-strengthening guidelines, with similarly low participation among men (2%) and women (2%). Overall, 30% of adults met both aerobic and muscle-strengthening recommendations combined, with a lower proportion of women (27%) meeting the guidelines than men (34%) (Health Survey for England, 2023).

This pattern of higher adherence to aerobic activity relative to muscle-strengthening activity is also observed in other nationally representative surveys. According to the 2023-24 Active Lives survey report by Sport England ($n = 171,926$), 64% of adults aged 16 and above reported an average of 150 minutes of activity per week, with men (66%) being more likely to be active (defined as achieving at least 150 minutes a week of physical activity) than women (61%) (Sports England, 2025). For muscle-strengthening guidelines, 44% of adults meet the guidelines in the 2023-24 report, with a higher percentage of men (47%) meeting the guidelines than women (41%) (Sports England, 2025). The Active Lives survey includes

most sports and physical activity, including walking, when analysing overall participation, whereas the Health Survey for England reports domestic activities and walking under separate domains (Health Survey for England, 2023, Sports England, 2025). These methodological differences, particularly in how muscle-strengthening activity participation is assessed, limit comparability between the two surveys. However, even when the measurement is broader and includes more activities, women remain less likely to meet the muscle-strengthening activity guidelines.

A similar pattern of disproportionately low adherence to muscle-strengthening activity, particularly among women, is evident in Scotland. In the 2023 Scottish Health Survey ($n = 4949$), 63% of adults (68% of men; 59% of women) met the aerobic guidelines. In contrast, only 1% of adults met the muscle-strengthening guideline (1% men; 1% women). Overall, 29% of adults met both aerobic and muscle-strengthening recommendations, with a higher proportion of men (32%) meeting the guidelines than women (26%) (Deakin et al., 2024a). This survey also provides a detailed breakdown of the aerobic and muscle-strengthening data and suggests that adherence to both guidelines decreases with age (Figure 1.4). Adherence was highest among adults aged 16-24 years (46%) and declined progressively with age, reaching the lowest level among adults aged 75 years and over (9%) (Deakin et al., 2024a).

Figure 6C: Highest adherence to MVPA guidelines and muscle recommendations was amongst 16-24 year olds

Adult adherence to MVPA guidelines and muscle strengthening activity, 2023, by age and sex

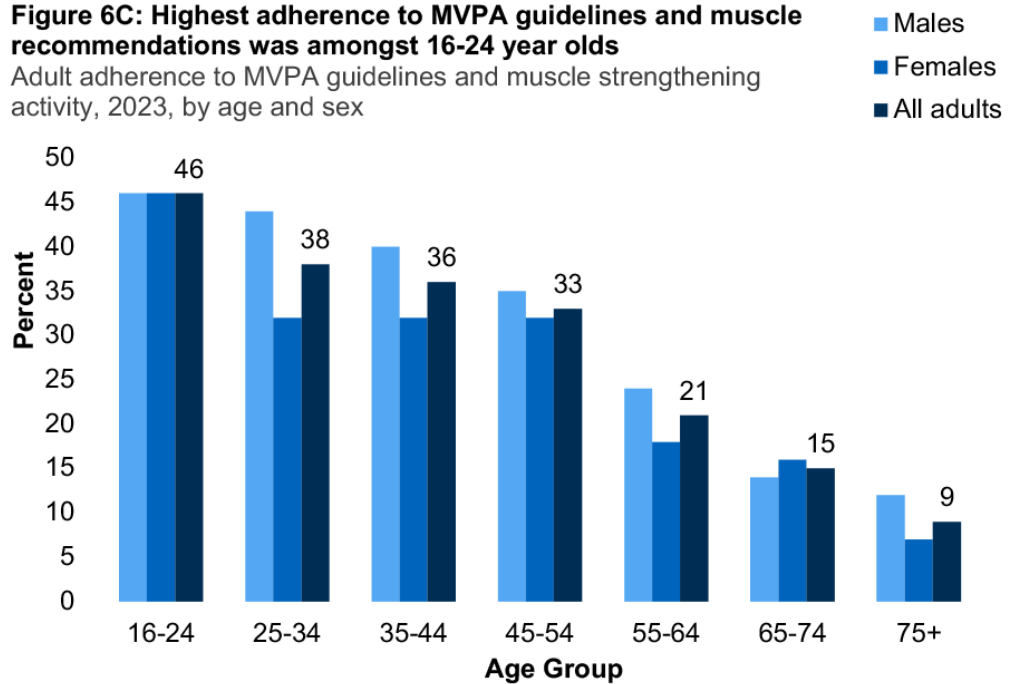


Figure 1.2: Adherence level to MVPA and muscle-strengthening activities guidelines according to age and sex, adapted from the 2023 Scottish Health Survey Deakin et al. (2024a).

In Northern Ireland and Wales, the national surveillance did not report data on muscle-strengthening activity; thus, adherence in these countries could not be assessed. Low adherence to muscle-strengthening activity guidelines is not unique to the UK but has been consistently observed internationally. Using data drawn from the European Health Interview Survey (EHIS Wave 2) between 2013-2014, Bennie et al. (2020a) assessed the self-reported MSE using the European Health Interview Survey Physical Activity Questionnaire (EHIS-PAQ) among 280,605 adults aged 18 years and older in 28 European Countries. It was reported that only 17% of adults performed MSE sufficiently (≥ 2 days per week). Highest MSE prevalence was reported in Iceland, Sweden and Finland (range 51.6% - 34.1%), and the lowest prevalence meeting the global MSE guidelines was reported in Romania, Poland, Malta and Cyprus (range 0.7% - 7.4%). It was also reported that women were less likely to perform MSE sufficiently, compared to men, with an adjusted prevalence ratio (APR) of 0.80 (95% CI: 0.79 – 0.81). Similarly, in the United States, using data from the 2020 National Health Interview Survey (NHIS) ($n = 30,407$) by Abildso et al. (2023), it was reported that only 35% of adults met muscle-strengthening guidelines and 25% of adults met combined guidelines (both aerobic and muscle-strengthening). However, a key limitation of self-reported MSE is the potential for recall bias. There are currently no device-based assessments for MSE, such as accelerometers for aerobic MVPA, meaning participation in MSE is almost exclusively measured via self-reported surveys. This limitation is consistent

across national and international surveillance and likely contributes to the underestimation of true adherence to the MSE.

In response to the limitations of existing self-report surveillance, Shakespear-Druery et al. (2022) developed and evaluated the Muscle-Strengthening Exercise Questionnaire (MSEQ). The MSEQ is a brief 9-item instrument designed to assess participation in MSE across multiple dimensions. It captures the type of MSE (item 1; 4 categories: weight machine, bodyweight exercise, resistance exercises and holistic exercise), frequency (item 2–3; participation over the past 7 days), duration (item 4; minutes spent per session), muscle groups targeted (item 5–8; 7 muscle groups which are legs, hips, back, abdomen, chest, shoulders, and arms) and intensity (item 9; 10-point scale from extremely easy to extremely hard). Items 2–9 are repeated for each type of MSE. The survey had a high test-retest reliability for the frequency, duration and intensity both by individual MSE types and when combined (ρ range 0.76 – 0.91). Reliability for the muscle groups targeted was moderate to substantial by MSE types (κ range 0.44–0.78) and fair-to-moderate when combined (κ range 0.35–0.51). Concurrent validity was moderate to high for frequency, duration and intensity (ρ range 0.30–0.77). Compared with existing national surveillance, the MSEQ provides a more detailed classification of MSE participation, allowing for the identification of patterns and prevalence across MSE types. However, population-level findings using the MSEQ have not yet been widely reported, limiting its current contribution to MSE surveillance.

Differences in how muscle-strengthening activity is defined and measured may partially influence reported prevalence estimates. Although the 2019 UK Physical Activity Guidelines included daily living muscle-strengthening activities, such as gardening and stair climbing, as part of the muscle-strengthening activity examples (Department of Health and Social Care, 2019), these activities are not consistently captured in adherence to the muscle-strengthening activity guidelines. For example, the 2021 Health Survey for England reported that heavy housework, heavy manual work, gardening, do-it-yourself (DIY) activities, and sports and exercise, as activities of at least moderate intensity, were reported separately from aerobic and muscle-strengthening activities (Health Survey for England, 2023). The exclusion of these activities in surveys may contribute to an underestimation of adherence to muscle-strengthening activities. As a result, although included as a means of achieving the national guideline in infographics and online advice, these activities are less consistently explored in research and surveillance compared to structured MSE.

Across national and international surveillance data, adherence to muscle-strengthening activity guidelines remains consistently low. This is particularly pronounced among women, who are less likely than men to participate in sufficient muscle-strengthening activity despite the well-established benefits. Taken together, these findings highlight a persistent gap between the guideline recommendations and real-world participation. Therefore, there is a need to better understand women's engagement in muscle-strengthening activity so that more targeted, acceptable strategies to increase participation can be developed.

1.3. BARRIERS TO MUSCLE-STRENGTHENING PARTICIPATION FOR WOMEN

Given the evidence on the health benefits from MSE and the persistently low participation among women, it is important to understand the barriers to participation among women. Several studies have identified barriers to women's participation in MSE. The most common barrier, as with for aerobic physical activity, often cited was perceived time constraint (Hurley et al., 2018, Vasudevan and Ford, 2022, Kulavic et al., 2013). While this barrier is common in both men and women, a systematic review and meta-synthesis of 20 studies among adult women aged 18 years and older from USA, UK, Australia, Canada and New Zealand by Vasudevan and Ford (2022) reported that the whilst time-effort barriers (from working, travelling and energy demand) are an issue, family commitments (from caregiving) or other obligations also act as barriers for women to participate in MSE which are more common in women. In addition to these, Vasudevan and Ford (2022) also reported the lack of knowledge and understanding to do MSE, the misconception of MSE only for physical appearance and not health, financial constraints for MSE, such as having to obtain gym membership or purchase equipment, injury concerns due to incorrect techniques, and illness further hindered women's participation in MSE.

Other qualitative studies also reported the social and environmental factors that affect women's participation in MSE. In a qualitative study by Coen et al. (2018) involving 52 participants ($n = 34$ women) in Canada, it was reported that women often felt uncomfortable being in the weight area of the gym, especially when men were taking up spaces, dominating equipment and being loud. Coen et al. (2018) also reported that socially constructed gendered area of the gym, such as feminine for the cardio area and masculine for the weight

area, has acted as a constraint to participation in different types of activities for women. Similarly, Vasudevan and Ford (2022) reported that gender-based social stigma also hinder women's participation in MSE, where women often do not want to participate in MSE because they do not want to look 'bulky' or 'manly', or women are discouraged from doing MSE due to comments from others, such as women should not be muscular (Bopp et al., 2004).

Taken together, these findings highlight the ongoing barriers that women face in participating in physical activity, particularly MSE, underscoring the need for research to better understand and address these challenges. Interventions designed to overcome these barriers are crucial as they would help to increase women's participation in MSE.

1.4. EVIDENCE ON INTERVENTIONS ON WOMEN'S PARTICIPATION IN MUSCLE-STRENGTHENING EXERCISES

As discussed in earlier sections, MSE offers substantial health benefits, yet participation among women remains persistently low. This highlights the need for effective intervention strategies to increase participation in MSE. Although many existing intervention studies target the general adult population, understanding which strategies could help women effectively is essential.

In 2025, Van Roie et al. (2025) published a systematic review of 69 studies evaluating real-life MSE intervention among healthy adults ($n = 18962$). This review synthesised studies of MSE interventions implemented in real-world settings rather than controlled laboratory environments, among adults aged 18 years and older. Most interventions in the review were research-led, delivered in a community setting and predominantly involved structured instruction, demonstration or supervised practice. Behavioural outcomes were commonly assessed using self-reported session attendance or adherence via logs, journals or diaries. Broader physical activity or MSE behaviour was based on questionnaires or accelerometry. However, as only nine studies reported changes in engagement in MSE, the review concluded that evidence for behaviour change outcomes was limited (Van Roie et al., 2025). Drawing from this review, studies were identified that were most relevant to women's participation in MSE. Studies were selected if they were exclusively for women or included sex-stratified data and reported behaviour outcomes related to intervention adherence. Of

the studies meeting these criteria, five are examined in detail below. Although adherence level does not directly reflect long-term participation, it provides an indicator of the intervention's feasibility and acceptability and offers insights into the type of MSE interventions that women are more likely to engage with and sustain.

Ashmead and Bocksnick (2002) published a one-group, pre-post study on the effect of home-based circuit training for 10 elderly women (mean age 66.4 ± 6.7 years). The intervention involved a 10-week, unsupervised, home-based circuit resistance training program using resistance bands, bodyweight, and dumbbells, delivered via an exercise video, 3 times per week. Prior to the intervention, participants attended a 1-hour seminar on performing the exercises. Adherence to the intervention, recorded via exercise journal, was 100%. The study reported significant improvement in right-hand grip strength ($t_{(8)} = 2.4, p < 0.05$), and improvement across six muscular endurance tests by 27.8% to 40% (all $p < 0.01$) after 10 weeks. Based on participants' self-reports of subjective improvement, the improvements observed were associated with increased confidence and ability to perform daily living activities more vigorously (i.e., gardening, getting up and down the stairs and carrying heavy objects), which may have contributed to exercise adherence. However, this study did not report how participants felt about the home-based exercises or different exercise modalities.

In the "Stronger, Healthy and Empowered" (SHE study) randomised control trial by Arikawa et al. (2011) on 164 overweight and obese women ($n = 82$ in the treatment group) aged 25 to 44 years old took part in 2 years MSE intervention that involved 4 months of supervised period (month 1 – 4) and unsupervised period in year 1 (month 5 – 12) and year 2 (month 13 – 24). The intervention was conducted at a community centre (YWCA fitness centre) twice weekly during the supervised period, aimed at targeting behavioural capacity, expectations, and self-efficacy. The sense of community was further strengthened through the social support gatherings strategy, held twice a year, which provided ongoing support for participants' continued involvement. The SHE studies also employed other strategies to support adherence, such as personal booster sessions, phone and email reminders, incentives, study website, letters or emails to significant others, childcare and gym membership. As a result of this community-based intervention, adherence level on MSE participation, recorded via workout log, was highest during the supervised period (95.4%). The adherence level dropped to 64.5% in year 1 and further declined to 51.4% in year 2. However, because the

relative impact of the specific adherence strategies was not evaluated, the effect of each strategy on adherence support cannot be concluded.

Another community-based MSE intervention was by Seguin et al. (2008), a nationally disseminated program over 40 states called the StrongWomen exercise program (SWP), which includes 45 to 60-minute sessions, twice per week for 12 weeks. In 2012, Seguin et al. (2012) published a one-group pre-post study to assess the effectiveness of the research program involving 367 women (mean age 63 ± 11 years) in 16 communities across five states in the United States. The study reported fitness test data by age groups (<60 years, 60-69 years, 70-79 years, and 80+ years). Significant improvements were seen in all six physical fitness tests that include chair stand, arm curl, 2-minute step test, sit-and-reach, back scratch and up-and-go (all $p < .01$) in each age group. While the study reported fitness test data separately by age group, adherence to the program (recorded via session attendance) was reported overall rather than by age. In the study, the class sessions ranged from 6 to 12 weeks, with an average of 10 weeks of classes. Although this intervention was conducted in a supervised, community-based setting, attendance was only 69.4% of the 20 weeks of twice-weekly classes. However, there was a lack of quantitative exploration limits the understanding of participants' acceptance or experiences with the intervention.

In 2016, Heiestad et al. (2016) published a multi-group randomised controlled trial in Norway involving three different resistance training implementations. The study involved 143 overweight women aged 18 to 65 years and was randomised into four groups ($n = 90$ analysed after drop-out; $n = 23$ BodyPump group exercises; $n = 27$ follow-up by a personal trainer; $n = 19$ non-supervised exercise; $n = 21$ control group). The exercise intervention was conducted at the SATS-fitness centres, including 45-60-minute sessions, three times per week for 12 weeks. Participants were prescribed 36 exercise sessions, and the attendance was logged via an exercise diary. Adherence to the exercise protocol was highest in the personal trainer group (33 ± 4.3 sessions), followed by the non-supervised exercise group (27.8 ± 6.6 sessions) and the BodyPump group (20.7 ± 7.8 sessions). The study discussed that exercising with a personal trainer may have increased participants' motivation, as they received feedback on their technique and performance. However, there is limited evidence to support this, as the study did not explore participants' perceptions of the exercise intervention they received and only assessed survey outcomes in exercise motivation (via

BREQ-2), self-perceived health (via SF-36), and quality of life (via Satisfaction with Life Scale [SWLS]).

In 2022, Prieto-Prieto et al. (2022) published a home-based exercise program on health-related quality of life (HR-QoL) and physical fitness among dementia caregivers in Spain. The randomised controlled trial involved 54 women ($n = 48$ included in final analysis), aged 50 years and above, who were randomly allocated to intervention ($n = 25$) or control ($n = 23$) groups. The intervention comprises a supervised, 9-month home-based exercise programme combining aerobic, mobility, and resistance exercises, with 72 sessions delivered in total, each lasting 1 hour, twice weekly. Adherence to the exercise was recorded based on the number of sessions completed by the supervising personal trainer. The mean number of sessions completed was 69.7 ± 3.4 (97% of sessions completed). The study reported that the flexibility of the program being offered at home and personalised to the caregiver's demands, as well as direct interaction with a personal trainer, may have contributed to the high adherence to the program.

Collectively, existing interventions suggest that women's participation in MSE can be improved through structured support, such as supervision or social support, and through flexible delivery formats, including group, community, and home-based settings. While not explicitly stated, interventions that reduce barriers to time (i.e., flexible scheduling or multiple sessions) and to skill acquisition (i.e., learning to perform the exercise correctly) could support women's participation in MSE. Among the few studies examined, some reported high adherence to the intervention, but the small number of studies and heterogeneity of intervention approaches leave limited clarity on which components of the interventions are most effective in encouraging and sustaining participation. Most interventions in the review by Van Roie et al. (2025) were mainly research-led and focused primarily on instruction, demonstration, or supervised practice. Very few studies have involved participants' input in the intervention design process (e.g., through co-design or focus groups), highlighting a gap in the development of participant-centred, contextually relevant interventions, particularly for improving adult women's participation in MSE.

1.5. RATIONALE

Muscle-strengthening activities were first included in the 2007 physical activity guidelines by ACSM and AHA (Haskell et al., 2007) because of the additional health benefits they offered (Bennie et al., 2020b), especially when combined with aerobic activities. The 2019 UK physical activity guidelines included several daily living muscle-strengthening activities, such as gardening, carrying shopping bags, and climbing stairs, as part of the muscle-strengthening guidelines (Department of Health and Social Care, 2019). However, national surveillance data do not currently capture these daily living activities when reporting adherence to muscle-strengthening guidelines. This limits the understanding of the types of muscle-strengthening activities adults engage in and how these activities are reported in muscle-strengthening guidelines may influence adherence rates.

Global estimates consistently show that physical inactivity remains higher among women (33.8%) than among men (28.7%) (Strain et al., 2024). As indicated by national surveillance data from England and Scotland, women are consistently less likely to engage in any physical activity, especially muscle-strengthening (Health Survey for England, 2023, Deakin et al., 2024a). Given the consistently low participation among women in MSE, numerous studies have highlighted that women are one of the target groups for interventions (Strain et al., 2016, Mielke et al., 2018, Strain et al., 2024, Van Roie et al., 2025). Several factors may contribute to low participation among women in MSE, including time and financial constraints, limited access to equipment or suitable spaces, and limited knowledge and low confidence. These barriers highlight the need for approaches that directly address women's experiences and contexts.

Although many MSE interventions have been developed for adults, recent evidence indicates limitations in how these interventions are designed and whose perspectives were reflected. Interventions have largely been research-led and focused on instructions, demonstration or supervised practice, with limited incorporation of participants' lived experiences. This raises concern about the extent to which existing interventions are aligned with women's everyday contexts, and points to a potential gap in participant-centred approaches to improving women's participation in MSE.

Taken together, these gaps highlight three key areas requiring further investigation, which are:

- What activities are adults in the UK currently participating in to meet the muscle-strengthening guidelines?
- How do women who meet and do not meet these guidelines experience MSE?
- How can interventions be developed collaboratively with women to ensure they are acceptable, feasible, and aligned with their experiences?

This PhD thesis aims to address these issues through a sequential programme of work, as outlined in the aims section below.

1.6. AIMS OF THE THESIS

The aims of this thesis are listed below.

The aims of **Chapter 2** are:

- To identify the types, frequency, intensity, and duration of activities adults participated in to meet the UK government's muscle-strengthening activities recommendations.
- To examine whether there are any differences between the sexes.

The aims for **Chapter 3** are:

- To explore the barriers and facilitators to participation in MSE among women aged 18 to 64 who are currently meeting the muscle-strengthening guidelines
- To identify strategies to improve involvement in these activities.

The aims for **Chapter 4** are:

- To explore the barriers and expected facilitators to participation in MSE among women who did not meet the muscle-strengthening activities guidelines.
- To co-design an MSE intervention to assist women's participation.

The aims of **Chapter 5** are:

- To assess the feasibility and acceptability of a co-designed MSE intervention for women.
- To investigate the effectiveness of the co-designed MSE intervention on body composition and muscular strength.

The aim of **Chapter 6** is:

- To retrospectively map the co-designed intervention components to the COM-B model and BCT Taxonomy to enhance theoretical transparency.

CHAPTER 2 – EXPLORATION OF ACTIVITIES PEOPLE PARTICIPATED IN TO MEET THE MUSCLE STRENGTHENING PHYSICAL ACTIVITY GUIDELINES

The current chapter has been submitted for publication:

Rosaini, N. D., Dighriri, A., Gray S. R., Ryde, G. C. (2025). Exploration of Activities People Participate in to Meet the Muscle-Strengthening Physical Activity Guidelines. *In Review – Scientific Reports*.

2.1. INTRODUCTION

Participation in muscle-strengthening activities, including resistance training, has numerous benefits, such as increases in a person's muscular strength, mass, endurance, or power (World Health Organization, 2020), which allows people to continue performing daily living activities (Mangione et al., 2010) and lead independent lives (Giovannucci et al., 2021, Stamatakis et al., 2018) during ageing. Studies show that regular muscle-strengthening activities can significantly reduce cardiometabolic disease risk by lowering systolic blood pressure by 4.02–5.08 mmHg, diastolic blood pressure by 1.73–4.93 mmHg, and fasting insulin levels by 0.59 μ U/mL, thereby decreasing insulin resistance (Grontved et al., 2014). Additionally, regular participation in muscle-strengthening activities was associated with a lower risk of all-cause and cancer mortality by 23% and 31%, respectively (Stamatakis et al., 2018).

Given these benefits, muscle-strengthening activities have been included in several countries' physical activity guidelines for adults since 2010 (Strain et al., 2016). The current 2020 global physical activity guidelines by WHO recommend two days a week of muscle-strengthening activities, focusing on the major muscle groups for adults (World Health Organization, 2020). This aligns with the 2019 UK CMO physical activity guidelines, which include activities such as weight training in the gym and sports, but also daily living activities like stair climbing, carrying shopping bags, and gardening (Department of Health and Social Care, 2019). However, the percentage of people meeting these recommendations remains low, particularly compared with those meeting the aerobic physical activity recommendations (Strain et al., 2016). For example, around 70% of UK adults adhered to the aerobic recommendations, whereas adherence to the muscle-strengthening

recommendations is below 35% (Birtwistle et al., 2022, Health Survey for England, 2023). Similar patterns of low adherence to muscle-strengthening recommendations were also observed in the United States (27.2%) (Calatayud et al., 2023) and European countries (17.3%) (Bennie et al., 2020a).

Daily living muscle-strengthening activities, such as stair climbing and carrying shopping bags, whilst included as examples in many guidelines, are rarely included in surveys intended to report these data. For example, the Health Survey for England reported these activities under the work, housework and gardening domain and not the muscle-strengthening domain (Health Survey for England, 2021). There is thus limited information on the types of activities people participated in to meet the guidelines. This information is important for understanding the current landscape of muscle-strengthening activity participation and for developing appropriate interventions to increase participation.

Therefore, this chapter aimed (1) to identify the types, frequency, intensity, and duration of activities adults participated in to meet the UK government's muscle-strengthening activities recommendations and (2) to examine whether there are any differences between sexes.

2.2. METHODS

2.2.1. Participants and Recruitment

From October 2023 to December 2023, adults aged between 18 and 64 years who are currently living in the United Kingdom (England, Scotland, Wales, and Northern Ireland) were recruited via promotional posters and adverts posted on platforms such as Nextdoor, Microsoft Viva Engage, LinkedIn, Facebook, and X. Eligibility criteria were: being 18 to 64 years old, currently living in the United Kingdom at the time of participation in the survey and being able to do muscle-strengthening exercises. The study was approved by the College of Medical, Veterinary and Life Science Ethics Committee at the University of Glasgow (Reference Number: 200220454) (Appendix 2-A) and adhered to the Declaration of Helsinki. A consent form for data collection and publication was provided on the survey landing page, and informed consent was obtained from all of the participants via an 'I agree/disagree' option. Participants could withdraw consent at any point during the survey, but not after

submission. Participant information sheets, consent forms, and recruitment poster are provided in Appendix 2-B to 2-D.

2.2.2. Survey

The survey was carried out via an online survey platform (Qualtrics Ltd.). The survey was developed by the principal researcher (NR) and the wider research team (SG and GR). Initial survey design was informed by the muscle-strengthening activity recommendations in the 2019 UK CMO report (Department of Health and Social Care, 2019) and the Muscle-Strengthening Exercise Questionnaire (MSEQ), a validated survey developed by Shakespear-Druery et al. (2022). The MSEQ informed the structure of the questions assessing participation in muscle-strengthening activities, including the reporting of activity frequency, intensity, and duration. To address the aim of the current study, additional items assessing daily living muscle-strengthening activities, as included within the 2019 UK CMO report, were added to the questions included in the MSEQ. This includes gardening, carrying shopping bags, stair climbing, lifting and carrying children, and wheeling wheelchairs. These items were formatted consistently with the MSEQ to ensure comparable reporting of activity participation, frequency, intensity and duration.

Prior to data collection, the survey was piloted with three adults from the research group who had no direct involvement in the study. Feedback from the pilot was reviewed by the research team to ensure content relevance, clarity and consistency with the study aims before the survey was finalised and distributed. The survey used for this study is available in Appendix 2-E.

2.2.2.1. *Demographics*

Participants' demographics included the year of birth, deprivation categories (derived from postcode), sex, working status, academic level, marital status, whether they were caregivers and wheelchair users. For the deprivation categories, quintile values were calculated from the country-specific Index of Multiple Deprivation. Age data were used to stratify participants following the age groups range in the Health Survey for England (2023) and the Scottish Health Survey (Terris et al., 2025).

2.2.2.2. *Adherence to Muscle-Strengthening Activities Recommendations.*

Participants were presented with the infographic and description from the UK muscle-strengthening recommendations, as shown in Figure 2.1. They were then asked to self-report whether they met these recommendations. Those who self-reported not meeting the recommendations were still asked to complete the survey. For analysis, participants were stratified into those meeting (the “Yes” group) and those not meeting (the “No” group) the recommendations.



The infographic above provides details about the 2019 UK Physical Activity Guidelines for adults and older adults. We are particularly interested in the “build strength” part of the guidelines. It is recommended that adult build strength on at least two days a week to keep the muscles, bones and joints strong. This can include activities such as using bodyweight, free weights, resistance machines or elastic bands, as well as activities of daily living such as stair climbing, wheeling your wheelchair, carrying shopping bags, lifting and carrying children, and gardening.

Do you think you meet these “build strength” guidelines by taking part in muscle strengthening activities twice a week or more during a typical week?

Figure 2.1: Question on self-report adherence to muscle-strengthening physical activity recommendations. Infographic was adapted from Department of Health and Social Care (2019).

2.2.2.3. *Muscle-Strengthening Exercises*

Participants were asked to report their participation in four types of MSE adapted from the MSEQ by Shakespear-Druery et al. (2022), which were:

- Weight machines: at home, in a gym or fitness centre.
- Bodyweight exercises: such as push-ups, sit-ups, and planking.
- Resistance exercises: using free weights such as dumbbells or resistance bands.
- Holistic exercises: including Pilates, Yoga, and Tai Chi.

Participants were asked to select the activities that they do in a usual week and report the frequency, intensity, and duration of their participation.

2.2.2.4. *Daily Living Muscle-Strengthening Activities*

Participants were asked to report their participation in five types of daily living activities that were included in the 2019 UK Muscle-Strengthening Physical Activity Guidelines (Department of Health and Social Care, 2019), which were:

- Gardening
- Carrying shopping bags
- Stair climbing
- Lifting, and carrying children
- Wheeling wheelchairs

Participants were asked to select the activities that they do in a usual week and report the frequency, intensity, and duration of their participation.

2.2.2.5. *Frequency, Intensity and Duration*

The frequency of participation was measured via a 7-day scale, and the duration of participation was measured via a 100-minute scale. The activity intensity was measured using the validated visual analogue scale by Robertson et al. (2003), where participants rated the difficulty of activities on a 0–10 scale. For this survey, an intensity of 0–4 was classified as low, 5–7 as moderate, and 8–10 as high intensity.

2.2.3. Statistical Analysis

The survey data were reported following the ‘Checklist for Reporting Results of Internet E-Survey’ (Eysenbach, 2004) (Appendix 2-F). Completed responses were analysed only if they did not have a missing value for sex or the “Do you meet the muscle-strengthening guidelines?” question. The frequency of activities was totalled to determine if they were meeting the muscle-strengthening guidelines of doing two or more days a week. Statistical analyses were conducted using SPSS V29.0.1.0. Crosstabulation was used for descriptive statistics of the participants’ demographics and the distribution of the types of muscle-strengthening activities, stratified by sex (male and female) and by self-reports of adherence to the muscle-strengthening guidelines (“Yes” and “No” groups). The Pearson χ^2 Test was used to compare participation in several types of muscle-strengthening activities according to sex. The continuous variables (frequency, intensity, and duration) for MSE and daily living muscle-strengthening activities were compared between sexes via Independent Sample T-tests. Significance was set at $p < 0.05$ throughout.

2.3. RESULTS

2.3.1. Participants

Of 1,058 survey responses, 443 were excluded due to incomplete data, not meeting inclusion criteria or a small number of responses from other sexes (Figure 2.2), leaving 615 included in the final analysis. The number of valid responses varies across demographic variables due to item-level missing data. Thus, the denominator differs for each characteristic reported in Table 2.1. Most responders were female (77%), in the 55 to 64 years age category (46%), in the least deprived category (35%), employed or self-employed (60%) and had achieved a university degree or higher (71%).

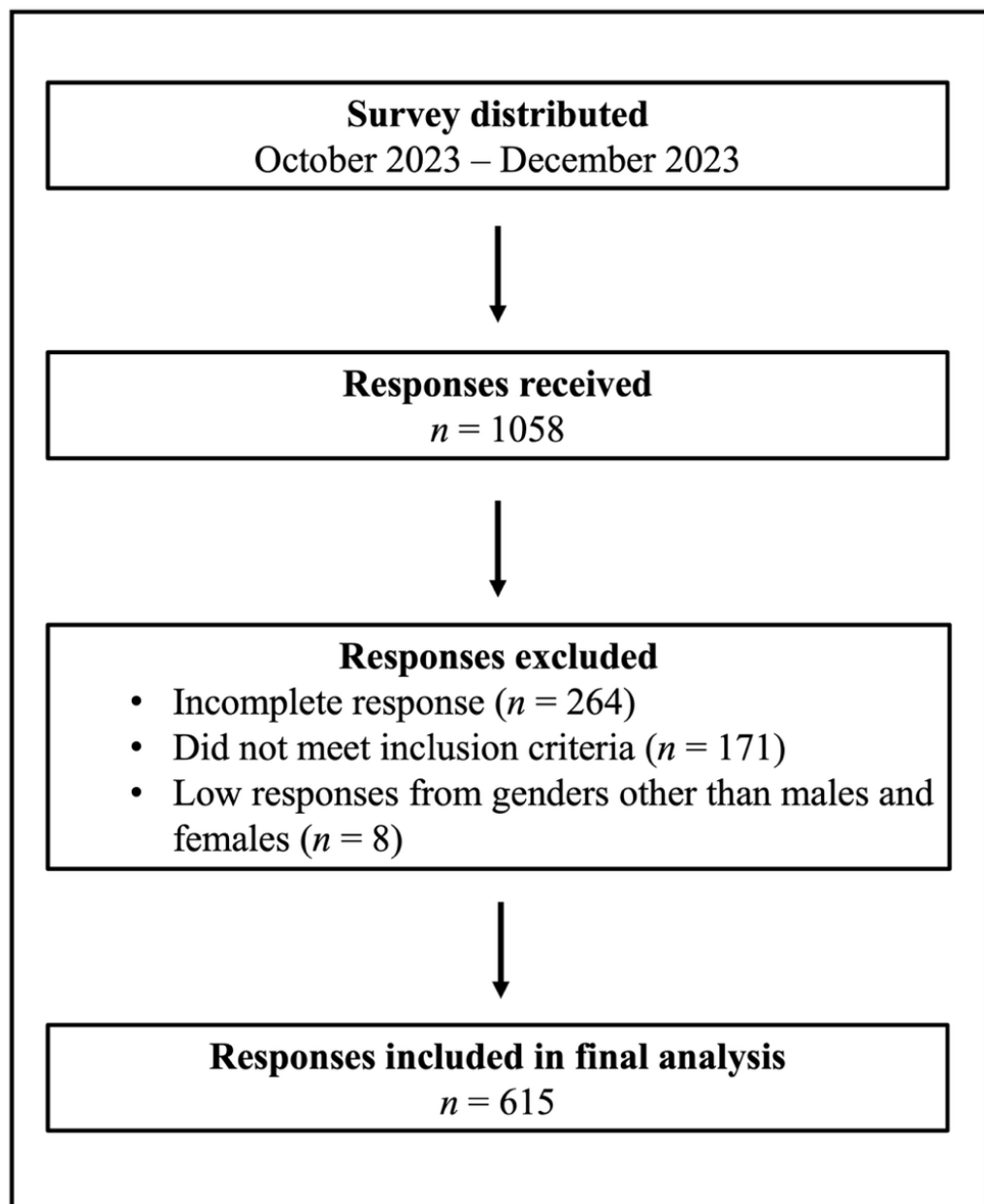


Figure 2.2: Survey flow chart.

2.3.2. Adherence to Muscle-Strengthening Activities Recommendations

470 participants (76%) from the final analysis responded “Yes”, and 145 (24%) participants responded “No” to meeting the recommendations. When assessing the reported activities of those who reported “No” to meeting the guidelines, 95% met the two days a week recommendation, with the majority meeting these recommendations when daily living muscle-strengthening activities, such as stair climbing, were included (Table 2.1). Additionally, four participants in the “Yes” group misreported meeting the guidelines, as their survey responses revealed they were doing muscle-strengthening activities less than two days a week (Table 2.1). Subsequent data are presented with participants in their initial self-reported “Yes” meeting guidelines and “No” not meeting guidelines groups.

Table 2.1: Demographic distribution of meeting the strengthening guideline.

		Total sample		Male (<i>n</i> = 144)				Female (<i>n</i> = 471)			
				“Yes” Group		“No” Group		“Yes” Group		“No” Group	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Deprivation Category	Most deprived	71	13.8	21	20.2	2	9.5	34	11.6	14	14.1
	2 nd most deprived	78	15.1	13	12.5	1	4.8	40	13.7	24	24.2
	Median quantile	86	16.7	19	18.3	3	14.3	48	16.4	16	16.2
	2 nd least deprived	100	19.4	14	13.5	7	33.3	64	21.9	15	15.2
	Least deprived	181	35.1	37	35.6	8	38.1	106	36.3	30	30.3
Age Group	18 to 24 years old	53	8.9	14	12.2	2	7.4	28	8.3	9	8.0
	25 to 34 years old	65	11.0	20	17.4	3	11.1	34	10.1	8	7.1
	35 to 44 years old	73	12.3	14	12.2	2	7.4	39	11.5	18	15.9
	45 to 54 years old	132	22.3	20	17.4	5	18.5	81	24.0	26	23.0
	55 to 64 years old	270	45.5	47	40.9	15	55.6	156	46.2	52	46.0
Working Status	Full-time student	99	16.1	23	19.7	6	22.2	47	13.4	23	19.5
	Employed or self-employed	367	59.8	73	62.4	17	63.0	212	60.2	65	55.1
	Doing unpaid work	27	4.4	1	0.9	0	0.0	20	5.7	6	5.1
	Unemployed	24	3.9	2	1.7	0	0.0	11	3.1	11	9.3
	Retired	91	14.8	18	15.4	3	11.1	59	16.8	11	9.3
	Not specified	6	1.0	0	0.0	1	3.7	3	0.9	2	1.7
Academic Level	No formal qualification after school	64	10.4	15	12.8	3	11.1	32	9.1	14	11.9

Adherence to Muscle- Strengthening Activities Recommendations	Trade, technical certificate, apprenticeship, or diploma	108	17.6	26	22.2	5	18.5	50	14.2	27	22.9
	University degree or higher	434	70.8	75	64.1	18	66.7	264	75.2	77	65.3
	Prefer not to say	7	1.1	1	0.9	1	3.7	5	1.4	0	0.0
	Only participated in muscle- strengthening exercises more than 2 days a week	18	2.9	4	3.4	1	3.7	11	3.1	2	1.7
	Only participated in daily living muscle-strengthening activities more than 2 days a week	136	22.1	9	7.7	14	51.9	33	9.3	80	67.8
	Participated in both activities more than 2 days a week	450	73.2	103	88.0	10	37.0	306	86.7	31	26.3
	Participated in both activities less than 2 days a week	11	1.8	1	0.9	2	7.4	3	0.8	5	4.2

The deprivation category is based on the quintile of the index of multiple deprivation (IMD). The full category of working status is as follows: 1) Full-time student, 2) Employed or self-employed, 3) Doing unpaid work (for own or family business/volunteering/looking after family or home), 4) Unemployed (looking for a job/unable to work due to illness or disability), 5) Retired, 6) Not specified. The total sample represents the total responses in each category whereas the percentage represents the percentage within the group. MSE: muscle-strengthening exercises. The number of valid responses varies across demographic variables due to item-level missing data; therefore, the denominator differs for each characteristic reported.

2.3.3. Types of MSE

Among the “Yes” group, the most frequently reported activities were bodyweight exercises ($n = 369$, 79%) and resistance exercises ($n = 342$, 72%), while the least reported activity was weight machines ($n = 211$, 45%). In the “No” group, bodyweight exercises ($n = 30$, 21%) and holistic exercises ($n = 29$, 20%) were the most frequently reported activities, and weight machines ($n = 12$, 8%) were the least reported activity.

Figure 2.3 shows males' and females' participation in different MSE, stratified by the “Yes” and “No” groups. Notable sex differences were found within the “Yes” group where more males participated in exercises using weight machines (57% males, 41% females, $p = 0.002$) and performed resistance exercises (80% males, 70% females, $p = 0.034$), but more females participated in holistic exercises, such as Pilates and yoga (33% males, 55% females, $p < .001$). However, no sex differences in the type of MSE performed within the “No” group.

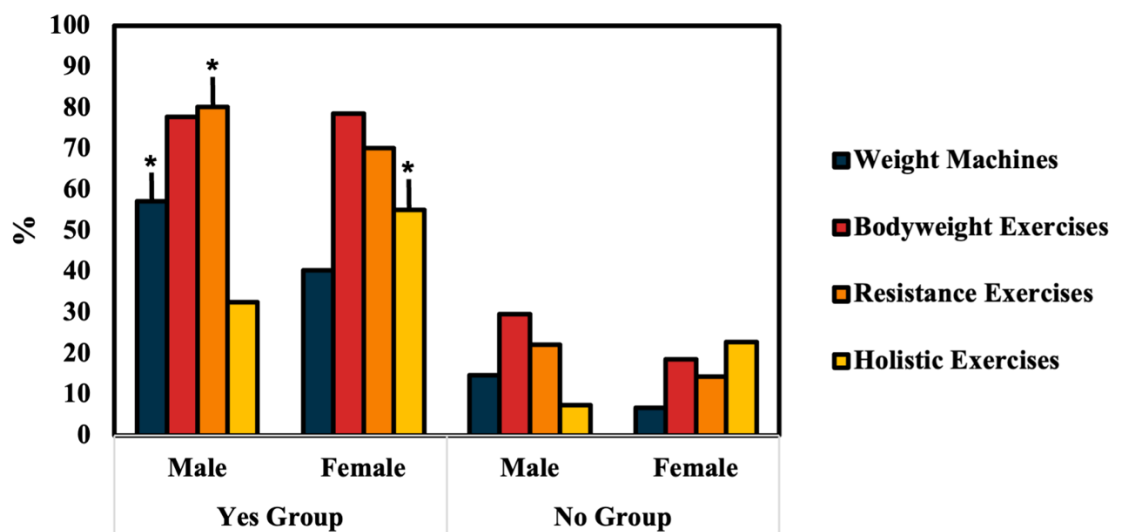


Figure 2.3: The distribution between sexes in the types of MSE. * Denotes the significance detected within the “Yes” group, where males participated more in weight machines and resistance exercises, whereas females participated more in holistic exercises.

2.3.4. Types of Daily Living Muscle-Strengthening Activities

For both groups, the most frequently reported activities were carrying shopping bags ($n = 420$, 89% for the “Yes” group; $n = 118$, 81% for the “No” group) and stair climbing ($n = 444$, 95% for the “Yes” group; $n = 130$, 90% for the “No” group). Wheeling a wheelchair was the least reported activity for both groups ($n = 12$, 3% for the “Yes” group; $n = 12$, 8% for the “No” group).

Figure 2.4 shows the participation of males and females in different types of daily living activities stratified by the “Yes” and “No” groups, with no differences between sexes in either group.

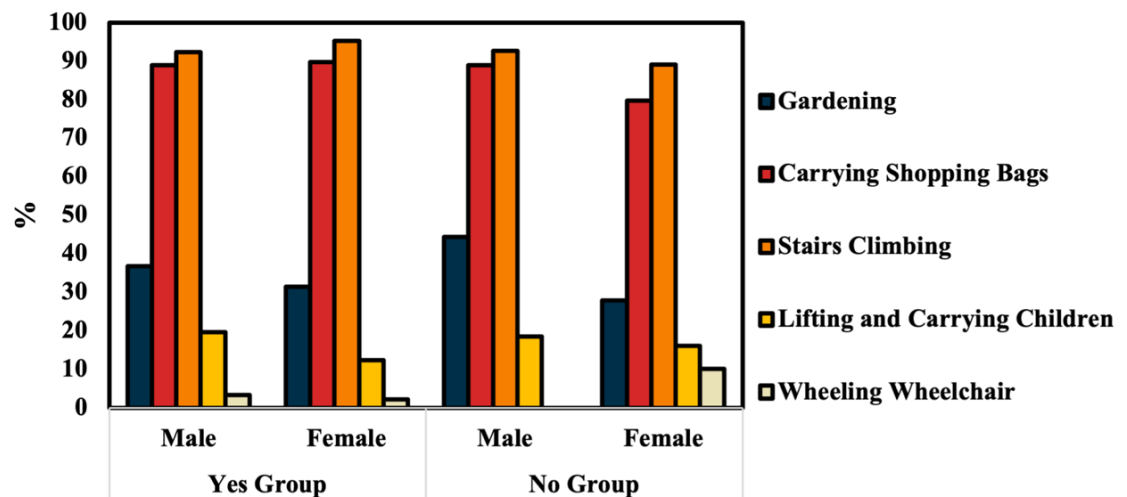


Figure 2.4: The distribution between sexes in the types of daily living muscle-strengthening activities.

2.3.5. Frequency, Intensity and Duration of MSE

Table 2.2 compares the frequency, intensity and duration of muscle-strengthening participation among those who reported performing each activity within the “Yes” and “No” groups and between the sexes. All four MSEs were performed on average three days a week in the “Yes” group and two days a week in the “No” group. Males in the “Yes” group participated more frequently in bodyweight exercises (males = 3.47 ± 1.61 days, females = 3.06 ± 1.41 days, $p = 0.035$), resistance exercises (males = 3.37 ± 1.24 days, females = 3.02 ± 1.29 days, $p = 0.025$) and weight machine exercises (males = 3.35 ± 1.27 days, females = 2.57 ± 1.15 days, $p < .001$) than females. No significant differences between sexes were seen in the frequency of participation in MSE for the “No” group.

On average, both groups performed all four MSE at moderate intensity with no differences between sexes in either group. Both groups performed MSE for an average of 30 to 40 minutes each time. When comparing the duration spent on all four MSE between sexes in both groups, no differences were noted, except for the duration of holistic exercises in the “Yes” group, where females spent a longer duration (males = 34.66 ± 19.09 minutes, females = 45.79 ± 19.19 minutes, $p = 0.002$) than males.

2.3.6. Frequency, Intensity and Duration of Daily Living Muscle-strengthening Activities

For daily living muscle-strengthening activities, most activities were performed an average of two days a week (Table 2.2). The most frequently reported activity in both groups was stair climbing. The frequency of participation in daily living activities was similar between sexes except within the “Yes” group, where males performed stair climbing more than females (males = 6.45 ± 1.13 days, females = 6.13 ± 1.60 days, $p = 0.024$).

On average, daily living activities were performed at low to moderate intensities in both groups. The intensity of different types of daily living activities showed no difference between sexes in either group, except for the intensity of stair climbing where females in the “No” group performed stair climbing at a higher intensity (males = 3.04 ± 1.52 , females = 4.34 ± 2.46 , $p = 0.002$) compared to males, and males in the “No” group reported lifting and carrying children at a higher intensity (males = 6.00 ± 0 , females = 4.29 ± 2.11 , $p = 0.004$).

Daily living activities were performed on average for 20–40 minutes each time, except for gardening, which was performed for around 45–50 minutes each time in both groups, with no differences between the sexes in either group.

Table 2.2: Comparison between sexes on the frequency, intensity, and duration of muscle-strengthening activities among those who reported doing each activity in the “Yes” and “No” groups.

	The “Yes” Group					The “No” Group				
	<i>n</i>	Male Mean (SD)	<i>n</i>	Female Mean (SD)	<i>p</i> -value	<i>n</i>	Male Mean (SD)	<i>n</i>	Female Mean (SD)	<i>p</i> -value
Frequency (days/week)										
Weight Machine Exercises	65	3.35 (1.27)	139	2.57 (1.15)	<.001	4	1.50 (0.58)	8	1.63 (0.74)	0.776
Bodyweight Exercises	87	3.47 (1.61)	272	3.06 (1.41)	0.035	7	2.86 (1.77)	21	2.10 (1.04)	0.315
Resistance Exercises	94	3.37 (1.24)	242	3.02 (1.29)	0.025	6	2.17 (1.47)	14	2.14 (1.03)	0.967
Holistic Exercises	35	2.77 (1.65)	186	2.75 (1.62)	0.936	2	2.50 (0.71)	25	2.20 (1.53)	0.788
Gardening	35	2.17 (1.50)	101	2.08 (1.15)	0.707	10	2.20 (1.40)	30	1.57 (0.86)	0.095
Carrying Shopping Bags	98	2.70 (1.29)	302	2.82 (1.36)	0.466	18	3.17 (1.43)	94	2.73 (1.23)	0.185
Stair Climbing	106	6.45 (1.13)	331	6.13 (1.60)	0.024	23	6.17 (1.47)	104	5.79 (1.68)	0.310
Lifting and Carrying Children	20	4.65 (2.35)	40	3.85 (2.17)	0.195	5	5.60 (1.95)	17	4.00 (2.09)	0.143
Wheeling a Wheelchair	3	2.00 (0.00)	8	3.13 (1.81)	0.122	0 ^a	-	11	2.45 (1.21)	-
Intensity (perceived difficulty, score 0-10)										
Weight Machine Exercises	65	6.71 (1.82)	142	7.08 (1.41)	0.142	4	6.50 (1.29)	8	6.13 (1.46)	0.673
Bodyweight Exercises	88	6.73 (1.90)	275	6.66 (1.78)	0.775	8	5.88 (1.64)	22	6.55 (2.09)	0.420
Resistance Exercises	92	7.18 (1.87)	245	6.76 (1.83)	0.059	6	5.50 (1.87)	17	5.59 (1.84)	0.921
Holistic Exercises	36	5.31 (2.33)	189	5.41 (2.01)	0.775	2	5.50 (0.71)	26	5.27 (1.51)	0.834
Gardening	40	4.20 (1.84)	110	3.96 (2.26)	0.554	12	3.92 (1.62)	31	4.48 (2.76)	0.411
Carrying Shopping Bags	97	3.18 (2.27)	306	3.35 (2.28)	0.503	22	3.68 (2.01)	91	4.16 (2.50)	0.342
Stair Climbing	96	3.24 (2.43)	312	3.06 (2.52)	0.548	23	3.04 (1.52)	102	4.34 (2.46)	0.002

Lifting and Carrying Children	20	2.90 (1.62)	42	3.83 (2.28)	0.106	4	6.00 (0.00)	17	4.29 (2.11)	0.004
Wheeling a Wheelchair	3	3.33 (1.53)	8	4.63 (3.34)	0.544	0 ^a	-	11	5.18 (2.71)	-
Duration (minutes/session)										
Weight Machine Exercises	66	40.00 (21.88)	143	34.92 (17.91)	0.102	4	37.00 (16.06)	8	32.38 (13.77)	0.614
Bodyweight Exercises	87	31.16 (21.66)	273	34.12 (17.30)	0.193	6	32.50 (20.16)	21	23.81 (13.92)	0.233
Resistance Exercises	92	40.30 (22.04)	242	38.42 (19.51)	0.447	6	35.33 (16.78)	16	25.38 (15.21)	0.198
Holistic Exercises	35	34.66 (19.09)	192	45.79 (19.19)	0.002	2	56.50 (36.06)	27	33.56 (19.99)	0.144
Gardening	40	54.75 (27.32)	110	53.17 (23.62)	0.729	12	46.42 (22.99)	33	45.12 (28.58)	0.889
Carrying Shopping Bags	93	23.09 (18.09)	297	22.35 (12.58)	0.714	20	23.40 (13.22)	91	23.98 (16.77)	0.885
Stair Climbing	99	22.73 (19.34)	305	20.83 (16.36)	0.340	20	27.55 (24.94)	95	19.72 (15.86)	0.191
Lifting and Carrying Children	20	27.30 (15.01)	37	30.19 (20.73)	0.585	4	47.50 (19.23)	16	35.44 (28.44)	0.437
Wheeling a Wheelchair	3	36.33 (18.72)	8	40.88 (28.56)	0.807	0 ^a	-	11	45.82 (26.31)	-

a. *p-value cannot be computed because at least one of the groups is empty.*

2.4. DISCUSSION

This study aimed to identify the types, frequency, intensity, and duration of activities adults participated in to meet the UK government's muscle-strengthening activity recommendations and to examine whether there were any differences between sexes. The study revealed that adults who participate in muscle-strengthening activities for at least two or more days per week achieve this with a combination of daily living activities and MSE, with bodyweight exercises as the most reported exercise type. While there were no differences between sexes for daily living activities, sex differences were observed in the type of MSE participation between males (weight machine and resistance exercises) and females (holistic exercises). The intensity of MSE was also greater (moderate) than daily living activities (low), with similar duration per session for both types of activities.

Understanding the muscle-strengthening activities of those who meet the guidelines offers insight into how others could also achieve this. For MSE, bodyweight exercises were the most reported activity across both the "Yes" and "No" groups (79%), while weight machines were the least reported across both groups. A cross-sectional study conducted by Loustalot et al. (2013) with 1,238 adults who engaged in muscle-strengthening for at least two days or more, reported similar findings, with most (55%) participating in callisthenics—a type of bodyweight activity. However, unlike the current study, they reported that free weights (classified as resistance exercises in the current study) were the most reported activity (58%). Bodyweight exercises typically require no or limited equipment and can be performed in various settings outside the gym, whilst still being shown to improve hypertrophy and strength (Ogawa et al., 2023, Kikuchi and Nakazato, 2017, Wei et al., 2023). Since they are key to achieving the recommendations and strengthening benefits, these activities should be explicitly stated in future guidelines, messaging and interventions.

There were sex differences in the types of MSE performed by participants in the current study, but no differences between sexes in daily living activities. Males reported participating more in exercises involving weight machines or resistance exercises, which include free weights and resistance bands, whereas females reported more participation in holistic exercises such as yoga and Pilates. Our findings align with a narrative review of five population-level surveys on exercise mode preferences by Nuzzo (2023), which showed that males preferred strength training over activities such as aerobics, flexibility exercises, or dancing, while females favoured those activities over strength training. This again suggests

the need for more relevant examples in the messaging of muscle-strengthening activities, and explicitly the preference for MSE by sex.

This study found that among those reporting participation in MSE, most were performed on two or more days a week, which aligns with current frequency recommendations (Bull et al., 2020, Department of Health and Social Care, 2019). The UK guidelines also indicate that muscle-strengthening activities should be performed “to the point where you need a short rest before repeating the activity,” suggesting a moderate/high intensity (Department of Health and Social Care, 2019). In this study, participants reported achieving moderate to high intensity during MSE, but not for daily living activities. This raises questions about the inclusion of daily living activities or at least some examples within the current recommendations, as the intensity of effort, alongside frequency, is key for maintaining or increasing muscle strength throughout life (Mangine et al., 2015, Wernbom et al., 2007). For instance, there is limited evidence concerning the benefits of carrying shopping bags on strength outcomes; thus, including this in the guidelines should be reviewed. Importantly, including daily living activities affects how adherence to the guidelines is measured. As shown in the current chapter, it significantly increases adherence estimates depending on whether these activities are counted as muscle-strengthening activity. This suggests that high apparent adherence among individuals who self-report not meeting the guidelines is due to inclusion of questions on daily living muscle strengthening activities, as included in the guidelines, which may, or may not, be of sufficient physiological stimulus to realise clear benefits. Duration is another significant factor in the ‘dose’ of activity required for strength benefits. Although not explicitly stated in the muscle-strengthening recommendations, this study reported 20–60 minutes per session of daily living muscle-strengthening activities and exercises. This duration is likely beneficial, as previous work has indicated that 30–60 minutes of muscle-strengthening activities per week are linked to a 10–20% risk reduction for mortality and cardiometabolic diseases (Momma et al., 2022). Therefore, this aspect should be considered in future guidelines.

To the best of our knowledge, the current study is the first to provide a detailed breakdown of muscle-strengthening activity among adults in relation to the UK 2019 Physical Activity Guidelines, by characterising activity by type, frequency, intensity, and duration rather than relying solely on adherence estimates. In contrast, national surveillances such as the Health Survey for England (2023) and the Active Lives Survey (Sports England, 2025) primarily

report adherence estimates to physical activity guidelines at the population level without detailed information on how activity is accumulated. These surveillance methods do not routinely differentiate between structured, exercise-based muscle-strengthening activities and incidental daily living activities. In comparison, the present study explored muscle-strengthening behaviour in greater detail by examining how activity is accumulated across distinct domains, including both structured exercise-based muscle strengthening activity and daily living activities. This enables a more detailed characterisation of muscle-strengthening behaviour beyond adherence estimates and provides insights into the relative contribution of different activities to guideline attainment. This study recruited individuals who met the muscle-strengthening recommendations and therefore did not represent the general population. However, no inferences about adherence to muscle-strengthening recommendations are made, and as expected, these were higher than previous reports. Notably, this study highlights that including daily living muscle-strengthening activities, which are often excluded from national surveillance, can substantially alter the adherence estimates. While these activities are included in the current national guidelines, future research should explore whether they effectively increase muscle strength and provide associated health benefits. The next limitation is the self-report nature of the data, where participants may have provided socially desirable or inaccurate responses (Wanner et al., 2017, Sandercock et al., 2022, Shakespear-Druery et al., 2022). Another limitation relates to the wording and interpretation of the survey items. Despite using a validated instrument for muscle-strengthening exercises, the items related to daily living activities may have been interpreted inconsistently by the participants. The phrasing of questions regarding frequency, intensity, and duration may have led to the variability in how respondents conceptualised the activities, potentially influencing the reported estimates of participation. There is also a possibility that the participants overestimated the duration of the daily living activities performed, such as carrying shopping bags and stair climbing, as these activities are typically incidental and intermittent in nature. Thus, it may not occur in a continuous bout of 20 to 40 minutes, which introduces the potential for measurement error. Whilst a validated survey was used and provided useful insight into the activities people participated in to achieve the guidelines, future work should build on this and further explore the experiences of those who manage to achieve the guidelines. This is especially the case for females who may have different experiences from males.

2.5. CONCLUSION

The study found that adults who participate in muscle-strengthening activities for at least two or more days per week achieve this with a combination of MSE performed at moderate intensity and daily living activities performed at low intensity. MSE that require limited resources, such as bodyweight exercises, were most reported with sex differences between the types of MSE performed, but not for daily living activities. Daily living activities were also performed at a lower intensity, highlighting the need to review the strength benefits of some of these activities. These findings provide insight into the need for more specific advice within guidelines, messaging and for tailoring interventions, especially by sex. Further qualitative work is needed to explore the barriers and facilitators for muscle-strengthening activities participation.

CHAPTER 3 – WOMEN IN STRENGTH (WISH STUDY): HOW WOMEN ENGAGE IN MUSCLE-STRENGTHENING EXERCISES

The current chapter has been published as follows:

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3.1. INTRODUCTION

Regular participation in physical activity reduces the risk of chronic diseases and improves mental health and well-being for the general population. For women, participating in muscle-strengthening activities offers additional benefits beyond those of aerobic activity alone, including reproductive health outcomes (Sabag et al., 2024), and reducing the risk of osteoporosis, sarcopenia and frailty (Sundell, 2011, Hong and Kim, 2018). In addition to aerobic exercises, muscle-strengthening activities have also been associated with improvements in postpartum depression and anxiety (Deprato et al., 2025). Studies have established that women face an earlier strength loss than men, from menopause due to the decrease in oestrogen (Calmels et al., 1995, Phillips et al., 1993, Montero-Fernandez and Serra-Rexach, 2013), and involvement in muscle-strengthening activities is important to mitigate this decline. This underscores the importance of muscle-strengthening for women across their lifespan.

Current guidelines from the 2020 World Health Organisation and 2019 UK Physical Activity Guidelines recommend at least two days a week of muscle-strengthening activities, targeting the major muscle groups (Department of Health and Social Care, 2019, World Health Organization, 2020). The UK national surveillance data from 2012 to 2023 in Scotland and England consistently reveal that women are less likely than men to meet these recommendations (Strain et al., 2016, Health Survey for England, 2023, Deakin et al., 2024a). For instance, the 2021 Health Survey for England reported that only 29% of women (vs 36% of men) meet the recommended muscle-strengthening activities guidelines (Health Survey for England, 2023). Similarly, the 2023 Scottish Health Survey reported that only 26% of women (vs 32% of men) met the recommendation (Deakin et al., 2024a). There are also clear age-related trends among women meeting the muscle-strengthening activities guidelines. The 2023 Scottish Health Survey showed an age-related decline in the proportion of women

meeting muscle-strengthening guidelines (Deakin et al., 2024b), with participation highest among young women aged 16 to 24 (46%), decreasing through early and mid-adulthood (33-34%, ages 25 to 54), and dropping sharply after the age of 55 (19%, ages 55 to 64)(Deakin et al., 2024b). These age-related trends likely reflect the different life stages women experience, such as during the childbearing years, when women's exercise participation often declines (Hesketh et al., 2023, Goncalves et al., 2024, Saligheh et al., 2016) and are essential to consider when aiming to understand why women engage in muscle-strengthening activities. As discussed in Chapter 2, these adherence values are likely to underestimate women's true participation in muscle-strengthening activities, as the national surveillance data primarily capture structured exercises and do not report daily living muscle-strengthening activities, such as stair climbing and carrying shopping bags, as part of the muscle-strengthening domain.

Previous studies have begun to explore participation in MSE in women. A systematic review and meta-synthesis of 20 studies ($n = 402$) by Vasudevan and Ford (2022) explored barriers and motivators to women's initiation and maintenance of strength training participation. Barriers include lack of knowledge and enjoyment, inadequate support, caring responsibilities and limited access to facilities or financial resources. Motivators included social support, observable improvements in appearance, mental and physical health, financial incentives and proper supervision during exercise (Vasudevan and Ford, 2022). These findings are consistent with a substantial body of literature that identifies comparable barriers and facilitators to women's participation in MSE (Hurley et al., 2018, Kulavic et al., 2013, Luckin et al., 2021, Coen et al., 2018, Petrov Fieril et al., 2014, Heiestad et al., 2016), and they underscore the multifaceted complexity involved in supporting women to achieve these guidelines.

While survey and surveillance studies provide important information on adherence and participation patterns in muscle-strengthening activity, they provide limited insight into how women actually experience MSE in real life, including the conceptual, social and behavioural factors that influence participation. Quantitative approaches can be limited in their ability to capture the complexity of experiences and human behaviour (Tenny et al., 2021), whereas qualitative approaches allow for a more in-depth exploration of behaviour within a specific context (Foley and Timonen, 2015). Therefore, a qualitative approach was

important for exploring womens' lived experiences in MSE participation and generating a richer understanding beyond what could be captured through qualitative measures alone.

Although previous research by Vasudevan and Ford (2022) synthesised international findings and including women who both did and did not engage in MSE, studies have typically focused on specific groups (such as those who initiate and adhere to short-term intervention) or populations (clinical populations, bodybuilders). Few have explored individuals in the general population who habitually engage in muscle-strengthening activities, which is essential for enhancing our understanding of behaviour maintenance in real-world, ecologically valid settings. Understanding the experience of women meeting the guidelines is important for identifying practical strategies and behaviour processes that may inform future intervention development to help inform women not meeting the guidelines how they might achieve this – via the development of an appropriate intervention. In addition, prior work typically emphasised barriers and facilitators, while only a small number of studies extend this to consider lived experience and solution-oriented strategies. Therefore, this chapter aimed to (1) explore the barriers and facilitators to participation in MSE among women aged 18 to 64 who are currently meeting the muscle-strengthening guidelines, and (2) to identify strategies to improve participation in these activities.

3.2. METHOD

3.2.1. Study Design

This qualitative study is part of the Women in Strength (WISH) research project. This study was approved by the College of Medical, Veterinary and Life Sciences Ethics Committee at the University of Glasgow (Reference Number: 200230238) (Appendix 3-A) and adhered to the Declaration of Helsinki. Data collection was conducted from March to May 2024.

3.2.2. Participants

Participants who completed the previous Muscle-Strengthening Participation Survey (Chapter 2) and expressed their interest in participating in follow-up research were contacted by email. Recruitment to the original survey is described further in the previous chapter (Chapter 2) but includes using promotional posters and posting a survey link on neighbourhood application (Nextdoor), Microsoft Viva Engage, LinkedIn, X and paid

advertising via Meta Ads. To be included in the current study, women had to be aged between 18 and 64 years old when they participated in the original survey, living in the United Kingdom, and participating in MSE for two or more days a week. Each participant was compensated with a £20 Amazon voucher for their time after completion of the interview. Participant information sheets, consent forms, and recruitment poster are provided in Appendix 3-B to 3-D.

3.2.3. Data Collection and Interviews

The interview topic guides (Appendix 3-E) were developed by the principal researcher (NR) and the research team (SG and GR) to explore participants' experiences with MSE, the barriers, facilitators and their strategies to improve women's participation. The current study focuses specifically on their participation in MSE such as weight machines, free weights (dumbbells, barbells and kettlebells), resistance bands, bodyweight exercises and holistic exercises such as yoga and Pilates. Structured MSE was selected because women participated in these activities less frequently than men (Chapter 2), and targeting these allows the study to better understand the disparities in engagement, identify practical barriers and facilitators. The guide, therefore, focused on key domains of participants' experiences, motivation, and perceived barriers. Example questions included: *"What initially inspired or motivated you to start participating in muscle-strengthening?"*, *"Can you tell me what challenges you faced when you were participating in muscle-strengthening?"* and *"What makes participating in muscle-strengthening easier for you?"*

All interviews were conducted by the principal researcher, NR (female, BSc, PhD student), alone, who had received formal training in qualitative research. NR had no prior relationship with the participants before the study began. NR's background in Sports Science, as well as her research interest in MSE, could influence her perspective during data collection and interpretation. To mitigate potential interviewer bias, the research team (NR, SG, GR) reviewed the interview topic guides to identify and edit any potentially leading questions, and reflective discussions were held throughout data collection and analysis to critically examine how researchers' assumptions may have shaped the questioning, coding, and theme development.

During the interview, open-ended questions were used, with neutral prompts for elaboration and follow-up questions that utilised the participants' own terminology. Participants were given the option to have an online (via Microsoft Teams) or in-person interview (at the University of Glasgow). Each interview slot was one hour long, and interviews were audio-recorded via Teams or a digital audio recorder if in person. Verbal (for online interview) or written (for in-person interview) consent to participate and to publish was obtained before the interview. Data saturation was not monitored, in line with the epistemological stance of reflexive thematic analysis, a qualitative method for identifying and interpreting patterns of meaning based on the researcher's subjectivity and reflexivity (Braun and Clarke, 2019). Reflexive thematic analysis prioritises depth and the development of nuanced interpretations over the completeness of themes (Braun and Clarke, 2021).

3.2.4. Participants' Demographics

Demographic and exercise background data (age, deprivation category, working status, academic level, marital status, frequency of participation in MSE, exercise setting for muscle-strengthening, and type of exercises participated in) were also collected during the interview. Postcode data were used to derive quintile values for deprivation categories, where 1 indicates the most deprived and 5 the least deprived, based on the country-specific Index of Multiple Deprivation, which combines indicators for income, employment, education, health, crime, housing, and living environment (GOV.UK, 2019, Northern Ireland Statistic and Research Agency, 2017, Scottish Government, 2020, Welsh Government, 2019).

3.2.5. Data Analyses

The current study is reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist (Tong et al., 2007) (Appendix 3-F). All audio recordings from the interviews were transcribed using Otter.ai and checked by NR. Braun and Clarke's reflexive thematic analysis approach was used to guide the analysis, following a six-phase process to identify, analyse, and report patterned meanings within the data, with emphasis on reflexivity and iterative theme development (Braun and Clarke, 2006, Braun and Clarke, 2019). NR and EO began the analysis process separately by familiarising themselves with the interview transcripts and generating initial codes inductively. Subsequent discussion between NR and EO focused on deepening the analytical insight and refining the coding framework, rather than achieving coder consensus. Codes were further

explored in a reflective discussion between NR, SG and GR to enhance interpretive depth and ensure analytical coherence before progressing to focused coding across the dataset. NVivo 12 Pro (QSR International Pty Ltd, Doncaster, Victoria, Australia) was used to code all transcripts. NR and GR developed and refined higher-order themes, descriptors, and a thematic map iteratively over three subsequent meetings (6 hours total), focusing on conceptual clarity and coherence of the thematic structure.

3.2.6. Trustworthiness

To ensure the trustworthiness of the analysis, peer debriefing was carried out through reflective discussions among the researchers. These discussions enabled emerging codes and themes to be critically examined and refined, supporting the credibility and confirmability of interpretations. Member checking was not conducted, consistent with the reflexive thematic analysis approach, which focuses on the researchers' reflexivity and interpretation (Braun and Clarke, 2006, Braun and Clarke, 2019).

3.3. RESULTS

3.3.1. Participants Demographic

137 participants who expressed interest in participating in follow-up research from the original survey were contacted, with 54 expressing their interest in participating in the interviews, and 24 consenting to the interviews. Demographic and exercise background data of the 24 participants are displayed in Table 3.1. Most of the participants were aged between 55 to 64 years old (50%), lived in the least deprived area (38%), were employed (58%), had a university degree (79%), and were married with children (54%). For the exercise location and type of MSE, participants could select all that applied; therefore, the total could exceed 100%. The most reported locations were the gym (58%) and exercising at home (46%). As for the type of MSE, the frequently reported were weight machines or resistance exercises (83%) and bodyweight exercises (50%).

Interviews produced 466 minutes and 44 seconds of recorded audio. 4 themes and 14 subthemes were identified (Figure 1). The themes are:

- 1) Reason for participating in MSE (2 subthemes) (Table 3.2)
- 2) Barriers to MSE participation (5 subthemes) (Table 3.3).
- 3) Facilitators to participating in MSE (5 subthemes) (Table 3.4).
- 4) Strategies to improve women's participation in MSE (2 subthemes) (Table 3.5).

Table 3.1: Demographic characteristics of participants.

	Participants n = 24 (%)
Age Group	
18 to 24 years old	1 (4.2)
25 to 34 years old	3 (12.5)
35 to 44 years old	2 (8.3)
45 to 54 years old	6 (25.0)
55 to 64 years old	12 (50.0)
Deprivation Category	
Most deprived	4 (16.7)
2 nd most deprived	1 (4.2)
Median quantile	6 (25.0)
2 nd least deprived	4 (16.7)
Least deprived	9 (37.5)
Working Status	
Full time student	4 (16.7)
Employed or self employed	14 (58.3)
Unemployed	1 (4.2)
Retired	5 (20.8)
Academic Level	
No formal qualification after school	1 (4.2)
Trade, technical certificate, apprenticeship or diploma	4 (16.7)
University degree or higher	19 (79.2)
Marital Status	
Single (never been married)	7 (29.2)
Married (with children)	13 (54.2)
Divorced/Separated (with children)	4 (16.7)
Frequency of MSE Participation	
2 to 3 days a week	17 (70.8)
4 to 5 days a week	4 (16.7)
6 to 7 days a week	3 (12.5)
Exercise Setting	
Gym	14 (58.3)
Home	11 (45.8)
Group exercise classes	6 (25.0)
Type of Exercises	
Bodyweight exercises	12 (50.0)
Weight machines or resistance exercises	20 (83.3)
Holistic exercises (i.e. yoga, Pilates)	7 (29.2)

The deprivation category is based on the quintile of the index of multiple deprivation (IMD). The full category of working status is as follows: 1) Full-time student, 2) Employed or self-employed, 3) Doing unpaid work (for own or family business/volunteering/looking after family or home), 4) Unemployed (looking for a job/unable to work due to illness or disability), 5) Retired, 6) Not specified. Marital status categories with zero responses (i.e. single (with children), married (without children), and divorced/separated (without children)) were omitted from the table. Participants could select more than one response for exercise location and type of exercise; thus, the total exceeded 24 and the percentage exceeded 100%. n = number of responses in each category, % = proportion within that category.

3.3.2. Thematic Map

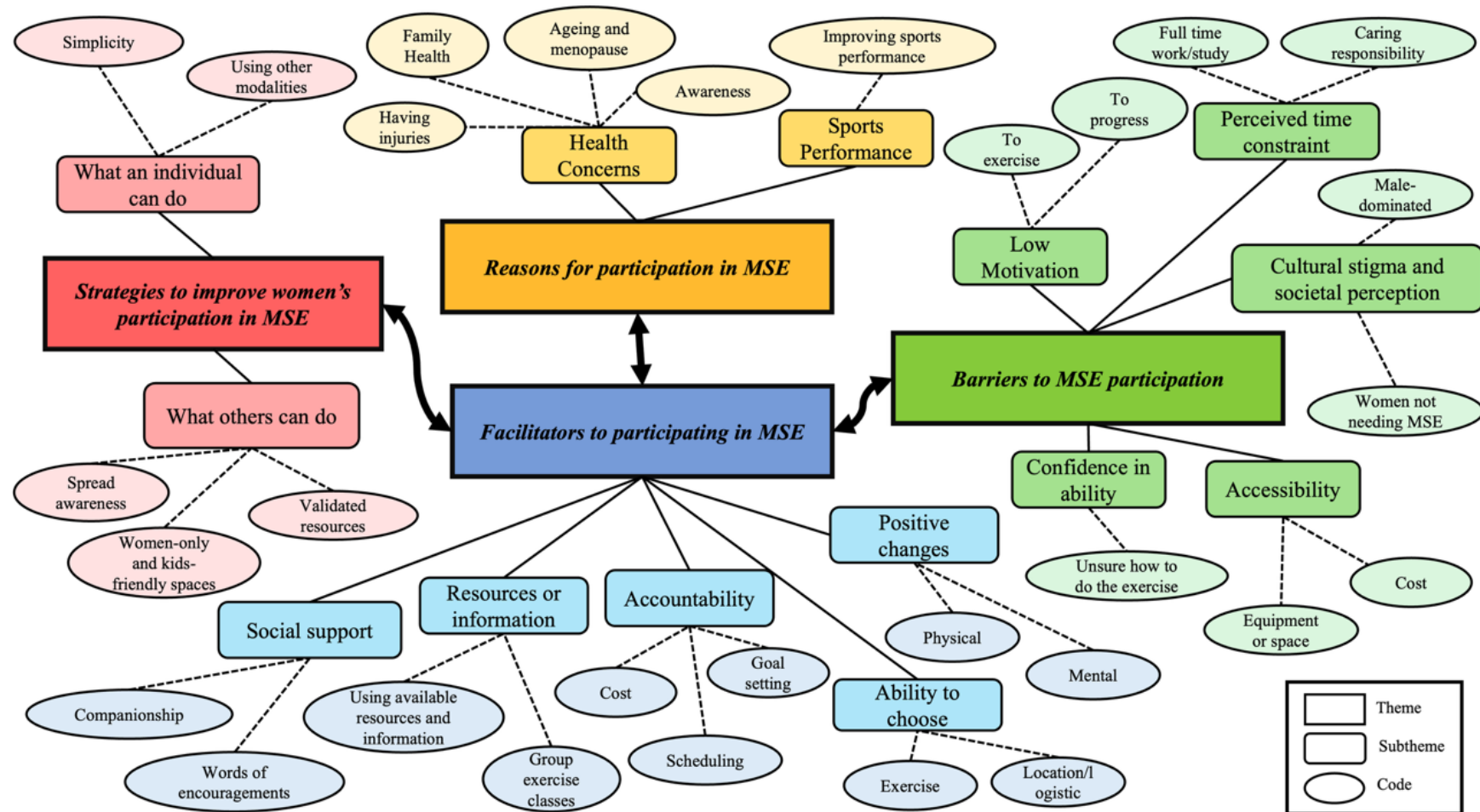


Figure 3.1: Finalised thematic map demonstrating 4 themes. MSE refers to muscle-strengthening exercises.

3.3.3. Theme 1: Reasons for Participating in MSE

This theme highlights the benefits of participating in MSE as a reason to begin participating. Initial reasons for taking part in MSE were linked to concerns about health, including injuries, family health, ageing, menopause, and the realisation of the need to maintain strength as they aged, as well as for improving sports performance for some. Table 3.2 presents indicative quotes corresponding to the codes, based on the reasons given by the participants.

3.3.3.1. *Health concern: Having injuries and family health*

Participants reflected on how having an injury shaped their participation in MSE. Some of the injuries mentioned were pain involving the back, such as sciatic pain, herniated or disk degeneration, and bone-related injuries such as plantar fasciitis and osteoarthritis. Though this was not limited to their own injury or health conditions, as participants also mentioned that looking at their families' health, such as parental health deterioration, including dementia, motivated them to start participating in MSE.

3.3.3.2. *Health concern: Ageing, menopause and awareness of maintaining strength*

Participants also described ageing as a reason for starting participation, whether due to their own ageing or observing family members' age. Concerns about ageing are also related to menopause. Those experiencing menopause said that it caused them to gain weight, and taking up MSE has helped them. Across accounts, there was a shared recognition that awareness or realisation that they need to maintain their muscle strength as they age has been a factor in their participation.

3.3.3.3. *Sports performance*

Some participants mentioned that they began participating in MSE to improve their sports performance. They agreed that the strength they gained from MSE had benefited their sports performance.

Table 3.2: Reasons for participating in MSE.

Codes	Subcodes	Indicative quote(s)
Health concerns	Having injuries	<i>"I have arthritis in my thumb. I found that my grip strengths got a lot better since I've been using, especially heavier weights, doing a lot of that kind of work" (P01, age 54)</i> <i>"When I was in my home country, like, a long ago, I was working as a medical representative, I used to carry a bag on my shoulder, which is relatively heavy. I started having really bad back pain, a lower back pain. And I was advised to strengthening my back muscle to support my spine more and better. I started doing some yoga then I thought that was not enough. That's why I started different kind of exercises." (P16, age 34)</i> <i>"Two years ago, I had really bad back. I had a herniated disc. It probably took a year to clear up completely, though. So, when my back was bad, I went to physio and was given a physio programme and that's basically what started me doing the muscle-strengthening exercises, and then I started going to Pilates...I think I sort of had the motivation. The motivation came from not wanting to be injured. Again." (P25, age 64)</i>
	Family health	<i>"I supposed the big motivation factor is my mom (health) was really poor. She had multisystem atrophy. So, we watched her kind of decline. And in the back of my mind is kind of like if I did better on baseline fitness, that if I do anything like that, I might have a better starting point than what she did." (P09, age 43)</i>
	Ageing	<i>"I think it's sort of for our future proofing, investing in my health, particularly to have seen my parents' health deteriorate." (P22, age 54)</i>
	Menopause	<i>"I've had children and in the middle of perimenopause. I found that I put on quite a lot of weight when I started menopause, and I found that this (muscle-strengthening exercises) has helped me stabilise my weight a lot more than cardio." (P01, age 54)</i>

	Having awareness or realisation of maintaining muscular strength	<i>“I think the realisation that you have to keep your muscle strength comes when you’re in your 30s. I think maybe when you realise that you do need to stay fit to look after your family...I probably always knew that everybody should do it. When I was young, doing nursing, it was very popular back then in the 80s and 90s to go to step classes and aerobics...as you got a bit older, you realised that you need muscle strength to kind of balance it.” (P24, age 58)</i>
Sports performance	Improving sports performance	<i>“I do a lot of leg work because that strengthens my rowing.” (P02, age 50)</i> <i>“I recently took up weights to improve my karate.” (P06, age 24)</i> <i>“When I was starting, I was doing sport (rowing). And I think some part of it was to get better at rowing is to be able to produce more strength in it.” (P10, age 26)</i>

3.3.4. Theme 2: Barriers to MSE Participation

Participants reported several barriers that arose regarding their participation in MSE. These barriers included perceived time constraints due to study and work commitments, lack of confidence in their ability to do the exercises, the accessibility regarding the cost and equipment availability, the cultural stigma and societal perception of MSE for women, and low motivation. These factors often compete with participants' intention to exercise, thus creating barriers that they must overcome to exercise. The indicative quotes that represent the codes for this theme are presented in Table 3.3.

3.3.4.1. *Perceived time constraints*

A recurring challenge shared by participants was perceived time constraints. Participants who studied and worked full-time found it hard to find the time for exercise. However, despite time being a challenge, participants shared that they will still find time or ways to exercise. Although this was not always the case, with the age demographic of this study being varied, some participants did not find time challenging, as they have now retired and have no caring responsibilities once their children grew up.

3.3.4.2. *Confidence in ability*

Participants commonly reported that confidence in their ability to participate in MSE challenged their participation. This is mainly because they are not sure how to do the exercises and whether they are doing them correctly or not. Therefore, they mainly participated in exercises that they were more confident in.

3.3.4.3. *Accessibility*

Participants also reported that accessibility is a challenge in participation in MSE. This included concerns about the financial cost of gym membership or hiring a personal trainer, as well as limited access to equipment (not enough lighter weights at the gym) and appropriate physical spaces to work out, both at home and in gyms.

3.3.4.4. *Cultural stigma and societal perception*

Another challenge described by the participants was the culture of stigma and societal perception of MSE for women. Participants felt like the gym environment was more male-

dominated and catered towards men, making them feel conscious, uncomfortable and intimidated. They also faced societal perceptions that women do not want to do MSE because they don't want to look big or bulky or risk injury.

3.3.4.5. *Low motivation*

Finally, some participants mentioned that, despite mostly meeting the guidelines, their motivation to perform MSE fluctuated on some days, making it difficult to maintain consistency. They also reflected that when the exercises become easy to do, it reduces their drive to push beyond their comfort zone.

Table 3.3: Barriers to MSE participation.

Codes	Subcodes	Indicative quote(s)
Perceived time constraint	Study and work commitment	<i>"I work full time and I'm doing a PhD. So, I kind of always struggled to find the time for exercise, but I fit it at the moment into my lunch hour."</i> (P01, age 54) <i>"I worked full-time. So, finding a slot where I could do it because obviously with personal training, there's only a certain amount of hours in the day and stuff. But I've now realised that I have to make the time because it's good for me and it's my time."</i> (P07, age 58) <i>"Yeah, it's one of the reasons why I do exercise at home because it can be done quickly. You can do it in maybe half an hour. Whereas at the gym it can take a long time."</i> (P19, age 60)
	Free time and no caring responsibilities	<i>"Before I retired, everything was a challenge because I had no time, and I was too tired. So not having to go out to work has made it very easy for me."</i> (P15, age 60) <i>"Got lucky with that. My children are around 20 to 25...So I don't really have any responsibilities around that anymore. It certainly would've been a bigger barrier years ago, trying to deal with childcare, and you prioritise the children's activities than your own."</i> (P23, age 55)
Confidence in ability	Unsure on how to do the exercises	<i>"I would never go to a gym and use their equipment because I will be thinking, gosh, I've never been to the gym. I don't know where to start. I don't know how to use this (equipment). I'd feel stupid."</i> (P05, age 62) <i>"...we've been away in our motorhome for four weeks. We took all our resistance bands so that we could do our strength training in the van. Well, they never came out. They never got out once...I am not confident with using resistance bands. So, I don't really know how they work. So, I couldn't pick one up and know instantly how to do the exercise."</i> (P17, age 64) <i>"My knowledge of using machines isn't good. So, I tend to go to different classes, whether it's like legs, bums, and tums, or circuits. I supposed my knowledge is recent, not basic. I suppose I would want to get better at identifying proper exercises."</i> (P23, age 55)

Accessibility	Cost	<i>“When I was a student here (university), I got a discount but as a working adult, some other gyms get quite expensive.” (P06, age 24)</i> <i>“I would love to sign up for a PT, but, you know, there’s one thing paying £25 a month for gym membership, but it was close to £25 a session for an hour minimum for a PT.” (P23, age 55)</i>
	Space and equipment availability	<i>“Depends what time you go. It could be that it’s so busy that you just cannot do the exercise that you have planned. And I’m autistic. So, I stick to the plan. And that’s a big challenge. If I can’t do my plan, and there’s a lot of waiting.” (P08, age 44)</i> <i>“At home, the challenge probably needing the equipment for lifting heavier weights. Possibly the environment, the space.” (P19, age 60)</i> <i>“In certain gyms, they have 15kg bars, which for a lot of women, it makes upper body workouts more accessible with a barbell. But some gyms will only have a 20kg bar. For women starting at 20kg is just too heavy.” (P20, age 58)</i> <i>“The weights I’ve got (at home) from lockdown, I want heavier ones, but I’m not going to get it but I’m also not going to get rid of them (the lighter weights). Because it was really hard to get hold of gym stuff during the lockdown and then it was really, really, really expensive. People were selling the most disgusting, rusty kettlebells that had been outside for like three years for like 80 pounds. But at that time, it was just virtually impossible to get hold of anything. But also, I don’t want to get rid of stuff in case we’re confined.” (P22, age 54)</i>
Cultural stigma and societal perception	Male-dominated and oriented and catered towards men	<i>“Sometimes in the weight room, you can imagine the man are all grunting and throwing the weights around and that’s quite just not very pleasant.” (P04, age 47)</i> <i>“When it’s really busy in the gym, I’m not gonna go and park myself in an area of the gym that’s full of men training.” (P09, age 43)</i> <i>“So much of the gym equipment isn’t designed for women. Like racks of dumbbells at 17 and a half, but there’s only one set of 12 and there are loads and loads of 2kg weights. That is patronising towards</i>

		<i>women...I would love to visit a gym that has been designed by women for women and see what it looks like. It doesn't mean everything is pink...One of the reasons I don't like (going to the gym) at six o'clock is it's all regulars. They are very male. They know exactly what they are doing. They monopolise the equipment." (P22, age 54)</i>
	Societal perception of women not needing MSE	<i>"There's a bit of a generation thing as well, because like my mom, in her generation, if you said to her you need to lift weights or do resistance training, they're kind of like, well I don't want big bum. But that's not the point of it." (P02, age 50)</i> <i>"My husband laughed when I told him I was going to do it and his initial thoughts was I was going to look like one of the bodybuilders with the bikini and everything...so I explained to him that I wasn't going to go on steroids and that I am not going to look like that." (P07, age 58)</i> <i>"I think unfortunately, there is still this assumption that it's probably going to change from women doing cardio to now they do yoga and Pilates, and the guys go to the gym. But I think that guys can get an awful lot of flexibility, just as much as women can get an awful lot out of strength...There are also a lot of misconceptions out there about strength where you can damage yourself or that as a woman you can get bulky. People come to me and go, oh, I don't wanna get bulky, and I've said, well, you're a woman, you haven't got the testosterone in your body." (P20, age 58)</i>
Low Motivation	Low motivation to do exercise	<i>"The only challenge I find is motivating myself to do it...with the videos, because I will think, oh, tomorrow I'll do that. Then tomorrow comes and you don't do it for one reason or another." (P05, age 62)</i>
	Low motivation to step out of the comfort zone	<i>"It does get to a point where you tend to do the same things because it's easier. It's harder to motivate yourself to progress on your own." (P19, age 60)</i>

3.3.5. Theme 3: Facilitators to Participating in MSE

This section covers the participants' experiences and facilitators for their continued MSE participation. These facilitators include the usage of information and resources, finding ways to make themselves accountable to do the exercises, having social support, and having choices of location and exercises. As they continued with these activities, they emphasised the benefits that influenced their long-term participation, including the positive changes in their physical and mental health. Table 3.4 presents the indicative quotes that illustrate the codes reported by facilitators for participating in MSE by the participants.

3.3.5.1. *Use of information and resources*

Having resources and information available helped participants. When asking about the kind of resources and information that they used, several examples were given (Table 3.4). For example, some participants explained that having these resources available has helped them to progress in their MSE journey. Others reflected on how they use group exercise classes as a gateway to become more comfortable and confident with exercise.

3.3.5.2. *Accountability*

Participants shared several other ways that made them accountable to do their MSE. Paying for gym membership, classes, or personal trainers helped them to stay accountable to do the exercise, while goal setting, such as aiming to increase strength, being able to lift heavier and look better, helped them to be consistent in their participation in MSE. Creating a routine, for example, by setting a specific time to exercise, was also described as a means to maintain participation amid time constraints.

3.3.5.3. *Social support*

Participants also shared that companionship and support systems help them maintain their participation in MSE. While some participants preferred to exercise alone, others found that having friends or partners to exercise with motivated them and made them more accountable. Words of encouragement from their family and friends have also helped participants continue participating in MSE. Several participants also shared that doing exercises that they enjoyed helped them to continue participating in MSE.

3.3.5.4. *Ability to choose*

Having the ability to choose the exercise location was also a factor that facilitated participants' journey in MSE, as it relates to accessibility and comfort. Participants described that having the gym location nearby and accessible made it easier for them to do the exercise. For the same reasons, several participants chose to exercise at home because it is easier and more convenient for them. The ability to decide to do something they enjoy, such as attending exercise classes, has helped them stay motivated to complete the exercise.

3.3.5.5. *Positive changes*

Participants shared that experiencing positive physical and mental changes reinforced their continued participation. Improvement in physical strength, flexibility, body shape and pain management were highlighted, as were improvements in confidence and mental well-being. For some, MSE became a form of self-care or therapy, offering both psychological and physical benefits, which in turn supported their participation in MSE.

Table 3.4: Facilitators to participating in MSE.

Codes	Subcodes	Indicative quote(s)
Use of information and resources	Using available resources and information	<i>“Having a personal trainer” (P07, age 58, P14, age 62, P20, age 58, P22, age 54, P25, age 64),</i> <i>“Using an application” (P10, age 26, P14, age 62, P22, age 54, P23, age 55, P25, age 64),</i> <i>“Going online such as Google and YouTube” (P05, age 62, P10, age 26, P15, age 60, P18, age 45, P19, age 60, P22, age 54, P24, age 58),</i> <i>“Going to exercise classes” (P05, age 62, P07, age 58, P11, age 63, P16, age 34, P22, age 54, P23, age 55, P24, age 58)</i> <i>“Buying online exercise course” (P17, age 64).</i> <i>“I just found a couple of YouTuber trainers that seemed to resonate with me, seemed reliable to me. And I like really focused on the videos. Actually, the very beginning, it wasn’t even YouTube. It was an article that I looked on Google, and I found the programme and I was following it for a while, then I start seeing how to do things, I would see videos and then eventually I would just watch the videos.” (P10, age 26)</i> <i>“I went to the gym a bit and signed up for a class...I started to go on an organised class to sort of see what it was all about, how I felt, get comfortable with the physical location and see how I felt with the exercises. So, I started doing classes, then I got a personal trainer. Then I moved with that, and I’ve gained more confidence to use all the equipment and free weights myself.” (P22, age 54)</i>
	Group exercise classes	<i>“I used to do that (classes) before I felt confident enough to just go to the gym by myself. But then as soon as I transitioned into that, I just stuck with no classes.” (P10, age 26)</i>
Accountability	Cost	<i>“If you sign up for a class, there’s accountability because you pay the classes involved in the monthly payment and if you cancel, you kind of let yourself down, if that makes sense. If you don’t show up, then it’s kind of like three strikes system then you’re blocked for a week.” (P23, age 55)</i>

		<i>"I'm up north so gym membership isn't expensive. Discretionary spend for some but if I were putting something down, whether it is an essential spend or discretionary, I would put gym membership as an essential spend...I realised the importance of it for my own health and healthy heart, importance of strength training as well." (P22, age 54)</i>
	Goal setting	<i>"I think, psychologically, not making it too difficult. Which is why I only use very light hand weights. Because I know I am not going to be too sore afterwards. I think that I just wanted to be as fit as I can be at this stage of life that I am." (P24, age 58)</i>
	Scheduling	<i>"I was confident enough when I was working to schedule it in my diary, so people knew. I used to have team meetings with my boss, and it started at quarter past nine in the morning, and I asked if we could change it to half past nine so that I could go to the gym, and with that extra 15 minutes, I was less sweaty and flustered and feeling rushed to it. I thought I felt confident enough to say, well if I don't ask, I won't know...So it's being confident saying, this is what I do, this is my time, and sort of scheduling it." (P22, age 54)</i>
Social support	Companionship	<i>"Having a friend to do it with me and not being on my own. Because that gives you a competitive edge to it. Like when you lift something, I always lift more when I'm with my friend. If I was on my own, I'd probably just be like, oh, I'm tired, I am going to leave now, you know. Having a person with you is great and also having someone telling you, you're doing great, and coming up with ideas, oh, we're doing stuff like this." (P08, age 44)</i> <i>"Meeting my friends when I first joined this new gym was brilliant. Because we held each other accountable, you won't want to let them down for not meeting them. That was really helpful." (P22, age 54)</i> <i>"I think I am more motivated that my partner does it with me in the morning on a workday. Because I think, to be honest, if I was in the house on my own, and it was like seven in the morning, I would</i>

		<i>probably just have two coffees. But because he motivated me to do 20 minutes, then I do the 20 minutes and then I have a coffee.” (P24, age 58)</i>
	Words of encouragements	<i>“For me, I would say that I have support at home. I have a very supportive partner. He will look after our child and his support allows me to spend time doing the things that I want to do.” (P04, age 47)</i> <i>“I have a partner who’s very encouraging. Like, if I’m not feeling like going one day, maybe he will push me to go because he knows I would like it.” (P10, age 26)</i> <i>“I think I probably surprised people. My husband said he’s really proud of me because I really sort of stuck at it. I think other people have said, I never saw her at the gym but now every time I go in there, she’s there!” (P25, age 64)</i>
Ability to choose	Exercise	<i>“I like lifting heavy things. I would say I like moving, particularly swinging a really heavy kettlebell or throwing a barbell around. Personally, I found that empowering as a woman.” (P20, age 58)</i> <i>“I think I like being flexible. I like doing things that make me feel flexible. So like getting into weird positions in yoga. For somebody who is 57, I like to think that I am a bit flexible. I also really like the fact that things like Pilates and yoga work quite a lot on your core. But you don’t really get in a sweat or out of breath.” (P24, age 58)</i>
	Location or logistic	<i>“My access to the gym has made it really easy for me. It’s all in my route going to the university, as well as within walking distance. I think if it wasn’t that it would be a bit of a challenge.” (P13, age 34)</i> <i>“It’s convenient and quick. Quicker than having to actually go somewhere. Being able to do it at home is part of why I would do it. It’s not like I couldn’t go to the gym. There’s a local gym. It’s just that I find the gym is not very welcoming a lot of the time.” (P19, age 60)</i> <i>“Motivation is good when I’m in a class because we are doing it together. If I were to do it myself, I don’t think I would do it.” (P11, age 63)</i>

		<i>“The feeling of achievement when I finished the class. I also enjoy it because it’s a group setting. I tried to go to the gym before, I just did not enjoy it. I did not feel motivated to finish the exercise. In the class, I like the structure of the class. I like that it’s like having a personal trainer, but in a group setting...also the motivation side of it when seeing people doing and pushing forward just made me want to do more.” (P16, age 34)</i>
Positive changes	Confidence	<i>“When I started it, I wanted to avoid the pain that I was having and for the state of my body. But now as you study more about the human body, it’s also for the health benefits that you get. When you first started, you were not sure about techniques, so you carried small weights and everything. Your confidence with the practice will then increase and yeah, you go and challenge yourself more. So that’s why it becomes more rewarding, and you become happier doing this stuff.” (P16, age 34)</i>
	Mental health	<i>“I started lifting because my eldest daughter was quite unwell and her psychiatrist said I needed to have counselling, to talk about her mental illness. We talked about it a lot and I couldn’t do that anymore. So, one day I started to go to the gym, and I found lifting heavy deadlifts became my therapy...that was the thing I did because you can’t think about anything else. When you pick something heavy off the floor, you’ve got to concentrate on it, you can’t be distracted, you can’t have any noise in your head, you just have to focus on what you’re doing and be in the moment and be present.” (P20, age 58)</i>
	Positive body image	<i>“...I supposed that kind of secondary benefit is that you look better in your clothes.” (P04, age 47) “My husband says my body shape is now back to what I had in my 20s...I definitely feel stronger, and you know, my body shape has changed considerably.” (P07, age 58)</i>
	Pain management	<i>“I have been diagnosed in the past as having disc degeneration in my lower back. I think it’s probably worse if I don’t exercise. So, I can use it as an excuse (to not exercise), but when I do exercise, it’s actually lessened the pain and much better.” (P19, age 60)</i>

3.3.6. Theme 4: Strategies to improve women's participation in MSE.

This theme refers to participants' advice and strategies to help other women participate in MSE. Strategies were described at both what an individual can do and what others could do to encourage participation in MSE. These strategies show how individual motivation, social, and physical environmental factors, such as women-only spaces, can encourage and maintain an exercise habit. This theme, with its indicative quotes representing the codes, is described in Table 3.5.

3.3.6.1. *What an individual can do*

At an individual level, participants emphasised keeping it simple and using different modalities, such as doing bodyweight exercises, using resistance bands or trying out Pilates and yoga as a start to build their confidence in participating. They highlighted that starting with MSE does not mean it must be done at the gym. They suggested that simple activities using resistance bands or body weight, searching online for how to do strength exercises and examples, can help to build their confidence. For those looking for extra guidance on building confidence and learning the correct way to perform the exercise, participants highlighted that working with a personal trainer or joining an exercise class would be beneficial.

3.3.6.2. *What others can do*

Participants reflected that spreading awareness of the importance of MSE would be helpful. Participants described that emphasising on the health benefits, not just losing weight or gaining strength, would help other women understand that participating in muscle strength is an investment for their future health.

Creating women-only spaces or sessions was suggested as a strategy to reduce feelings of intimidation and self-consciousness in gym environments. Providing kid-friendly classes was also described as beneficial for women with childcare responsibilities, as they can still attend the classes without having to find childcare.

Having more personal trainers who specialise in women's fitness was discussed as important, given that women experience different stages of development throughout their lives,

including puberty, pregnancy, and menopause. Participants also highlighted that looking for online content made by women and that is suitable for people of various abilities would help women get started in MSE. While participants noted the concerns about the reliability of the digital resources, they emphasised that accessible, valid content could help to address accessibility issues such as cost and distance, making participation in MSE more feasible.

Table 3.5: Strategies to improve women's participation in MSE.

Codes	Subcodes	Indicative quote(s)
What an individual can do	Simplicity	<i>"Participating in muscle-strengthening, as I say, doesn't necessarily need to be in a gym. I think that a lot of women have that as a massive stumbling block to approach, signing up for the gym, being in a gym with the environment being male-dominated, and so many things. If they are not confident yet in their knowledge or ability, it's a massive thing to ask them to do...so I think that targeting what people can do at home is a very good point to start." (P13, age 34)</i> <i>"Have some gentle and we're starting off gentle anyway. Because a lot of it is very simple, isn't it? I think when you see these, when you go online, some of these exercises are really simple to do. And people perhaps don't think that they, it's something they might think, "oh, well, I haven't done any exercise for yours. I can't do it." But when you see how simple it's just a matter of, you know, raising your heels and standing on your toes or something as a start. It's very, you know, it's very simple. So, everyone can do it. But I think maybe a lot of people think that it's just not for them." (P05, age 62)</i>
	Using other modalities	<i>"You could do something. I mean, you could get some resistance bands and do things at home as simple as that would benefit your health." (P02, age 50)</i> <i>"Yeah, depends on who you are. Start off slowly. Maybe do a bit of yoga, Pilates, but the things that's really going to make a difference is using weights. And that takes less time. Quicker, more effective. That would be my advice. But again, everybody is different. I know some people prefer just the bodyweight only." (P18, age 45)</i>
What others can do	Spreading awareness	<i>"I guess if people were more educated on how important it is, throughout their life. I think one of the reasons that women get intimidated about it is because of that kind of thing when people are building muscle for the way they look and want to have big biceps, all that kind of stuff. Most women don't want that. That's not a priority for them. They don't want to be big and muscular. I</i>

		<i>think if there was more emphasis on muscle strength and how it helps your overall metabolism, how you burn calories, how you are going to stay strong and not fall over and all that kind of stuff. I think it would improve people's perception of strength training." (P19, age 60)</i>
	Women-only spaces and kid-friendly classes	<i>"I think seeing people like yourself (women) in that space will make you feel welcome." (P04, age 47)</i> <i>"One of my old gyms had a female-only group. I think that was quite beneficial. I mean, because I trained around guys in karate all the time, it doesn't bother me going to the gym full of guys. But yeah, I certainly feel like a lot of people, well, I would still find it assuring when I see other girls around the gym. It is sort of a peer influence." (P06, age 24)</i> <i>"When I first worked as PT, there was a rule that babies could not be on the gym floor. So, you'd have a woman with a small baby, and she was told that she couldn't bring it with a carrycot into the gym. Well, that child is safe in that. They're not gonna come into harm. So, from a safety point of view, there's not an issue, but because there was a rule that you couldn't have a crying baby in a gym or whatever. Equally with my studio here, when I have clients as I am pre and postnatal trained, I've had clients that had children and I will say, well, bring your baby. Because I can coach you and if the baby wakes up, I can hold your baby and I can still coach you. So, you haven't got that added barrier of who am I going to take the baby to for childcare? What is the cost of childcare and the added logistic burden of actually getting the babies somewhere else and then going to pick them up afterwards? They can just go to the gym with the baby." (P20, age 58)</i>
	Women's fitness specialist	<i>"I can tell you from my perspective because I am in a team sport, like a league as well. There's a big thing about being well-informed about perimenopause. We have quite a lot of female focus (trainers) in our league. So, they have been working to raise awareness about perimenopause." (P08, age 44)</i> <i>"I chose my personal trainer very carefully, who understood menopause as well. I think it's the same with new mums. You have to be careful, don't you? Because of your muscles and you are</i>

		<i>getting back to exercise as well. So, it's finding the right group of experts. I think it's really important."</i> (P22, age 54) <i>"I think looking for content, like YouTube content, for example, with women. That way, you can see, because most people at the gym are fit and muscular, so it's good to be able to see a woman. It would help you realise that it's possible. It helps you realise what you can end up looking like. Because obviously, you wouldn't look like a man."</i> (P10, age 26)
	Reliable and accessible resources	<i>"I went on the internet to see how much information is out there for people. If you just googled strengthening exercises, there's tonnes of information, there's tonnes of videos, there's tonnes of posters. So, one of the things I like to think of is whether it is validated. If the information has come from some sort of NHS or academic, I think you can believe in it."</i> (P05, age 62) <i>"There's so much out there. And I don't know if it's true. I can always go by myself (to exercise). And it made me feel stronger, rather than those videos. But of course, I do get sucked into all these videos that say, these five exercises to work on will change your life, and then I do fall for those sometimes. I don't know which one is the best."</i> (P18, age 45) <i>"There's lots of free stuff. People put things on YouTube, who knows what they talk about and are good trainers. You don't have to pay for it. But I do think even if you are paying for it, it's a good thing. It's better than doing nothing at all. And I think maybe if they pay for it, that might motivate them to do it. I know that nobody knows that you pay for it. So, it's not accountable to anyone but yourself. I think maybe that's true. I've never paid for YouTube trainers, but my husband has, and it motivates him to do it."</i> (P19, age 60)

3.4. DISCUSSION

Considering the importance of muscular strength for women, understanding the barriers and facilitators they face is crucial. The study aimed to explore the barriers and facilitators to participation in MSE among women aged 18 to 64 who are currently meeting the muscle-strengthening guidelines, and to identify strategies to improve involvement in these activities. Since many of the themes are interconnected, the discussion is organised according to Sallis's ecological model (Sallis et al., 2006), which frames behaviour across four interacting levels: individual, social environment, physical environment and policy, highlighting the multilevel determinants of women's participation in MSE.

3.4.1. Individual Level Factors

Women's initiation and participation in MSE were shaped by both personal motivations and barriers. Health concerns, particularly for injury prevention or management (e.g., sciatic pain, plantar fasciitis), motivated some women to start MSE. This aligns with Staley et al. (2024), who found that the multi-dimensional impact of injury includes increased awareness of physical vulnerability, decline in strength and mobility, and age-related health concerns. This served as motivation to women in our study to participate in MSE as they experience the physical limitation from injury and realise the importance of maintaining strength as they age. Other women in the current study were motivated by the prospect of improved physical performance in sports. Jones et al. (2025) reported that younger women's (18 to 34 years old) MSE participation was linked to health, strength and endurance improvements. While these women were younger than the current sample and did not yet face the additional age-related health concerns, emphasising the benefits of MSE for health and fitness remains important across the age span. It also suggests potentially different strategies and messaging for MSE participation by age group, such as targeting women when they begin noticing health changes or emphasising the benefits for sport and wider activity participation.

Low confidence in their ability to perform exercises or knowledge of using equipment was a major barrier, consistent with previous literature highlighting the role of knowledge and education as factors impacting women's participation in MSE (Luckin et al., 2021, Petrov Fieril et al., 2014, Heiestad et al., 2016, Vasudevan and Ford, 2022). For example, Luckin et al. (2021) found that of athletes who were asked for reasons why they didn't take part in strength training required for their sport, 58% reported uncertainty about what exercise to

do, how to progress, or proper training and lifting techniques. Similarly, in a systematic review and meta-synthesis of 20 studies ($n = 402$) by Vasudevan and Ford (2022), knowledge gaps were reported as a consistent barrier to participation in MSE for women across different populations, activity status and age groups. To overcome this, participants in the present study utilised resources such as personal trainers, online platforms, or exercise classes to build confidence and knowledge of MSE. Such suggestions are supported by previous research. Indeed, in a 2016 randomised controlled trial, Heiestad et al. (2016) reported significantly higher adherence to MSE among previously inactive, overweight women ($n = 143$) who exercised with guidance from a professional, such as a personal trainer than those who did not. Whilst there are fewer studies on the benefits of digital resources for MSE adherence, especially targeting women's habitual activity, a randomised controlled trial comparing in-person supervision to app-guided support reported similar levels of adherence between the two approaches ($n = 79$; 88.2% versus 81.2% respectively) (Gavanda et al., 2025). Whilst ensuring the credibility of digital resources is an ongoing challenge, the use of such cost-effective resources warrants further investigation.

3.4.2. Social Environment Level Factors

Social relationships were found to shape women's participation in MSE. Witnessing the decline in family members' health motivated some women in the current study to engage in MSE as a preventive measure, consistent with Bandura's (1977) concept of vicarious learning, in which witnessing adverse health outcomes in loved ones motivates preventive health behaviours. Social support also played a crucial role, with women describing that having companionship during exercise and encouragement from family and friends as important facilitators. Exercising with others fostered accountability and made MSE more enjoyable and motivating (through friendly competition). This is consistent with the findings by Vasudevan and Ford (2022), who identified that camaraderie and support from family and friends promoted sustained participation in MSE across a large number of studies.

Cultural stigma and societal perceptions on women and MSE remained significant barriers to women's participation in MSE, as reflected in the current study and prior work (Vasudevan and Ford, 2022, Peters et al., 2019, Burton et al., 2017, Cavill and Foster, 2018). In the qualitative study by Coen et al. (2018) exploring women's perceptions of gyms, it was reported that women felt 'uncomfortable and unwanted' in the gym when the men were

‘taking up the spaces, hogging equipment and being loud’. However, the women in the current study utilised companionship during exercise (from peers or personal trainers) to help empower themselves and to reduce self-consciousness, in these often intimidating, male-oriented gym environments (Coen et al., 2018, Vasudevan and Ford, 2022). Collectively, these findings illustrate that MSE participation is embedded within social environment dynamics, where social support can facilitate participation and overcome cultural stigma and societal perceptions.

3.4.3. Physical Environment Level Factors

Structural barriers related to time, cost, and accessibility significantly impacted MSE participation. Although perceived time constraints reflect individual priorities, they are also shaped by external demands, such as work schedules and caregiving responsibilities. Prior studies consistently identify time as a universal barrier to exercise of any type, regardless of gender (Ashton et al., 2015, Kulavic et al., 2013, Luckin et al., 2021, Hurley et al., 2018), with women, particularly those balancing multiple roles, reporting greater challenges (Ominyi et al., 2025). Vasudevan and Ford (2022) also noted that work and family commitments limit women’s availability to engage in strength training. These structural constraints represent a physical environment barrier rather than solely individual time management issues, highlighting the multilevel nature of influences on participation. Despite this, women in the current study described individual-level strategies that had a positive impact on them and helped to navigate this structural barrier, such as creating a schedule and blocking specific time for exercise. Consistent with the survey findings by Luckin et al. (2021), aligning the training program with personal schedules and preferences can reduce perceived time challenge. The findings highlight that personalised, individual-level adaptations can mitigate potential physical environment barriers.

Accessibility issues related to cost, equipment and exercise space had a substantial impact on participation. Gym memberships and personal trainers’ fees limited access to professional guidance and appropriate facilities, while inadequate space or equipment at home posed additional barriers. These findings align with Vasudevan and Ford (2022), who identified financial barriers, lack of equipment and poor inclusivity of facilities as barriers to participation. Women in the current study highlighted the value of having flexibility in choosing exercise locations, with some preferring nearby gyms for convenience and others

favouring home-based exercise and using freely available digital resources to reduce travel time, cost and social discomfort.

Women in the current study also suggested changes to the physical gym environment, specifically women-only spaces and kid-friendly areas, to overcome some of the individual and social environmental barriers mentioned, such as cultural stigma and societal perceptions. This aligns with Hurley et al. (2018), who found that for college students ($n = 116$), women-only classes or areas in fitness centres reduce feelings of discomfort and support greater engagement in exercise sessions.

3.4.4. Integration Across Ecological Levels and Implications for Future Research

Women's participation in MSE is influenced by interacting factors across multiple ecological levels, with barriers at one level potentially overcome by facilitators in another. For example, a woman motivated to begin participation in MSE due to an injury may be hindered by low confidence in their ability to perform specific exercises (individual). This can be facilitated by social support from a training partner or buddy (social environment), access to professional guidance (social environment and physical environments), and exercising in women-friendly spaces (social environment and physical environments). The multi-level nature of the barriers suggests the need to consider both individual-level determinants, such as confidence and knowledge, and system-level determinants, including social environment and physical environment factors, including accessibility, affordability, and social norms. Whilst the current study identified factors across three ecological levels (individual, social environment, and physical environment), the policy level was not captured in the findings. Future research should investigate how workplace, community, and governmental policies influence women's participation in MSE, aiming to provide a comprehensive understanding across all ecological levels.

These findings also offer practical strategies for both women who are not yet engaging in muscle-strengthening activities and for practitioners and policymakers seeking to increase participation. While some of the barriers and facilitators identified are already well recognised and relevant across genders (perceived lack of time), persistent low levels of involvement among women indicate that current approaches to promote and maintain MSE

activity in women remain insufficient. Future strategies need to encompass wider determinants of behaviour in combination and a system level approach as opposed to focusing on one level of influence. For example, a digital resource is more likely to be successful if it is expert approved and evidence based, and there is also signposting to local, affordable women-only exercise spaces. Viewing these recommendations through the ecological model lens highlights that sustainable change requires multi-level approaches that integrate the individual, social environments, and physical environments.

3.4.5. Strengths and Limitations

While previous research examined the barriers and facilitators to women's participation in strength training (Vasudevan and Ford, 2022), this current study offered a solution-oriented strategies based on the challenges and facilitators faced of those who met the recommended guidelines. By examining the barriers and actionable strategies through the social ecological model, it offers practical insights into how individual, social environment and physical environment factors work together to influence health behaviour.

Nonetheless, certain limitations exist within this present study. The relatively small sample size limits the generalisability of the findings. Additionally, the lack of information about the participants' cultural and ethnic diversity limits the applicability of the findings to women from diverse cultural backgrounds, as their experiences may differ. Participants were predominantly university-educated and resided in the most affluent areas, which may not reflect barriers faced by women from lower socioeconomic backgrounds. In addition, women at different life stages, such as during pregnancy or postpartum, or living with disability, may encounter unique barriers and facilitators to participate in MSE, which is not explored in this study. Future studies should explore the experiences of women across diverse demographic, socioeconomic, and cultural backgrounds to better understand how multiple-level factors shape engagement in MSE. These insights would be valuable in informing more inclusive strategies or interventions to improve women's participation in MSE.

3.5. CONCLUSION

This study provides new insights into the experiences of women who already meet the muscle-strengthening guidelines. While many barriers remain consistent with earlier studies, our findings reveal how women navigated and responded to them through lived experience and solution-oriented strategies at multiple levels of influence, such as scheduling, social support, and building confidence through digital resources and professional guidance. Participants also suggested broader physical environment solutions, such as adapting gym environments, creating women-only spaces, and improving the credibility of digital resources. These findings enhance understanding of women's engagement in MSE by highlighting how individual, social, and physical environments interact to influence participation. Findings suggest that strategies are needed that target all levels of influence to help increase participation in MSE.

CHAPTER 4 – WOMEN IN STRENGTH (WISH STUDY): THE CO-DESIGN PROCESS OF A MULTICOMPONENT MUSCLE-STRENGTHENING EXERCISE INTERVENTION FOR WOMEN

4.1. INTRODUCTION

In the UK, approximately less than 30% of women (compared to 32% to 36% in men) participated in a minimum of two days a week of muscle-strengthening activity (Health Survey for England, 2023, Deakin et al., 2024a, Department of Health and Social Care, 2019). MSE provide substantial benefits for women's health, for example, in the prevention of cancer (Strasser et al., 2013), cardiometabolic disease (El-Kotob et al., 2020, Sundell, 2011), osteoporosis (Hong and Kim, 2018), and frailty (Sundell, 2011). The hormonal changes that occur across different life stages, such as adolescence to puberty, pregnancy, and menopause, emphasise the importance of maintaining muscle strength and mass (Kodete et al., 2024). Given the persistently low participation in muscle-strengthening activities among women despite the health benefits they offer, traditional exercise promotional strategies may not effectively address the challenges to participation. Using a participatory approach, such as co-design, helps gain a deeper understanding of the challenges and facilitators and to develop an intervention aligned with people's real-life experiences.

Over the years, the use of co-design methodology in promoting public health and physical activity participation has gained increasing attention. Co-design is a participatory approach that involves incorporating the insights of the targeted population when creating new plans or strategies for improvement (Vargas et al., 2022). Unlike the traditional top-down strategy often used in public health intervention (Leask et al., 2019), previous literature has shown that incorporating participants in the intervention design enhances the relevance, acceptability and sustainability of the intervention created (Frank et al., 2014). These interventions provide better service quality (Crawford et al., 2002), higher participant satisfaction (Martin et al., 2005) and are ultimately more effective (Durand et al., 2014).

For example, in Families Moving Together, a community-based physical activity intervention co-designed with low-income mothers of preschool-aged children, community leaders, and physical activity experts explored the problem, potential solutions, and designed

an intervention aimed at increasing school readiness and health (Dlugonski et al., 2024). This program emphasised the importance of overcoming physical inactivity for female caregivers and children, which is crucial to breaking the generational cycle of physical inactivity that can impact the health of children (Dlugonski et al., 2024, Hesketh et al., 2019). In 2017, Verloigne et al. reported the use of a co-design approach to promote physical activity in adolescent girls in vocational schools (Verloigne et al., 2017). The rationale of involving the girls themselves in the creation of the intervention was that it was more likely to increase engagement in physical activity (Verloigne et al., 2017, Greenhalgh et al., 2016). The co-designed intervention was then tested with 229 adolescent girls. (Verloigne et al., 2017) with the co-design approach leading to significant improvements in self-efficacy (+0.34 for intervention school; -0.57 for control school on a 5-point scale) and minutes spent in extracurricular sports participation (+0.36 min/day for intervention school; -0.11 min/day for control school) (Verloigne et al., 2017). The use of the co-design approach was positively accepted by the target group and was feasible to promote physical activity among adolescent girls (Verloigne et al., 2017). These principles of including the target group and their lived experience underpin the current study's usage of the co-design methodology to develop a MSE intervention grounded in women lived experiences.

The development of health behaviour interventions should be informed by both evidence and stakeholder perspectives to enhance their relevance, acceptability and implementation potential. The Medical Research Council (MRC) framework for developing and evaluating complex interventions highlights the importance of systematically identifying the problem context, drawing on existing evidence, and involving relevant stakeholders during intervention development (Skivington et al., 2021). As several interventions have sought to increase participation in MSE more broadly (Ashmead and Bocksnick, 2002, Arikawa et al., 2011, Seguin et al., 2012, Heiestad et al., 2016, Prieto-Prieto et al., 2022), this approach is particularly relevant to promoting MSE in women, given the limited interventions specifically co-designed with women to improve MSE participation.

The current chapter builds on the work presented in Chapters 2 and 3. In Chapter 2, a survey was conducted among UK adults aged 18 to 64 to explore participation in different types of muscle-strengthening activities and to examine differences between the sexes in the types of muscle-strengthening activities they participated in. Given the gap in participation between

men and women (women are less likely to participate) in MSE, follow-up interviews (Chapter 3) were conducted and described in Chapter 3 and involved discussions with women who engaged in MSE at least twice a week. These women shared that health concerns and sports performance as key reasons for initial participation in MSE. Barriers to participation included perceived time constraints, low motivation, cultural stigma and societal perception, limited confidence in ability and accessibility. Facilitators that supported participation included access to resources or information, accountability, social support, the ability to choose exercises and seeing positive changes. These findings highlight that gaining insight into women lived experiences through co-design would lay the groundwork for a practical, relevant, and sustainable MSE intervention. Therefore, the aims of the current chapter are (1) to explore the challenges and potential facilitators to participation in muscle-strengthening exercises among women who did not meet the muscle-strengthening activities guidelines and (2) to co-design a MSE intervention to assist women's participation.

4.2. METHODS

4.2.1. Study Design

This qualitative study employs a descriptive, non-experimental design, utilising the Participatory Appreciative Action and Reflection (PAAR) approach to the co-design process (Ghaye et al., 2008). The study follows the Leask et al. (2019) framework for utilising participatory methodologies in the co-creation and evaluation of public health interventions and reports where possible on these principles and recommendations. This study was approved by the College of Medical, Veterinary and Life Sciences Ethics Committee at the University of Glasgow (Reference Number: 200230238) (Appendix 3-A) and adhered to the Declaration of Helsinki. Prior to participating, all participants provided written informed consent for participation and publication by signing a consent form. This study benefited from an interdisciplinary team. The principal researcher, NR (female, BSc, PhD student), has a background in Sports Science and specialises in women's fitness. GR (female, PhD, senior lecturer) specialises in women's personal training and holds a qualification in group exercise delivery, with over 25 years of experience in physical activity research. SG (male, PhD, professor) specialised in muscle and metabolic health, with over 20 years of experience in exercise physiology research.

4.2.2. Participants Recruitment

Using a purposive sampling method, participants who had completed the previous Muscle-Strengthening Participation Survey (Chapter 2) and expressed interest in participating in follow-up research ($n = 34$) were contacted by email to participate in the workshop. Additional participant recruitment was carried out through promotional posters on neighbourhood applications (Nextdoor), and Microsoft Viva Engage at the University of Glasgow. To be included, women had to be aged between 18 and 64 years old, living in Glasgow, Scotland, and self-report not participating in MSE for two or more days a week (i.e. not meeting the current guidelines). No sample size calculation was employed in this study, but the aim was to include at least 6 to 12 participants in each session as suggested by Onwuegbuzie and Collins (2007). While there are no exact guidelines for qualitative research sample size, Sandelowski (1995) suggested that the sample size should be sufficiently small to yield in-depth analysis while remaining large enough to generate rich and meaningful data. Participants were compensated with a £20 Amazon voucher for their time after completion of the workshop. Participant information sheets, consent forms, and recruitment poster are provided in Appendix 4-A to 4-C.

4.2.3. Co-Design Workshop

Two separate co-design workshops were held with a choice of morning or evening sessions. The principal researcher (NR) was responsible for the planning and organisation of the workshops, preparation of the workshop materials, delivery of the workshop presentations, facilitation of discussion, coordination of activities with support from the research team and student volunteers from the University of Glasgow and oversight of the data collection procedures throughout the sessions. The content of the workshop was guided by the findings from Chapter 3 on the barriers, facilitators and suggestions for MSE participation by women who meet the muscle-strengthening activity guidelines and was further discussed and refined by the research team (NR, GR and SG). Each workshop session was two hours long and took place in the BHF Glasgow Cardiovascular Research Centre, University of Glasgow, in June 2024.

Participants were considered stakeholders in the co-design process because they represented the target group for the proposed MSE intervention. Their lived experiences and perceptions regarding MSE were considered essential for informing the development of an acceptable and relevant intervention. Before the workshop began, participants were introduced as

stakeholders in the co-design process, alongside the researcher, and the aim and expectations for the participants during the workshop were explained. The consent form and demographic data, including age, postcode (for deprivation categories as explained in Chapter 3), working status, academic level, and marital status, were collected via a paper form to characterise the workshop sample and to explore the diversity of perspectives represented within the discussions.

The full content of the co-design workshop is detailed in Table 4.1. The workshop consisted of three topics, each with six group activities (two in each topic), to promote participation by participants and researchers, and was guided by a PowerPoint presentation. Participants engaged in activities within small breakout groups (2–5 participants), during which researchers facilitated and supported discussion as required. Small-group discussions encouraged active participation, facilitated interactions, and allowed all participants to contribute their views (Benz et al., 2024). The research team facilitated and supported discussions as needed, while also allowing participants to lead conversations and generate ideas together. The co-design approach allows for the participants and research team to learn from one another. For example, the research team gained deeper insights into participants' experiences with MSE, and participants expanded their knowledge of MSE. This was followed by a whole-group discussion reflecting on the key messages emerging from each breakout group.

The workshop focused on three main topics: participants' experiences with MSE (Topic 1); exploring challenges, facilitators, and motivations for improving participation in MSE (Topic 2); and designing and developing an MSE intervention (Topic 3). Participants were provided with an individual worksheet for each activity, along with sticky notes and markers, to record their answers and participate in discussions. The workshop content was intentionally structured to progress from exploring participants' experiences with MSE, to identifying the barriers, facilitators and motivations for participation before collaboratively generating ideas for the intervention design. This sequence was designed to ensure that the intervention suggestions were informed by participants' experiences and perceived needs.

A post-workshop survey, via Qualtrics Ltd., was sent out one week after the workshop to gather feedback on participants' experience with the workshop. Participants were asked a

series of questions which includes the rating of their overall experience with the workshop, what they liked the most and what they liked the least from their experience, do they find the workshop useful, rating of their understanding of muscle-strengthening exercises before and after the workshop, if they tried to do MSE in the past 7 days (frequency and types) and suggestion for workshop improvement. The post-workshop survey question is attached in Appendix 4-D.

Table 4.1: Overview of the co-design workshop content.

Topic	Objective	Tasks
-	Introduction	Introduce the stakeholders, explain the aim, outline what is expected from the participants and researchers, and establish ownership by branding the co-creators as the Women in Strength (WISH) Team.
Participants' experiences related to MSE	Topic 1: Getting to know MSE - To understand how the participants conceptualised MSE - To explore if the participants are aware of the benefits of MSE. - To educate on how muscular strength evolved throughout the lifespan.	Group activities: <i>Activity 1:</i> Draw what MSE look like to you. <i>Activity 2:</i> How do you think MSE benefit women? Researcher's tasks: Demonstrate examples of MSE, upskill participants on the benefits of muscle-strengthening activities, and explain how muscular strength evolves throughout the lifespan.
Exploration of challenges, facilitators, and motivators to improve participation in MSE	Topic 2: Challenges, facilitators and motivators to MSE participation - To understand the challenges of participation in MSE. - To identify methods to overcome those challenges. - To introduce behaviour change techniques (scheduling) to participants to incorporate MSE into their routine.	Group activities: <i>Activity 3:</i> Discuss the challenges that you faced in participation in MSE and list possible ways you think would help you overcome these challenges. <i>Activity 4:</i> Create an alternative schedule and identify where you can possibly fit MSE in your day. Researcher's tasks: Ask the participants to list the challenges and facilitators and then showed them the challenges and facilitators from the follow-up interviews (Chapter 3). Share the online tools for participation (paid and free options) that were previously

		suggested (Chapter 3). Introduce to the participants to methods to help fit exercises into their daily routine.
Design and Development of a MSE Plan	Topic 3: Build your MSE plan • To introduce MSE variations to the participants, including ways to modify, begin and progress (progressive overload). • To teach participants how to incorporate these exercises into their daily routine. • To design an exercise plan with the participants.	Group activity: <i>Activity 5:</i> Demonstration of upper and lower body MSE using different methods (bodyweight, resistance bands, household items). <i>Activity 6:</i> Create a MSE plan that you think you would like/prefer to do. <i>Vote your preferences</i> Researcher's tasks: Demonstrate several exercise examples while encouraging participants to try, provide feedback on how they feel, and share their preferences. Encourage questions and answers during the discussion. Provide several pictures of different types of MSE and ask them to create an exercise plan that they think is doable (consider the frequency, methods of exercise, logistics) Explore the logistics of MSE that they prefer (i.e. exercising in a group or alone, at home or outdoor, etc.).

4.2.4. Data Collection

Data were collected using individual worksheets, comments and images written or drawn on sticky notes, written notes from the research team during whole group discussions and reflective notes kept by the research team throughout the workshops. Immediately after each workshop, a researcher debrief was held (1hr) to discuss the data collected during the workshop, adding in additional comments and thoughts to the reflective notes, with a consensus summary of the key points created.

4.2.5. Data Analysis

The qualitative data are reported following the PRODUCES reporting guidelines (Leask et al., 2019) (Appendix 4-E). The descriptive statistics of the participants' demographics were generated using Microsoft® Excel V.16.98 (Microsoft Corporation, Redmond, WA, USA). Results are presented as *n* (%). The data from the worksheets and sticky notes were entered into Microsoft® Excel V.16.98 (Microsoft Corporation, Redmond, WA, USA) and cross-tabulated with the predefined topic of the workshop activity by NR. NR and GR then met in several iterative sessions (5 hours in total) to compare these with the summaries of the reflective notes and to create an initial list of potential intervention elements. The initial list of intervention elements was created by examining convergence across data sources (workshop input and reflective notes), participant emphasis, and their relevance to the research aim. During this stage, preliminary feasibility was also assessed to determine whether the emerging components were practical to implement and accessible. NR and GR then met with SG, who was presented with these initial findings, and discussions (2 hrs) ensued until full agreement was reached and the final key elements of the co-designed intervention were confirmed. The decision-making process involved evaluating the relevance of each proposed intervention component against participant input and resource requirements. The post-workshop survey results were entered into Microsoft® Excel V.16.98 (Microsoft Corporation, Redmond, WA, USA) and are presented descriptively as *n*.

4.3. RESULTS

4.3.1. Participant Characteristics

The demographic data of the participants are displayed in Table 4.2. Thirty-five participants signed up for the workshop sessions, where $n = 4$ were recruited from the previous survey (Chapter 2), and $n = 31$ were newly recruited ($n = 15$ for the morning session and $n = 20$ for the evening session). Twenty-one participants ($n = 7$ for the morning session and $n = 14$ for the evening session) were included in the analysis, with the main reason for dropout being unable to attend the session (Figure 4.1). Most of the participants were aged between 18 and 30 years (48%), lived in the least deprived area (33%), were full-time students (62%), held a university degree (86%), and were single (57%).

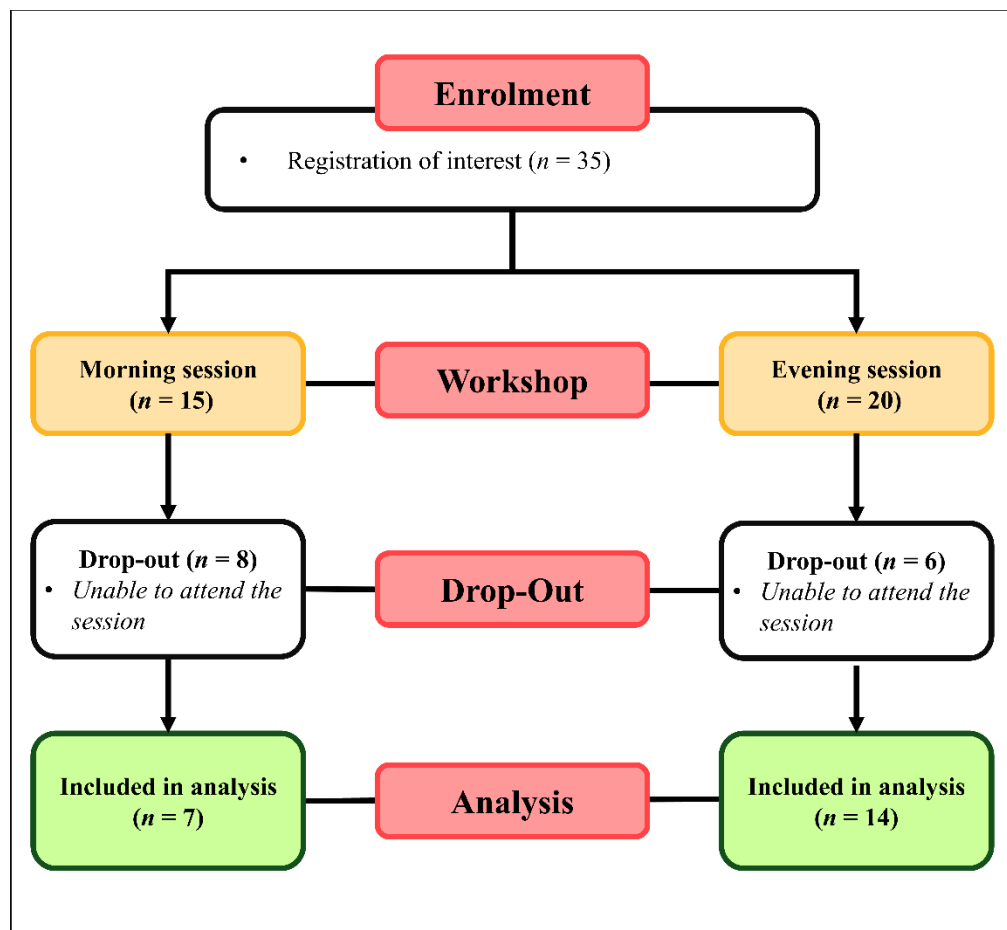


Figure 4.1: Participant flow chart.

Table 4.2: Demographic characteristics of participants.

	Participants <i>n</i> = 21 (%)
Age Group	
18 to 30 years old	10 (47.6)
31 to 47 years old	8 (38.1)
48 to 64 years old	3 (14.3)
Deprivation Category	
Most deprived	4 (19.0)
2 nd most deprived	5 (23.8)
Median quantile	3 (14.3)
2 nd least deprived	2 (9.5)
Least deprived	7 (33.3)
Working Status	
Full time student	13 (61.9)
Employed or self employed	6 (28.6)
Doing unpaid work	1 (4.8)
Unemployed	0 (0)
Retired	1 (4.8)
Academic Level	
No formal qualification after school	1 (4.8)
Trade, technical certificate, apprenticeship or diploma	2 (9.5)
University degree or higher	18 (85.7)
Marital Status	
Single	12 (57.1)
Married (without children)	4 (19.0)
Married (with children)	4 (19.0)
Divorced/Separated (with children)	1 (4.8)

The deprivation category is based on the quintile of the index of multiple deprivation (IMD). The full category of working status is as follows: 1) Full-time student, 2) Employed or self-employed, 3) Doing unpaid work (for own or family business/volunteering/looking after family or home), 4) Unemployed (looking for a job/unable to work due to illness or disability), 5) Retired, 6) Not specified.

4.3.2. Co-Design Workshop Outcomes

Workshops revealed that participants were aware of what MSEs are and their benefits and were able to list several challenges and potential facilitators they identified that could help them to participate in MSE. The completed worksheets from the workshops are included in Appendix 4-F. The participants' challenges and potential facilitators to assist participation in MSE were classified into five categories, which were (1) routine and prioritisation, (2) knowledge and self-efficacy, (3) physical and psychosocial, (4) cultural stigma and societal perception, and (5) accessibility and environment (Table 4.3).

Table 4.3: Summary of the challenges and potential facilitators that can assist in participation in MSE, directly extracted from participants' worksheet outputs.

Categories	Challenges	Potential Facilitators
Routine and Prioritisation	• Lack of time • Other priorities (study, work, childcare) • Being consistent • Life gets in the way • Weather • Lack of structure • Increase friction (having to change clothes, pack a bag, shower)	• Better time management • Creating a routine or schedule and intentionally blocking the time • Breaking the exercises into smaller chunks throughout the day • Making muscle-strengthening a non-negotiable habit by calling it a self-help session • Having a tracker • Joining exercise classes • Removing friction (pre- and post-preparation)
Knowledge and Self-Efficacy	• Lack of knowledge • Not knowing where to start and what the right exercises are • Not knowing how to use the equipment, correct posture and what weight to start with • Fear of doing it wrong and fear of injury • Fear of making a huge error or making things worse	• Getting instructor help • Female-focused resources based on level (beginner, intermediate and advanced) and stage of life (example: menopause) • Knowing the benefits of muscle-strengthening exercises • A non-competitive class
Physical and Psychosocial	• Pain and discomfort from exercises • Having an injury or illness • Depression • Lack of motivation, boring	• Choosing the exercise that you enjoy • Having an accountability buddy or coach • Being able to see visible or measurable results • Getting encouragement or support

	• Laziness and phone distractions • Lack of visible results • Smell and sweat aversion	• Having fun group exercise classes
Cultural stigma and societal perception	• Stigma for women exercising (example: MSE are not important for women), male bias or stereotypes. • Feeling embarrassed and being judged • Fear of being watched and stared at • Cultural differences (example: male and female participation, clothes)	• Having a safe and supportive environment • Women-only gym or club • Peer support • More female coaches • Having an exercise partner or going to the gym with friends
Accessibility and environment	• Limited finance and affordability (example: cost of gym membership and at-home equipment) • Lack of space at home	• Having more affordable options (using cheaper modalities such as resistance bands and reduced gym membership) • More community spaces • Paid or free classes or sessions

4.3.3. Co-Design Intervention

A programme theory was developed, guided by the previous interview with women who do MSE (Chapter 3) and the outcomes of the co-design workshops. Figure 4.2 illustrates the relationship among the problem, potential intervention components, and outcomes.

The participants agreed that flexibility and autonomy surrounding the MSE delivery should be provided to women to support their engagement in MSE. In this context, flexibility refers to the ability to perform MSE according to participants' schedules and circumstances, while autonomy refers to having personal choice and control over which type of MSE is performed, and how, when, and where. Given the diverse priorities that women face, such as studying or working full-time and caring responsibilities, having the ability and flexibility to choose both the type and location of exercise was considered essential. The participants agreed that the intervention should not be restricted to specific exercise types, such as traditional resistance training with barbells and dumbbells, but that women should be able to select from a broader range of MSE, including bodyweight exercises, resistance bands, and holistic exercises such as Pilates or yoga. Offering flexibility to choose the exercise location, whether at home, a gym, or exercise classes, was also reported as essential to accommodate different lifestyles (i.e., work, study or family commitment) and preferences (i.e., exercising in a group setting, with a personal trainer or alone). This flexibility in scheduling and planning was also considered important for supporting the development of routine. In this context, routine refers to a personally structured and repeatable pattern of MSE participation, where the participants plan specific days and/or time for exercise in a way that is consistent enough to support habit formation but flexible enough to accommodate changing weekly demands.

Three key elements were identified as necessary components of interventions to improve women's participation in MSE. These elements were prioritised based on their recurrence across the data sources, perceived importance to participants, and feasibility for implementation in a real-world setting. These elements were (1) education (strength education session), (2) flexibility and social (online support group and optional group exercise session) and (3) modalities (access to various modalities and logging the training).

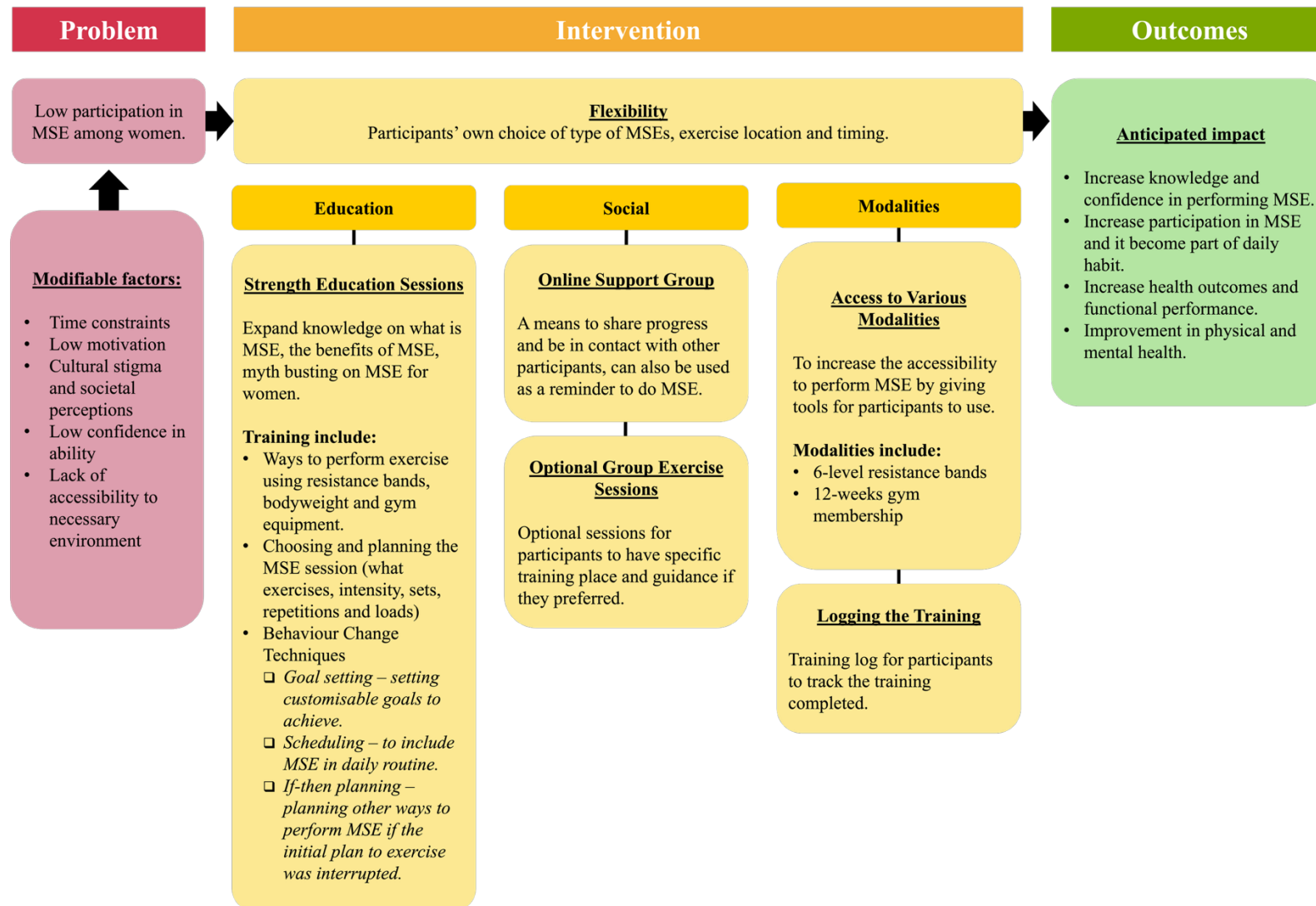


Figure 4.2: Programme theory of the co-designed intervention. MSE: muscle-strengthening exercises.

Key Element 1: Education

Potential intervention component: Strength Education Sessions.

The participants emphasised the need for an education session at the beginning of the intervention to improve knowledge and self-efficacy in performing MSE. This would provide an opportunity to establish an evidence-based foundation for communicating the benefits of muscle strength across the lifespan, correct misconceptions about MSE among women, and increase understanding of what constitutes an MSE. Providing a variety of achievable options for MSE beyond traditional heavy lifting may also help women feel more capable and confident about getting started. The participants believed that many women may not feel motivated or equipped to engage in MSE if they lack this foundational knowledge. The participants also agreed that introducing and implementing behaviour change techniques (BCTs) that address both motivation and challenges were crucial to getting women started and encouraging continued participation in MSE. The BCTs discussed included scheduling, action planning and goal setting. These techniques were viewed as supporting the establishment of a regular, structured pattern of MSE participation, in which exercise is integrated into a predictable daily routine that fits their lifestyle. Creating a schedule and action plan for specific days and times to do the exercises was considered an important facilitator. This is linked to the earlier emphasis on having the choice to do the exercises that fit their lifestyle.

Key Element 2: Social

Potential intervention component: Online Support Group

The participants emphasise that social support is necessary to support motivation and accountability for participating in MSE. Many described that having an accountability buddy or group would help them to follow through, particularly during periods of low motivation or a busy schedule. An online messaging platform (i.e., WhatsApp) is practical and accessible, enabling participants to communicate with one another and with the researcher. It is also intended to create a sense of community and a place to share information and opinions about the exercises, without imposing additional time or travel demands.

Potential intervention component: Optional Group Exercise Session

Although preferences for exercise may differ (e.g., some participants prefer to exercise alone, whereas others prefer to exercise in a group), participants indicated that a group exercise session could complement the educational sessions. While flexibility in when, where, and how MSE is performed was considered essential, a structured group could enhance exercise motivation, provide structure for incorporating MSE into their routine, and support continuous learning (e.g., exercise techniques). These sessions were considered beneficial, particularly in the early stages of the intervention, when confidence and skill acquisition remain low. Having a guided exercise session tailored to skill levels can reduce anxiety and fear of performing the exercise and increase confidence and enjoyment. Furthermore, participants could ask questions and get direct feedback on their performance.

Key Element 3: Modalities

Potential intervention component: Access to Various Modalities

The participants highlighted that having an inclusive environment and affordable resources is essential to assist women's participation in MSE. Many women found that the gym environment often felt intimidating, especially for beginners. One common deterrent cited was that the gym felt like a male-dominated space. To address this, participants suggested that having a peer support or exercise partner, as well as a women-only gym or sessions, would help women try out MSE. For affordable resources, participants noted expensive membership costs and the need to buy equipment for home use. The participants suggested offering more affordable membership or a free trial membership, such as a 12-weeks gym membership, to encourage women to visit the gym. The participants agree that, even with these things accounted for, not all women may like the gym and that introducing resources and alternatives to gym-based exercises, such as using resistance bands and performing exercises at home, would be beneficial. These resources are particularly important for women who prefer to exercise privately at home and for those with busy schedules.

Potential intervention component: Logging the Training

To further support exercise motivation, participants also suggested that tracking or logging training sessions could reinforce consistency. Logging completed training may serve as a reminder to perform the exercise and provide a visual record of progress throughout MSE.

4.3.4. Experiences with the Co-Design Process

Of 21 participants 10 participants completed the post-workshop survey. Overall, participants responded positively to the workshop ($n = 8$ extremely satisfied; $n = 2$ somewhat satisfied). As a result of participating in the workshop, eight participants began incorporating MSE into their routine. Participants shared that the co-design workshop allowed them to feel heard and meet women with similar experiences. This helped them to identify ways to overcome the challenges they faced. Further information is available in Appendix 4-G.

4.4. DISCUSSION

This chapter presents the results of a co-design process to inform interventions to promote MSE among women who do not meet the muscle-strengthening guidelines. Through co-design workshops, participants informed the modifiable factors (challenges and potential facilitators), and suggested intervention components and how it should be delivered. Overall, participants in the co-designed workshop were aware of what MSEs are and their benefits. The challenges and potential facilitators discovered were classified into five categories, which were (1) routine and prioritisation, (2) knowledge and self-efficacy, (3) physical and psychological, (4) cultural stigma and societal perception and (5) accessibility and environment. The challenges and potential facilitators that emerged were similar to those of women who meet the MSE guidelines, as explained in Chapter 3. Based on the challenges and potential facilitators, three key elements were identified: (1) education (strength education session), (2) social support (online support group and optional group exercise session) and (3) modalities (access to various modalities and logging the training). Combined, these have led to the creation of a programme theory that can be used for the development of MSE interventions moving forward.

Having choices in exercise type or location also emerged as an essential factor in helping women participate in MSE. Having the flexibility to choose and change a preferred MSE means women can choose something they are more likely to enjoy which may lead to increased and sustained participation. Hagberg et al. (2009) explored the importance of exercise enjoyment in health-care-based interventions to promote physical exercise among 102 patients and found that enjoyment of the exercise can facilitate increased exercise adherence. Lakicevic et al. (2020) explored novelty as a key factor for maintaining physical activity and agreed that introducing new exercises or varying familiar routines can boost

participants' interest and enjoyment. This, in turn, can lead to greater adherence and improved health (Lakicevic et al., 2020). As this present study and Chapter 3 of the current thesis have explored the challenges and facilitators among women who did and did not engage in MSE, participants agreed that an intervention to improve women's participation in MSE should include flexibility in choice and timing to accommodate varying schedules.

The identified key elements offer valuable insights into understanding what women need to participate in MSE. Comparing with the findings from Chapter 3, the facilitators and suggestions to improve women's participation in MSE offered by women who did MSE were similar to those suggested by the participants in this current study. Knowledge, or the lack of it, often emerged as the main challenge and a facilitator of exercise participation (Luckin et al., 2021, Petrov Fieril et al., 2014, Heiestad et al., 2016). To overcome this, an education session on the benefits of the exercise, how to perform it, and how to plan it would encourage women to engage in MSE. As previously discussed in Chapter 3 and in prior research, an education session would allow participants to increase their knowledge, thereby boosting their confidence and self-efficacy (Luckin et al., 2021, Petrov Fieril et al., 2014). Both groups of women (those who engaged in MSE and those who did not) emphasised the importance of education. To encourage participation in MSE, interventions should incorporate educational sessions that introduce these exercises and equip women with strategies to increase their involvement using different BCTs.

In line with the flexibility in the choice of exercise and location, the following key elements that were agreed upon were social and modalities. Previous findings from Chapter 3 also noted that these factors facilitate participation in MSE. In previous study by Coen et al. (2018), it was reported that women often felt uncomfortable and unwanted in the weight area of the gym. Hurley et al. (2018) reported that creating a women-only space or session would help to mitigate this challenge. Participants in the current study agreed that having a women-only space or session would help them try MSE. Still, it is essential to remember that preferences may differ, and some women may not like exercising in a group setting or at the gym. In regard to modalities, providing a variety of resources, such as resistance bands, would help them participate in MSE outside of the gym setting. In a systematic review and meta-analysis of 8 studies by Lopes et al. (2019) on the effects of resistance bands and conventional resistance exercises (i.e., machine-based and free weights), the authors

concluded that resistance bands can also promote similar strength gains. Interventions to improve women's participation in MSE should consider the inclusion of resistance bands and other equipment that can be used at home or in non-gym settings to offer flexibility in terms of exercise choice and timing to do the exercise, due to their practicality and as a cost-effective choice (Lopes et al., 2019, Lopes et al., 2018).

Several strengths and limitations emerged from the current study. The key strength of this study is the use of the co-design methodology, which allows women to actively contribute to identifying challenges and to create an intervention based on their experiences. To our knowledge, this is the first study to apply the co-design approach specifically to women who do not engage in MSE, thereby addressing a key intervention group. The workshops encouraged discussion among participants and the researchers, ensuring that the intervention aligns with participants' real-life experiences and reflects the researcher's expertise in MSE. With the participants' age group ranging from 18 to 64, this allowed for a better understanding of the different life stages these women faced and how these may influence their participation in MSE. However, this current study is not without limitations. Only two workshop sessions were delivered with similar activities in both. Leask et al. (2019) suggested multiple meetings to allow for refinement and enhancement of the intervention component. Whilst the findings from this study and the programme theory can provide a starting point for other studies and interventions exploring MSE in women who do not meet the guidelines, there is a need to confirm these findings in different populations and contexts. The co-design was conducted in the United Kingdom, with demographic data showing higher participation among those aged 18 to 30, living in the least deprived areas, and holding a university degree, and with no ethnicity data, further research is necessary to evaluate these findings in other populations. Another limitation is that the final intervention components were not sense-checked with participants, which is a key stage in intervention development (Skivington et al., 2021), although this is explored further in Chapter 5.

4.5. CONCLUSION

In conclusion, the present study employed a co-design approach to develop a muscle-strengthening intervention that reflects women lived experiences, accounting for their challenges and potential facilitators. The key components of future interventions in women who do not currently meet the MSE guidelines should include education sessions to improve

participants' knowledge, confidence and self-efficacy in performing MSE, social support through an online support group and optional group exercise sessions to foster a sense of community and accountability while providing continuous learning and modalities such as access to various modalities such as offering gym membership and resistance bands as enablement to exercise and logging the training to monitor progress and support exercise motivation. By including the target group in the intervention design, this study contributes to the development of MSE interventions that are both behaviourally informed and contextually meaningful.

CHAPTER 5 - WOMEN IN STRENGTH: FEASIBILITY, ACCEPTABILITY AND EFFECTIVENESS OF A PILOT RANDOMISED CONTROLLED TRIAL OF A CO-DESIGNED MUSCLE-STRENGTHENING EXERCISE INTERVENTION FOR WOMEN

5.1 INTRODUCTION

There are numerous well-established benefits to participating in MSE specifically for women. Research has shown that these activities can improve women's reproductive health outcomes (Sabag et al., 2024), reduce the risk of osteoporosis, sarcopenia and frailty (Sundell, 2011, Hong and Kim, 2018), and alleviate postpartum depression and anxiety (Deprato et al., 2025). Women experience earlier bone and muscle mass decline than men due to the hormonal changes associated with menopause (Kohrt et al., 2004, Montero-Fernandez and Serra-Rexach, 2013), making them at higher risk of functional decline as they age. Yet, recent data from the 2021 Health Survey for England and the 2023 Scottish Health Survey reported that less than 30% of women (compared to 32% to 36% in men) meet the recommendations for participation in muscle-strengthening activities from the UK Physical Activity Guideline (Health Survey for England, 2023, Deakin et al., 2024a, Department of Health and Social Care, 2019). Taken together, these findings highlight the urgent need for strategies to help women begin and maintain their participation in MSE.

Numerous studies have explored challenges and facilitators to participation in MSE. Over the years, time constraints have often been cited as a challenge to participation (Ashton et al., 2015, Kulavic et al., 2013, Luckin et al., 2021, Hurley et al., 2018). However, evidence suggests that this barrier can be mitigated when MSE programs are designed to align with women's schedules and personal exercise preferences, thereby increasing feasibility and adherence (Luckin et al., 2021). In addition to time-related barriers, low confidence or knowledge in performing MSE exercises are also cited as factors that negatively influence participation (Luckin et al., 2021, Petrov Fieril et al., 2014, Heiestad et al., 2016). Educational support and clear instruction have been proposed as practical solutions to this challenge, as improving knowledge can enhance confidence and self-efficacy, which in turn supports sustained engagement (Petrov Fieril et al., 2014, Luckin et al., 2021, Hurley et al., 2018).

Sociocultural barriers further compound these practical challenges. For example, Velija and Kumar (2009) found that adolescent girls often perceive weightlifting as a ‘masculine’ activity. Similarly, Vasudevan and Ford (2022) systematic review and meta-synthesis of 20 studies reported that gender-based stereotypes and social stigma continue to deter women of all ages from participating in resistance training (Peters et al., 2019, Burton et al., 2017, Cavill and Foster, 2018). These perceptions are reinforced by gym environments that are frequently described as male-dominated, leading many women to feel uncomfortable, unwelcome, or self-conscious in weight-training areas (Vasudevan and Ford, 2022, Coen et al., 2018). To address this barrier, the provision of women-only classes or designated spaces within fitness centres has been suggested as a strategy to create more supportive and inclusive environments, thereby reducing discomfort and promoting participation (Hurley et al., 2018).

Building on these insights from previous literature, Chapter 3 of the current thesis explored the challenges and facilitators faced by women who engage in MSE for two or more days a week. They shared many of the main challenges identified in the previous literature, including perceived time constraints, low confidence, and discomfort in the gym during exercise, as well as facilitators such as being accountable, having the ability to make choices, and utilising available resources. The suggestions for improvement, such as adapting gym environments, creating women-only spaces and validating online resources, were also in agreement with previously proposed solutions. This was then harnessed in Chapter 4 to co-design an intervention to help women participate in MSE. This co-designed workshop with women who did not do MSE revealed similar challenges and potential facilitators suggested by participants in Chapter 3. These insights, from both women who met and did not meet the recommended guidelines, informed the co-design of a tailored intervention based on their lived experiences. The current chapter builds directly on this work by piloting the co-designed intervention.

When aiming to improve participation in physical activity, complex interventions are often required, which involve multiple interacting intervention components. A complex intervention explores how it works toward its intended outcome but also identifies its impact, assesses the process and resources needed, and how it can be translated to real-world practice (Skivington et al., 2021). In the 2021 Framework for Developing and Evaluating Complex

Intervention by the Medical Research Council (MRC) and National Institute of Health Research (NIHR), the second phase following the intervention development is the feasibility phase, where the feasibility and acceptability of the intervention created is tested, as these would provide information about the population targeted, recruitment, adherence and fidelity of the intervention, which will then inform intervention refinement (Skivington et al., 2021). Therefore, the aims of the current chapter were (1) to assess the feasibility and acceptability of a co-designed MSE intervention for women and (2) to investigate the potential effectiveness of the co-designed intervention on body composition and muscular strength among women.

5.2 METHODS

5.2.1 Participant Recruitment

Recruitment was conducted in December 2024 through posters, paid advertising on Meta Ads, workplace communication channels at the University of Glasgow (Microsoft Viva Engage), and by contacting participants from the previous co-design workshop (Chapter 4). All participants were women, aged between 18 and 45 years, living in the Glasgow area, and who self-reported not currently meeting the current government muscle-strengthening activity guidelines. While the overall thesis focused on adults aged 18 to 64 years, consistent with the UK Physical Activity Guidelines (Department of Health and Social Care, 2019), the age range of the current study was restricted to 18 to 45 years to align with the demographic profile of participants in the co-design workshop (Chapter 4). The narrower range was selected to reflect the population most represented in the intervention development phase and to enhance homogeneity in life-stage characteristics relevant to MSE behaviour. Exclusion criteria included unable to exercise, not passing the Physical Activity Readiness Questionnaire (PAR-Q+), blood pressure $\geq 150/90$ mmHg, currently pregnant, or having intellectual disabilities. The study was approved by the College of Medical, Veterinary and Life Sciences Ethics Committee at the University of Glasgow (Reference Number: 200240060) (Appendix 5-A) and adhered to the Declaration of Helsinki. Written informed consent was obtained after participants were briefed about the study and before the first data collection began. Participant information sheets, consent forms, recruitment posters, and PAR-Q+ are provided in Appendix 5-B to 5-E.

5.2.2 Study Design

The study was a pilot randomised controlled trial (RCT) with a mixed-methods design. A pilot RCT was chosen over a single-group pre-post feasibility design to assess the feasibility of implementing a random allocation procedure within the co-design intervention and for the preliminary evaluation of effect sizes. In line with the MRC framework for developing and evaluating complex interventions (Skivington et al., 2021), this would allow for the estimation of variability in outcome measures that will inform sample size calculation for a fully powered trial. Following completion of baseline measurements, participants were randomly allocated to either the control or intervention group (1:1). Random permuted block sizes of 2, 4 and 6 were used when allocating participants to maintain balance across the groups. Randomisation was carried out by a researcher independent of the research team, with randomisation by study ID stored in opaque envelopes. This study was registered at Clinicaltrials.gov (NCT07095322, 23/7/2025) (Appendix 5-F). The study period was 24 weeks (12 weeks of active intervention and follow-up at week 24). During the baseline visit in week 0, participants signed the consent form and provided demographic data, including age, postcode (for deprivation categories, as explained in Chapter 3), ethnicity, working status, academic level, and marital status, collected via a paper form. Past MSE history data were collected from participants in the intervention group during their post-intervention interviews at week 12. All four lab visits (baseline, mid-intervention, post-intervention, and follow-up) were conducted at the Sir James Black Building, University of Glasgow. The overall study design is shown in Figure 5.1.

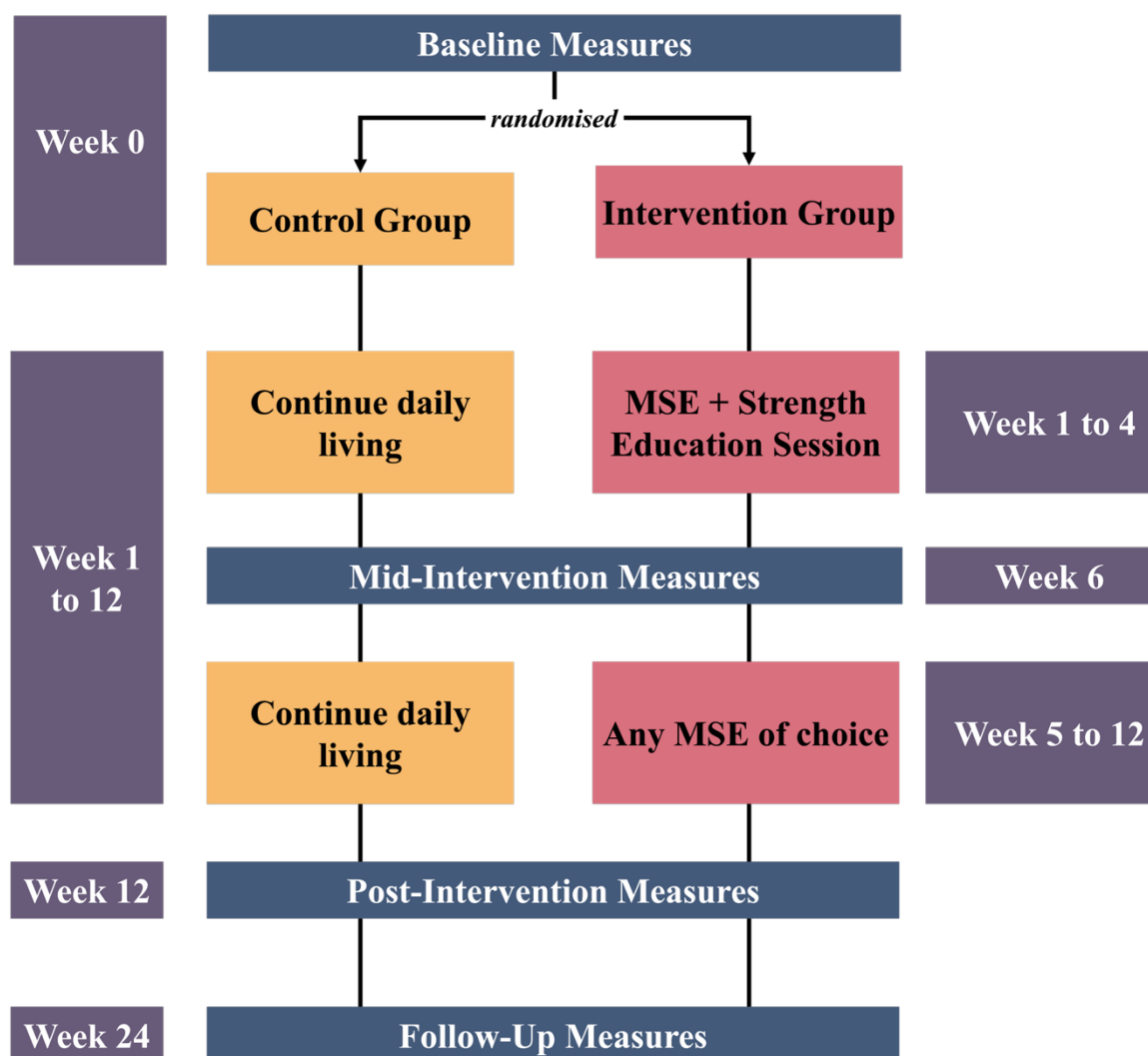


Figure 5.1: Study framework. MSE refers to muscle-strengthening exercises.

5.5.3 Intervention

5.5.3.1 Control Group

The control group were asked to maintain their habitual activity and were offered a 12-week University of Glasgow Sports membership after they completed all four lab visits.

5.5.3.2 Intervention Group

The intervention group were asked to participate in any type of MSE of their choice, on two days a week. The exercises they could choose from were weight machines, free weights, resistance bands, bodyweight exercises, holistic exercises such as yoga and Pilates, alongside strength training classes like Body Pump. The intervention involved five components, which were: 1) a strength education session, 2) optional group exercise sessions,

3) an online support group, 4) logging training and 5) access to various modalities. The intervention started with strength education sessions (1 per week) from week 1 to week 4, and, from week 5 to week 12, the participants were asked to continue performing two sessions of MSE of their choice per week, targeting the major muscle groups. During weeks 5-12, weekly reminders were sent, and participants could attend optional group exercise sessions led by NR. A 12-week gym membership was provided from week 1 to week 12 at a gym of their choice to be as convenient as possible. From week 13 to week 24, the gym membership, weekly reminders, and optional group exercise sessions were discontinued, and participants were asked to continue their new routine. Each of the five intervention components is described in detail below.

Strength Education Sessions

The strength education sessions took place over 4 consecutive weeks at the University of Glasgow exercise lab and took the format of presentations and practical demonstrations. Participants were also provided with a Strength Education Session booklet that included a guide for each session, which could be taken home and kept as a reference. The booklet content was informed by the findings from Chapter 3 and Chapter 4, specifically identifying knowledge gaps, misconceptions and participants-identified learning needs related to MSE. The key areas included the importance of MSE, different exercise modalities and techniques, and strategies to support engagement and confidence. The booklet was initially developed by the principal researcher (NR) and then iteratively refined through discussion and review with the research team (GR and SG). Revisions were made to ensure that the content was evidence-based, aligned with the co-design findings and appropriate to deliver within the 4-week education sessions. The collaborative process ensured both academic rigour and relevance to the target population. The Strength Education Session booklet is included in Appendix 5-G. The content of each week is outlined below:

- Week 1: Education session 1 was an in-person group session that covered the benefits of MSE and the fundamentals of MSE exercise, such as progression and target muscle groups. A demonstration of upper-body home-based band/bodyweight exercises was given, and participants were asked to perform these on two days per week before the next session.

- Week 2: Education session 2 was an in-person group session that included follow-up and troubleshooting of the upper-body exercises from week 1, a demonstration of lower-body band/bodyweight exercises, and initial goal setting about what the participant hoped to achieve from the intervention and how best to achieve it. Participants were asked to perform upper- and lower-body exercises on 2 days per week before the next session.
- Week 3: Education session 3 was an in-person group session that included follow-up and troubleshooting of the lower-body exercises from week 2 and an introduction to safely performing exercises in the gym environment. Participants were asked to perform either gym-based or home-based lower-body and upper-body exercises on two days per week before the next session.
- Week 4: Education session 4 was an in-person or online, 1-2-1 discussion session that involved follow-up and troubleshooting of the previous weeks' exercises alongside guidance on suitable muscle-strengthening classes. Participants were asked to perform either gym- or home-based upper- and lower-body exercises or attend classes on two days per week, based on their preferences. A mix of gym, class or home-based exercise was allowed.

Optional Group Exercise Session

Optional group exercise sessions were offered from Week 4 to Week 11, with a range of two to four sessions offered weekly. Participants were given a notice a week before each session, noting the times and format (online or in-person University of Glasgow exercise lab), and were asked to sign up for the session if they were interested in joining it. The optional group exercise session plan was as follows:

Table 5.1: Optional group exercise sessions plan.

Week	Content	Format	Date and time
4	Gym-based exercises	In-Person	• 4 February 2025 (8 AM) • 4 February 2025 (1 PM) • 6 February 2025 (8 AM) • 6 February 2025 (1 PM)
5	Bodyweight exercises	Online	• 10 February 2025 (1 PM) • 11 February 2025 (1 PM)
6	Resistance bands	In-Person and Online	• 18 February 2025 (8 AM) • 18 February 2025 (1 PM) • 20 February 2025 (8 AM)

			• 20 February 2025 (1 PM)
7	Gym-based exercises	In-Person	• 24 February 2025 (8 AM) • 24 February 2025 (12 PM) • 25 February 2025 (8 AM) • 25 February 2025 (12 PM)
8	Bodyweight exercises	Online	• 3 March 2025 (8 AM) • 3 March 2025 (1:15 PM) • 4 March 2025 (8 AM) • 4 March 2025 (1:15 PM)
9	Resistance bands	In-Person	• 10 March 2025 (8 AM) • 10 March 2025 (1 PM)
10	Gym-based exercises	In-Person	• 17 March 2025 (8 AM) • 17 March 2025 (12 PM) • 18 March 2025 (8 AM) • 18 March 2025 (12 PM)
11	Resistance bands	In-Person	• 24 March 2025 (8 AM) • 24 March 2025 (1 PM)

Online Support Group

An online support group, facilitated via WhatsApp, was established with two aims: 1) for communication with the researcher and 2) for social interactions between participants to talk with each other and share their experiences. The online support group was also used to send notices about upcoming group exercise sessions, reminders to complete at least two days a week of MSE, and reminders about upcoming lab visits.

Logging Training

Participants were provided with an A5 physical training log, in which they were asked to record each MSE they performed. The log contained sections for the day, date, time, type of activity, rate of perceived exertion (RPE), set, repetitions, and load (where applicable). Participants were asked to complete this in as much detail as possible throughout the 24 weeks. The intensity of the activities, recorded by RPE, was based on the validated visual analogue scale by Robertson et al. (2003), where participants rated their perceived exertion and difficulty of activities on a 0–10 scale. For this study, intensities 0–4 were classified as low, 5–7 as moderate, and 8–10 as high. In the first week of the exercise, participants were advised to continue until they reached a score of 4–6 on the RPE scale. In the subsequent weeks, they were asked to aim for 8–10 on the RPE scale. Once they were able to complete

the same activity at an intensity of 4-6 on the RPE scale, they were advised to progress by increasing the weight or moving up the resistance band level. The training log is included in Appendix 5-H. Throughout weeks 1 to 12, participants received a weekly reminder to complete the exercises and a voting poll in the WhatsApp group to indicate which sessions they had completed. The voting poll consisted of four choices based on the number of exercise sessions completed, which were none, one session, two sessions and more than two sessions.

Access to Various Modalities

Participants were given provision to allow two types of modalities to be performed: 1) a 12-week gym membership and 2) 6 levels of resistance bands. Both modalities were given at the start of the intervention. Participants had the option to choose either the University of Glasgow Sports membership, an external gym membership, or an exercise classes membership, such as Pilates. External membership costs were capped at £40 per month.

5.5.4 Outcomes

The primary outcome was to assess the feasibility and acceptability of the co-designed MSE intervention. Feasibility was assessed based on accrual, retention (completion of all lab visits), and adherence, and acceptability was assessed through qualitative interviews. The feasibility and acceptability were explored within the intervention group. The primary outcome was assessed at post-intervention (week 12) and follow-up (week 24) through an interview. Secondary outcomes were the changes in body composition (bodyweight, body mass index, body fat percentages, fat-free mass, and vastus lateralis muscle thickness) and muscular strength (handgrip strength, back strength, and knee extensor maximal isometric strength). The secondary outcome measurements were conducted at baseline (week 0), mid-intervention (week 6), post-intervention (week 12), and follow-up (week 24). Participants received a £25 Amazon voucher for each lab visit they completed.

5.5.4.1 Feasibility and Acceptability

Two interview topic guides (Appendix 5-I) were developed by the lead researcher (NR) and further finalised with the research supervisors (SG and GR). The intervention group were invited to an interview during their post-intervention and follow-up visits with the lead researcher to explore the feasibility and acceptability of the five-intervention components

offered (strength education session, optional group exercise session, online support group, logging the training and access to various modalities) as well as their experiences with the study overall. The interview lasted around 60 minutes at University of Glasgow and was audio-recorded for analysis. Participants who did not attend the follow-up session were invited to take part in the online interview via Microsoft Teams. During the interviews, open-ended, non-judgemental questions, neutral prompts to encourage elaboration, and the usage of the participants' own terminology in follow-up questions were used to eliminate potential interviewer bias.

Adherence to the study was recorded based on attendance at the strength education sessions and the optional group exercise session. Training data adherence was recorded in two ways: from the training log (24 weeks) and a voting poll in the online support group (for the first 12 weeks) and was based on the number of sessions completed. As the voting poll was conducted on either Wednesday or Friday each week, the voting poll data was cross-checked against the final extracted training log for the 12-week intervention. If data were available in the voting poll but not in the training log, the voting poll data were used; similarly, if data were available in the training log but not in the voting poll, the training log data were used. However, if data was not available in either the training log or the voting poll, it was classified as 'no sessions completed' for that week.

5.5.4.2 Body Composition and Muscular Strength

While the primary focus of the thesis was to improve participation in MSE, changes in body composition and muscular strength were included as exploratory outcomes to provide some early understanding of the potential effects from MSE participation. Body composition and muscular strength measures were selected because they are commonly reported health-related outcomes in resistance training research and provide objective indicators of musculoskeletal adaptation.

Body Composition

Participants' height and body mass were collected using a stadiometer (Seca 220, Hamburg, Germany) and a digital weight scale (SECA 877, Hamburg, Germany). Body mass index (BMI) was calculated using the BMI formula ($\text{BMI} = \text{kg/m}^2$). Participants' body fat percentages and fat-free mass were measured using a segmental body composition analyser (TANITA BC-418). Vastus lateralis muscle thickness was measured using a small handheld

ultrasound device (Telemed LS128 CEXT-1Z, Vilnius, Lithuania). Measurements were taken at 50% of the distance between the lateral condyle of the femur and the greater trochanter, and the probe was placed at 10% of the circumference, measured from the thigh anterior midline (Ismail et al., 2019). In addition, to increase acoustic coupling and minimise near-field artefacts, a water-soluble transmission gel was applied to the skin. All ultrasound images were digitised and analysed with ImageJ software v.137 (US National Institutes of Health, Bethesda, MD, USA).

Handgrip Strength

Handgrip strength was measured using a handgrip dynamometer (JAMAR J00105, Lafayette Instrument Company, IN, USA). Handgrip strength test was selected as a pragmatic and validated indicator for evaluating muscle function and overall physical ability (Vaishya et al., 2024), which is commonly used in physical activity and resistance training research. To do this test, the participants were asked to squeeze the handgrip dynamometer with as much force as possible while seated, with the elbow flexed at 90 degrees. Participants were asked to perform this test three times for each hand, with a rest between each attempt. The highest value was used for analysis.

Back Strength

Back strength was measured using a Back and Leg Strength Dynamometer (Takei 5002, Takei Scientific Instruments Co., Ltd., Niigata City, Japan). The back strength test was selected to measure functional trunk strength, which is important in many activities of daily living. Participants were asked to stand on the base with their feet shoulder-width apart, bend their knees slightly, and hold the handle with both hands, keeping their back straight as they pulled upwards. The test was performed three times with a rest in between each attempt. The highest value was used for analysis.

Knee Extensor Maximal Isometric Torque

Knee extensor maximal isometric torque was measured on the right leg during a maximal voluntary contraction (MVC). This test was selected to measure the lower limb maximal force production, which is important for functional movements like getting up from a chair or climbing stairs. The setup has been explained previously in Andrews et al. (1996).

Participants were asked to sit in a chair with their legs at a 90-degree angle. A strap was placed around the right ankle, which was connected to a force transducer which recorded the force via a load cell (Biometrics Ltd, Newport, UK). Participants were asked to contract maximally with the leg fixed in position, and the force was recorded for 10 seconds. Participants performed three contractions, with a 1-minute rest between each contraction. A fourth contraction was performed if there was a >10% difference between the third and second contraction. The highest value was used in the analysis. Limb length was measured using a tape measure from the centre of the knee joint's axis of rotation (medial femoral condyle) to the top of the ankle, where the force transducer was attached. Torque was calculated according to the formula below, where τ is the torque, r is the lever arm, and F is the force:

$$\tau = r \times F$$

5.5.5 Sample Size

This was a pilot RCT study, and no formal sample size calculation was carried out. The main component of the intended work is to collect preliminary data to inform the sample size calculation for a subsequent definitive trial. The sample size was therefore based on guidelines from Julious (2005), where 12 participants per group is recommended for a pilot study. Considering a 20% dropout rate, the aim was to recruit a total of 34 participants (17 participants per group).

5.5.6 Statistical Analysis

This study is reported following the Consolidated Standard of Reporting Trials (CONSORT) (Hopewell et al., 2025) (Appendix 5-J). All audio recordings from the interviews were transcribed verbatim using the 1st Class audio transcription service and checked by NR. Transcripts were analysed deductively to assess the feasibility and acceptability of the co-designed intervention. The analysis followed Braun and Clarke (2006) a six-step thematic analysis, but the categories were structured according to pre-defined intervention components rather than generated inductively from the data. All the transcripts were coded using Atlas.ti v25.0.1. The Participant Perception Matrix for Intervention Component was developed as a structured analytical display to summarise participants' qualitative views on each of the five intervention components, based on interview data. Matrix-based displays in a tabular format are recommended because they allow the data to be presented in one clear

place and support detailed analysis of patterns and comparisons across participants and components (Miles et al., 2014). Following the thematic coding, each participant's perception of each component was interpretively classified into one of five ordered categories (1= no reference, 2 = needs a lot of work, 3 = needs some work, 4 = doing okay, 5 = doing great). The no-reference category indicates the absence of comment on the intervention component rather than a negative perception. The transformation of qualitative data into quantitative data is consistent with a mixed-methods analysis approach to facilitate comparison (Creswell and Plano Clark, 2018). Ratings were performed independently by two authors (NR and GR). In cases of disagreement, the researchers met to discuss the rating and reach an agreement on the final score. The Participant Perception Matrix is included in Appendix 5-K.

Training log data was extracted to Microsoft® Excel V.16.98 (Microsoft Corporation, Redmond, WA, USA) and classified based on the type of exercises (weight machines, free weights, resistance bands, bodyweight exercises, holistic exercises or exercise classes/videos), the total number of exercises in each type of exercise, sets, repetitions and average rate of perceived exertion (RPE) weekly over the 24-week study for each participant. Participants' knowledge and satisfaction ratings were recorded on a scale of one to five. The mean and standard deviation of each (training log and rating of knowledge and satisfaction) were then calculated using Microsoft® Excel V.16.98 (Microsoft Corporation, Redmond, WA, USA).

Statistical analysis for quantitative data (body composition and muscular strength) was performed using IBM SPSS v29.0.2.0. All data were tested for normality before selecting the appropriate test. A repeated-measures ANOVA was conducted to determine the effect of time and time-by-group interactions on the secondary outcome variables. A post hoc t-test with the Bonferroni correction was applied to identify within-group differences across all four time points following a significant time effect in the ANOVA. Significance was set at $p \leq 0.05$ throughout.

5.6 RESULTS

5.6.1 Participant's Demographic Characteristics

In December 2024, 182 women expressed interest in participating in this study. 60 women were assessed for study eligibility after replying to the screening email, and 37 were eligible to participate. In January 2025, 34 participants were enrolled and randomised (100%). Of these, 91% of participants completed all four lab visits (31/34 participants; 94% for the control group, 88% for the intervention group) (Figure 5.2). The demographic descriptions of the trial participants are reported in Table 5.2. The trial participants were mainly from an affluent area (36% least deprived), white (45%), well-educated (97% university degree or higher), full-time students (52%), single (77%), with a mean age of 28.90 ± 7.6 years (range 19 – 45 years old). No adverse events were reported during the trial.

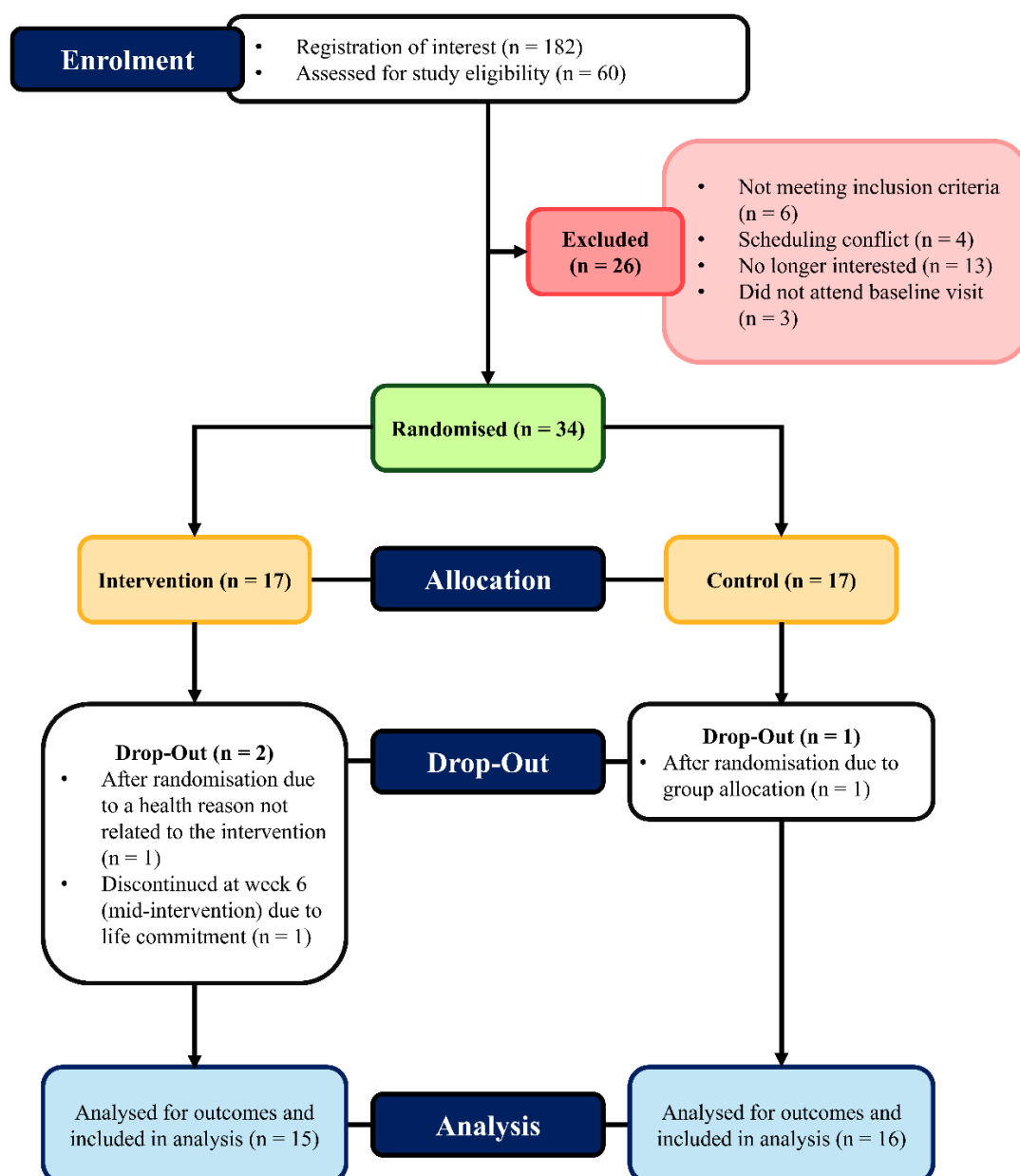


Figure 5.2: CONSORT diagram of participant flow during the study.

Table 5.2: Demographic characteristics of participants.

	Total <i>n</i> = 31 (%)	Control <i>n</i> = 16 (%)	Intervention <i>n</i> = 15 (%)
Age (Mean $\pm$ SD, years)	28.9 $\pm$ 7.6	31.1 $\pm$ 7.6	26.6 $\pm$ 7.1
Deprivation Category			
Most deprived	9 (29.0)	5 (31.3)	4 (26.7)
2nd most deprived	2 (6.5)	0 (0.0)	2 (13.3)
Median quantile	4 (12.9)	3 (18.8)	1 (6.7)
2nd least deprived	5 (16.1)	3 (18.8)	2 (13.3)
Least deprived	11 (35.5)	5 (31.3)	6 (40.0)
Ethnicity			
White	14 (45.2)	9 (56.3)	5 (33.3)
African/Scottish African/British African	2 (6.5)	0 (0.0)	2 (13.3)
Asian/Scottish Asian/British Asian	11 (35.5)	4 (25.0)	7 (46.7)
Mixed, multiple or another ethnic group	4 (12.9)	3 (18.8)	1 (6.7)
Working Status			
Full-time student	16 (51.6)	7 (43.8)	9 (60.0)
Employed or self-employed	12 (38.7)	8 (50.0)	4 (26.7)
Doing unpaid work	2 (6.5)	1 (6.3)	1 (6.7)
Unemployed	1 (3.2)	0 (0.0)	1 (6.7)
Academic Level			
Trade, technical certificate, apprenticeship or diploma	1 (3.2)	0 (0.0)	1 (6.7)
University degree or higher	30 (96.8)	16 (100.0)	14 (93.3)
Marital Status			
Single (never been married)	24 (77.4)	12 (75.0)	12 (80.0)
Single (with children)	1 (3.2)	1 (6.3)	0 (0.0)
Married (without children)	2 (6.5)	2 (12.5)	0 (0.0)
Married (with children)	3 (9.7)	0 (0.0)	3 (20.0)
Divorced/Separated (with children)	1 (3.2)	1 (6.3)	0 (0.0)

The deprivation category is based on the quintile of the index of multiple deprivation (IMD). The full category of working status is as follows: 1) Full-time student, 2) Employed or self-employed, 3) Doing unpaid work (for own or family business/volunteering/looking after family or home), 4) Unemployed (looking for a job/unable to work due to illness or disability) The total sample represents the total responses in each category whereas the percentage represents the percentage within the group.

5.6.2 Feasibility of the Co-Designed Intervention

Of the initial 17 participants in the intervention group, 14 (82%) participated in an interview. Three participants self-reported being complete beginners in MSE, and 11 were restarting their MSE journey.

5.6.2.1 Adherence to intervention

Adherence data are not reported for weeks 13 to 24 due to insufficient and incomplete data captured during the follow-up period. During the 12-week intervention phase, adherence was monitored using both the training log and weekly voting poll within the online support group, which allowed for the cross-verification of the reported MSE sessions. However, during weeks 13 to 24, the participants no longer engaged in the structured intervention components and the weekly voting poll was discontinued. As a result, adherence during the follow-up period relied solely on self-reported training logs, which were mostly incomplete during this period and could not be utilised. Seventeen physical copies of training logs were distributed at the start of the intervention, and 15 training log data were extracted (88%) for 12 weeks of intervention. Participants were expected to complete at least 24 exercise sessions (2 per week) over 12 weeks to be considered fully adherent. The finalised intervention adherence data are presented in Figure 5.3.

Adherence was highest at the start of the intervention, with all participants completing 2 or more sessions a week in weeks 1 and 2. A gradual decrease in participation was observed from week 3 onwards, with notable drops in weeks 8 and 9. At week 3, the adherence was 87% ($n = 13$), then further declined to 73% ($n = 11$) in weeks 4, 6, and 7. At week 5, adherence slightly increased to 80% ($n = 12$) before declining further to 53% ($n = 8$) at weeks 8, 10, 11, and 12. The lowest level of adherence was 47% at week 9, when only seven participants attended two or more MSE sessions. Throughout the 12 weeks, only four participants adhered to the intervention of doing at least two days a week of MSE.

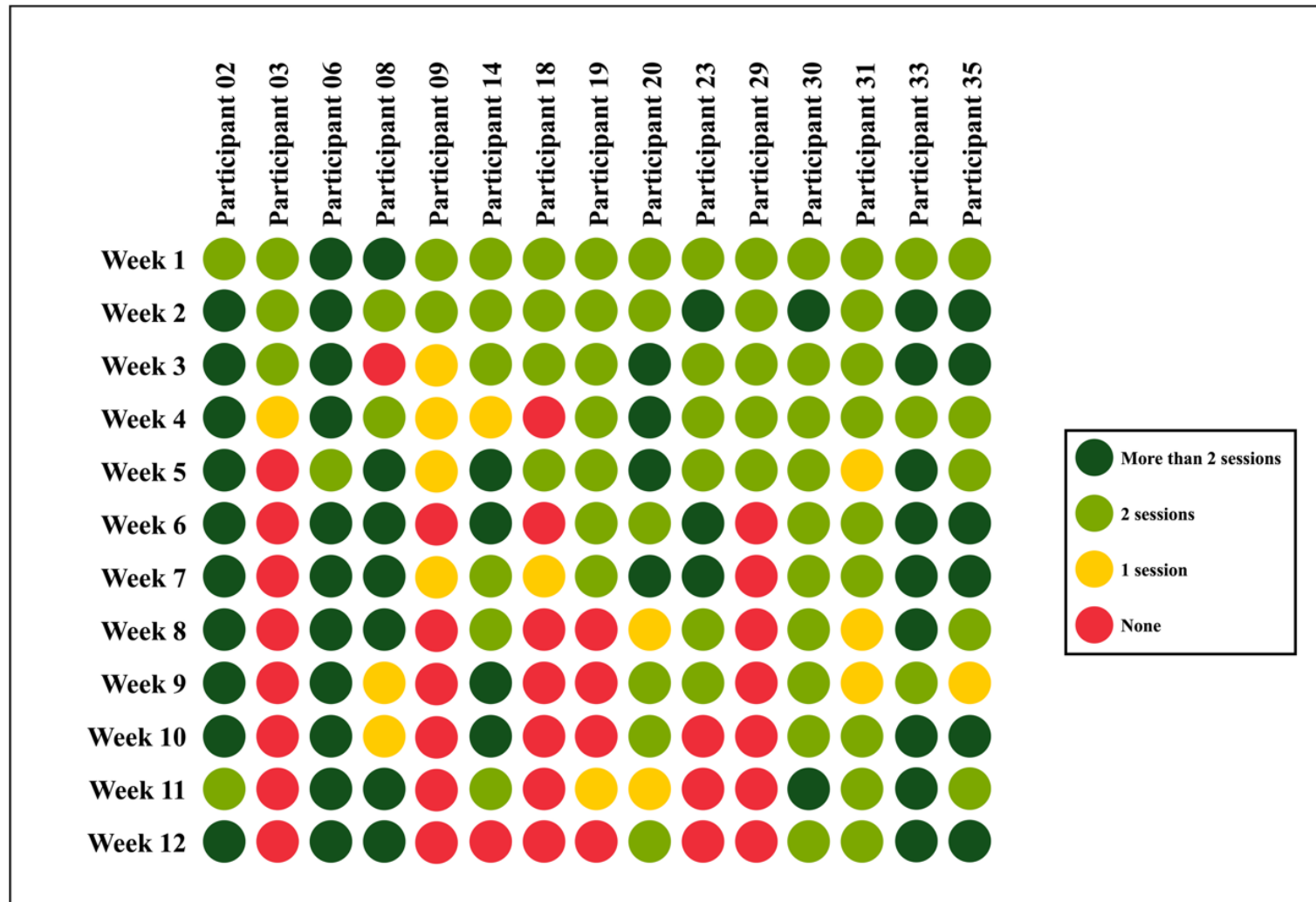


Figure 5.3: 12-week of intervention adherence record for each participant based on the combined training log data and voting poll.

5.6.2.2 Training Log Data

Table 5.3: Summary of training log data across 12 weeks.

	Intervention (<i>n</i> = 15) Mean ± SD
Exercise Sessions	24 ± 15
Duration (minutes)	1212 ± 1254
Weight Machine	
Number of Exercises	30 ± 40
Sets	98 ± 167
Repetitions	1081 ± 1973
Rate of Perceived Exertion	6 ± 2.6
Free Weights	
Number of Exercises	33 ± 32
Sets	102 ± 115
Repetitions	2371 ± 4919
Rate of Perceived Exertion	5 ± 2.9
Resistance Bands	
Number of Exercises	21 ± 25
Sets	56 ± 86
Repetitions	609 ± 929
Rate of Perceived Exertion	5 ± 2.6
Bodyweight Exercises	
Number of Exercises	20 ± 31
Sets	67 ± 159
Repetitions	876 ± 2189
Rate of Perceived Exertion	5 ± 2.3
Holistic Exercises (yoga or Pilates)	
Number of Exercises	6 ± 9
Rate of Perceived Exertion	3 ± 3.5
Exercise Classes/Videos	
Number of Exercises	2 ± 4
Rate of Perceived Exertion	2 ± 3.2

Note: Due to the nature of holistic exercises and exercise classes/videos, sets and repetitions were not recorded.

Table 5.3 presents the training log data extracted from 15 participants over 12 weeks, providing an overview of MSE adherence, training durations, modalities used, sets, repetitions, and exercise intensity. Overall, participants completed a mean of 24 ± 15 sessions over 12 weeks, with substantial variability in adherence among individuals. Eight participants completed more than 24 sessions, one participant completed 21 sessions, and six participants completed fewer than 16 sessions over 12 weeks. For training duration, an average of 1212 ± 1254 minutes of MSE was performed over the 12-week study period. This corresponded to approximately 50 minutes per session, which indicated that participants generally accumulated moderate sessions durations that are typical with resistance training sessions rather than brief activity bouts

Across modalities, free-weight exercises were the most frequently performed MSE type, with an average of 30 exercises, followed by weight machines, resistance bands, and bodyweight. In contrast, holistic exercises and exercise classes/videos were the least frequently performed by the participants. Across all MSE types, the average intensity was moderate (RPE 5 – 6), except for holistic exercises and exercise classes/videos, where the intensity was reported as low (RPE 3). Overall, the data indicate that participants engaged in a mix of structured resistance training and flexible exercise modalities, with moderate intensity and substantial variability in participation.

5.6.2.3 Session Attendance

Of the 17 participants in the intervention group, 15 completed all four lab visits (88%). For the strength education sessions, the first week of education sessions had an 87% attendance rate, and the second through to fourth education sessions had an 80% attendance rate. Nine out of 15 participants completed all education sessions (60%), three participants completed three education sessions (20%), one participant completed two education sessions (7%), and two participants completed one education session (13%). The optional group exercise sessions were conducted from Week 4 to Week 11, with a range of two to four sessions offered weekly. Over the eight weeks, two participants joined for four weeks (one attended four sessions; the other attended seven sessions), and two participants joined for one week (one session each), with the remaining participants not attending any sessions.

5.6.2.4 Feasibility of Data Collection

During the interview, participants were asked about their opinions of the testing protocol during the lab data collection sessions. Five tests were conducted in the lab, which are body composition, vastus lateralis muscle thickness using ultrasound, handgrip strength, back strength, and knee extensor maximal isometric torque through maximal voluntary contraction. Participants expressed that the instructions given by the researcher and the purpose of the test were easily understandable. The tests were perceived as straightforward. Many participants highlighted that being able to see changes in their body composition and muscular strength made them more motivated, and this contributed to their sense of enjoyment in participating in the intervention. The participants also shared that they felt comfortable during the testing and viewed the testing protocol as non-invasive and easy to complete. Lastly, participants reported satisfaction with the duration of the data collection sessions, where they described it as quick and well-balanced. Table 5.4 presents some of the indicative quotes according to the participants' opinions.

Table 5.4: Participants' opinions on the testing protocol.

Codes	Indicative quote(s)
Understanding the test	<i>"Yeah, they seem fine, they seem appropriate. Obviously, I don't know anything about the actual equipment, so you'll know if it's the right way of testing, but it's not difficult."</i> (P03, age 36) <i>"Yeah. Simple enough, yeah, and I think you're testing a range of different things, that's good, they're all quite easy, like, non-complicated tests, so it's good, yeah."</i> (P14, age 24)
Enjoyment and motivation	<i>"I think they're good because that's what I was thinking today. I hope I'm not at the same level as I was the last time. So, it's good to see that progress. Even when you measure the muscle, it's nice to see that actually there is a change when you've been three months."</i> (P06, age 43) <i>"I think it tells me about my own progress, because again I can't really tell from my appearance, but you would be able to tell from the data"</i> (P19, age 20)
Comfort during the testing	<i>"Yeah, I'm really comfortable with that. And it's really easy to achieve, so it's really nice."</i> (P02, age 26) <i>"They're good, I don't feel uncomfortable during the test at all, so I'm happy to do them."</i> (P30, age 27)
Length of the session	<i>"It's fine, yeah, it's quite quick."</i> (P14, age 24) <i>"I think it was perfect, so it's not too rushed, but it's also not dragging for too long, so I think it's the perfect time."</i> (P33, age 23) <i>"The testing, I think it's fine. Actually, it's always faster than I think, especially the six-week one, because there was no interview; it's just that. It's fairly quick."</i> (P35, age 20)

5.6.3 Acceptability of the Co-Designed Intervention

Figure 5.4 illustrates the participants' perceptions of the five intervention components. Overall, having the strength education session and access to various modalities was crucial for helping women participate in MSE. The following subsections provide a brief explanation of each component.

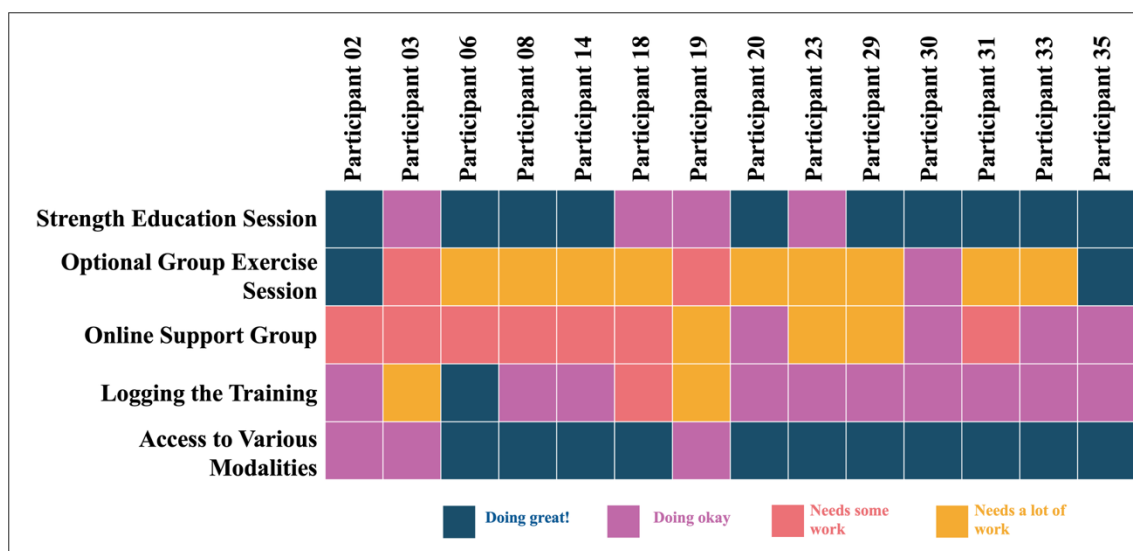


Figure 5.4: Participants' Perception Matrix for the WISH Intervention Component.

5.6.3.1 Strength Education Sessions

The strength education session offered at the beginning was seen as essential for participants to gain and refresh their knowledge of conducting MSE. The three main benefits of the strength education component, according to the participants, were having the ability to ask the expert, group interactions, and demonstration of exercises. The knowledge gained from the education sessions helped the participants to plan their exercises on their own. Some participants who joined the session online appreciated the flexibility of the delivery method, and one provided feedback on improvements for the online version of the education session. While participants were happy with the overall content of the education sessions, several topic suggestions for future sessions were offered, including warming up and cooling down, more information on gym-based exercises, dietary intake during strength training, and training during menstruation. Table 5.5 presents the indicative quotes according to the participants' opinion of the strength education session.

Table 5.5: Participants' opinions on the strength education session.

Codes	Subcodes	Indicative quote(s)
Opinion	Knowledge	<i>"Very useful, I didn't know of the stuff before, especially the one where it said females aren't supposed to look bulky."</i> (P30, age 27) <i>"I thought it was really good. I thought because I hadn't really ever used any of, for example, the gym equipment, or I didn't know the different exercises I could do, it was really useful as an introduction to strength training exercises. So, when I did go to the gym or when I was at home, I actually was able to pull from those education sessions and plan a workout there. I could actually know what I was doing, which was nice. Because that was a real challenge for me before, and that's what really put me off doing strength training exercises."</i> (P29, age 22)
	Ability to ask the expert	<i>"I think they were really helpful. It was broken down in a way that's easy to understand. Even though I know that I would be able to understand some bits, reading it at a more complex level, it's just difficult to understand it and personalise it to you and relate that to yourself. So, I think having someone else break it down into a way that was easy to understand and start off with the basics was really good. And also linking it to studies really helped because it does come up, so I think being able to relate, oh, this is what I've learnt from the strength training, I can do that."</i> (P35, age 20)
	Group interaction	<i>"You're doing it as part of a community, and I suppose that's the benefit of not having it pre-recorded. Because then you're like, oh, I can do it anytime, whereas if it's like, listen, this session's going to run once this week and you have to attend, then you're more likely to get up, just do it, and then you know that you've done your bit"</i>(P03, age 36) <i>"And I think it's very interesting because it's more like a group interview. So I have some ideas from them as well and also, I see I'm not alone, like everyone has the same feeling as mine, so it's good to know that all of us are trying to push ourselves into this."</i> (P20, age 22)
	Exercise demonstration	<i>"I found it really helpful. A lot of the things I've already known before from my past experiences, but I did also find it really helpful how you were actually demonstrating, and it wasn't just talking."</i> (P29, age 22)
	Online delivery	<i>"It was good because I joined it online, so for me it was convenient, and it was, like, I didn't have any clue about how to use the resistance bands, I'd never used them before. So seeing you and how to use them was the first time I'd had any exposure. And then when I joined the exercise class, obviously, they used resistance bands as well, so that was informative. And I think, you know, if I wasn't, for whatever</i>

		reason, to join a gym or keep joining the gym, I would at least know how to use the resistance bands. Which I think are such a good tool, and if you've got them then they're so easy to, kind of...although they're not, they're not easy to use, as in, they're hard, but you can do, you're shown enough different ways to make it...impacting your different areas. So that was useful for me." (P18, age 37) "What do I dislike about the session? I don't know, maybe it's a practical thing, maybe you could have changed, but I realise you were doing some in-person people as well, maybe you could have changed the angle of the camera, so it was a bit more like an aerobic session or a YouTube video. So, just a bit more front facing, maybe with a mirror behind you, would have been useful, so maybe in a gym kind of setting. But, like I say, it's just a practical thing, it's nothing in terms of the actual content of the session." (P03, age 36)
	In-person delivery	"They were good. I think for me as well, because I came in groups that were quite small, I was able to ask questions about form and things like that, so that was really helpful. And then you could help us make adjustments for anything, like for injuries and stuff, so I thought that was really good to have that one-to-one, because I did all of them in person as well, so that was really good." (P14, age 24)
Suggestion	Warm-Up and cool Down	"Yeah. Actually, like there are some warming-up exercises, just maybe tell people how to do it. Because all of us know how to do the regular ones, but maybe some people don't know what it's for. Is this better for your back or better for your arms? They have no idea. They just know everyone is doing these things, so we just follow, yeah." (P02, age 26)
	Gym-based exercises	"Maybe, like, a couple more sessions. Like, especially with the gym-based ones, just a few more to get you going." (P31, age 19)
	Dietary intake	"I think the content was pretty good. I feel like if you wanted to, you could include something about, like, diet, about protein and, like, when...Because I think one thing I would struggle, is whether I should eat before or after the gym, like, what I should eat before and after the gym, but that's just me, and also, like, I just Google it. I just sort of, you know, consult the internet, but maybe some people wouldn't want to do that, just in case." (P20, age 22) "I feel like, exercise-wise, I'm doing quite well. Like I said, just the diet, so I can actually see a difference in my body, because I do know that if you don't eat but you're still working out every day, you won't really see any difference. So definitely just nutrition-wise and what calories you need to eat, and protein and all that." (P33, age 23)

	Training during menstruation	<i>"I think that would be helpful, because like, it's hard to exercise during that period of time (menstruation)." (P08, age 31)</i> <i>"I feel like it's something to definitely include, just...not even, like, as a, you should train on these days because of this, more like a, you might find that you feel weaker during these periods, this is why. During these times, maybe you could, like – I don't know – focus more on things that you enjoy rather than things that you're doing specifically for, like, a purpose, so like, you could be like, if you enjoy squats more than lunges, do squats during this time, but, like, lighter, more reps, type thing, but that's just me." (P20, age 22)</i>
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5.6.3.2 Optional Group Exercise Sessions

The optional group exercise sessions were the least effective intervention component among the five components. Participants who joined the session found it useful, while those who did not reported that this was mainly due to scheduling conflicts and the session's location. Several suggestions for improvement were made by the participants, such as scheduling more sessions, varying locations, and making the sessions mandatory. Table 5.6 shows the participants' opinions and suggestions regarding the optional group exercise session.

Table 5.6: Participants' opinions on the optional group exercise sessions.

Codes	Subcodes	Indicative quote(s)
Opinion	Joined the session	<i>"You did the different exercises because I think I kept doing the same exercises, so you gave me something different. So, that was good, and I could also fit it in during my day." (P30, age 27)</i> <i>"I think they were good, because I know I'm typically on campus, so for me it's like, I always tell myself, oh, you can only go to the gym in the morning or in the evening, because if you go in the middle of the day, you probably want to go home. Even if I go to my current gym, I'm going to see my bus home, and I'm going to be like, that's it, there. But I think here there was just a bit more accountability, knowing that there's someone there who is going to watch you do your exercise and is going to critique you positively, make sure that you're doing it right. And I think it was a really good time to ask questions, and also just getting it over and done with. I think if someone else scheduled it, it's easier to put in a timetable, get it over and done with, and then it's like you've got one of your sessions done, which I think is really helpful." (P35, age 20)</i>

	Did not join the session	<i>"My reason is my planner because I had it in my planner, sometimes if I had time, but this time was allocated to the gym I was going to already, so I just didn't want to break my routine. That was the only reason. Otherwise, I would come and join in, but because I've already had plans in the planner, I didn't."</i> (P06, age 43) <i>"So, for me, I have, like, if I have two days that I'm doing the sessions that I'm committing to regularly, I can't do anything on top of that. My, on top of, like, work, little one, family, my commitment...and I've got other extracurricular things that I do. My commitment is very limited."</i> (P18, age 37) <i>"Yeah, so for me, the main reason that I couldn't make it was because it was really far for me to go home, so if I were to go to university, I would have to take a second bus just to come here. So that was the main reason."</i> (P33, age 23)
Suggestion	Frequency of sessions	<i>"Usually, between 8, obviously, I wouldn't be able to do it because that's when I get the kids ready for school, et cetera. But 1 pm is my gym time. If there were more options within the days probably be helpful"</i> (P06, age 43) <i>"I think it would, but I also think it's one of those things where it's too much for you to do, then...like if it's too much for you to do, like, more days, multiple times a day, then, you know, like that is like a separate issue. But I do think that would probably help, yeah."</i> (P20, age 22)
	Varied locations	<i>"Oh, definitely, definitely. There's, yeah, there's so many...it's just so much easier (varied location), just because of where we are, it's so central and then the parking is difficult, there's just a lot of walking as well, so it just takes time out of your day rather than driving to somewhere in the suburbs, quickly parking up, running in, doing your thing. And even if you did the live sessions then, I think a lot of people would come and attend, they'd see it as a fitness class, and they would come and attend. Especially if it's, like, early in the morning or in the evening, where they can just do it around their other commitments, I think it would be really a good idea."</i> (P03, age 36) <i>"Yeah, for sure. If it (session) were closer and it was easier for me to get to, then I would definitely participate."</i> (P33, age 23)
	Mandatory session	<i>"I think there can be more group sessions, or we can make them mandatory. I think that will increase the turn-up rate."</i> (P19, age 20)

5.6.3.3 Online Support Group

While the main purpose of the online support group was to facilitate social interaction between the participants and the researcher, this goal was not fully achieved, as there was

only limited interaction among participants. The online support group was mostly researcher-led, and participants responded to the researcher (NR) more than they posted about their MSE participation or interacted with each other. However, participants appreciated that the online support group was useful for weekly reminders to complete the exercise sessions and for fostering a sense of community, knowing that other participants were in a similar situation to them. Participants suggested improvements to the online support group, such as sending an exercise plan, videos, and articles. The indicative quotes of participants' opinions are described in Table 5.7.

Table 5.7: Participants' opinions on the online support group.

Codes	Subcodes	Indicative quote(s)
Opinion	Limited social interactions	<i>"I was expecting people to be more active. I'm quiet as well, so I'm not saying, so I was expecting as well, oh, people will be asking lots of questions, how to do this, this, this, posting their pictures. This is me after the gym. I thought people were more social." (P06, age 43)</i> <i>"But it was more the WhatsApp, I kind of thought that the girls might have been like, this is what I'm doing, what are you doing? Or, like, nobody really talked, and I was, like, fair enough, busy studying, working. But nobody spoke, and I was like...so I tried things like, oh, hi. And everyone hearted it, and I'm hoping it was actually like, oh, my name is this and I'm these years old, and I've been doing this for a year or two years, I've just started. So, it was kind of weird that way." (P08, age 31)</i>
	Reminders	<i>"Good for reminders, yeah. I don't think I've used it that much otherwise because I've not been in the, like, optional classes, but, yeah, it's definitely good for reminders or questions or things that you think would be helpful for everyone." (P14, age 24)</i> <i>"It is important for me to have that reminder, because I'm a very forgetful person. I sometimes just completely will go through my life and forget things, and, like, having the reminders was really helpful as well, with me, like, thinking whether or not I had done two sessions that week and knowing that, oh, okay, I need to go today." (P20, age 22)</i>
	Sense of community	<i>"Yeah, and I think it's just nice that we've got a place where we can, like, just send...so, like, I know that if I need help, I can either message you or I can send something in the group and be like, has anyone else had this problem, so yeah." (P20, age 22)</i> <i>"It was a great motivator, we could see everyone was trying their best, or if I was struggling, and I saw that I wasn't the only one struggling. So, that was very helpful." (P30, age 27)</i>

		<i>“Having the reminders and also...more like for the comfort of knowing that if I have an issue that I could just message the group and then somebody will get back to me, instead of being completely isolated and by yourself.” (P33, age 23)</i>
Suggestion	Exercise plan	<i>“I think, like, some examples of workout plans, or some exercises and stuff. And, like, warm-up, cool-down and stuff.” (P31, age 19)</i> <i>“I would definitely love that. I think that’s such a great idea, because sometimes it feels like I’m doing the same thing over and over again, so I’d like to change. But then I’m also a bit scared of changing because I’m like, what if I’m doing it wrong? So, it would definitely be helpful to have a different routine every now and then that you can try out and see how that feels.” (P33, age 23)</i>
	Videos	<i>“Yeah, let them try. You can take a video to tell people how to do it, and also maybe you can send them a link, maybe a YouTube link or anything else, but at least give people a sample, let people know what to do, maybe they can just try by themselves. This also works, yeah.” (P02, age 26)</i>
	Articles	<i>“I think that would be really useful, or it's like, oh, I found this interesting article on this to do with weight training and running, like, you know, I'd enjoy reading that if there's just interesting things about exercises, or this is like a quick read, I find this really interesting. I love those little things of like little, short bursts. I find that Instagram posts have great information, like those kinds of things, so I'm like, oh, that's an interesting kind of thing.” (P23, age 27)</i>

5.6.3.4 Logging the Training

Most participants found that having a record of their training was beneficial for them as they were able to see their progress over time, and that this contributed to a sense of motivation. However, one participant expressed mixed feelings about the training log, as it was not helpful for her to track the exercises she completed. While the purpose of logging the training was positively accepted by the participants, most participants found that filling in the physical copy of the training log was hard. Several participants voiced their suggestions for a digital version of the training log, such as an online platform or an application. Table 5.8 presents the indicative quotes by the participant regarding logging their training.

Table 5.8: Participants' opinions on logging the training.

Codes	Subcodes	Indicative quote(s)
Opinion	Having record	<i>"I find this helps me so much, and I can see the progress, like looking, I have done 20kg, so now it means it's lighter, so I can write down for the next week, I'm increasing 2.5, etcetera. So, definitely, I don't feel like I will stop."</i> (P06, age 43) <i>"Yeah, like it's good to see, because after a week, you can be like, I've had a really good week, or maybe I've done less this week, and I'll try harder next week. You can, kind of, compare them, and think, like, and then the RPEs, you can use that to gain, like, you can say, oh, they're lower this week, so maybe I can increase the weight, or I can increase the amount I'm doing."</i> (P08, age 31) <i>"As I mentioned I have started doing, I've gone up from the light to either the medium or heavy spring in the reformer class, so I think you can, like, I can naturally feel that I'm ready to do a harder option, but also I can have the proof that I, and maybe I've gone down to a five or a six and then I, if I put it up then I see the next week it's gone to seven or eight, so then it feels a good way to mark that I'm progressing."</i> (P14, age 24) <i>"I know, because before I never used to like reflecting on the past. I'm still not a fan of it, but I do think it forces you sit down and actually think through, and then you get to be a little bit strategic about your planning, like, that means I know when I go to the gym, I'm not just mindlessly picking an exercise, I've got a little plan set. Sometimes I'll do it just before I go to the gym, it's like, I want to do this exercise, I want to try this weight, try this rep range and stuff. It helps you just plan it going forward"</i> (P35, age 20)
	Subjective	<i>"I would still do it (logging the training), but I wouldn't keep track as much, because the specific data sets are for you, but I don't really need to keep track of that on my own. I don't dislike it, it's just that I don't really see the point in it because it's so subjective."</i> (P19, age 20)
Suggestion	Digital version	<i>"I think it would be easier if it's an online version because it's very easy to log in, and also you can write it down as soon as possible because it's on your phone."</i> (P02, age 26) <i>"I think the most difficult part of it, although is writing down what I've done, because I always forget. I always sit there on my phone, I'm like, writing it down in my notes, I'm like, what have I...what did I...what exercise did I just do? I get, like, complete amnesia when I'm on there."</i> (P20, age 22) <i>"Again, just with gym, they give me this little app where I'm logging in my weights, and at the end of the session, you put down the effort level as well or how difficult you find it. So, it's transferring over what's been going into the logbook, but into the app, if that makes sense. So, at the end of every</i>

		<i>session, they might say, you've increased how much. Yeah, it's like, you've broken three new personal records or whatever, it might say you've lifted the equivalent of, like, eight monkeys or something." (P23, age 27)</i> <i>"Perhaps a mobile application because when I'm at the gym, I like to record it on the booklet straight afterwards, and I have my phone." (P30, age 27)</i>
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5.6.3.5 Access to Various Modalities

Other than the strength education sessions, participants shared that having access to various modalities, such as free resistance bands and free gym membership, helped them greatly with their participation in MSE. Having free access to the gym for the first 12 weeks allowed the participants to get comfortable with the gym environment and try out the equipment. They also reported that having resistance bands helped them when exercising at home or added variety to their exercise plan. Most participants appreciated that there are no set exercises to complete in this study, as it allowed them to explore the type of MSE that they prefer and enjoy. When asked if they would consider continuing their gym membership after the intervention, the majority of participants responded yes, as they had gained initial experience with the membership offered in this study. Participants also offered several suggestions, such as additional information on the proper form for the exercises and ways to progress with them. The indicative quotes of participants' opinions regarding access to various modalities are shown in Table 5.9.

Table 5.9: Participants' opinions on access to various modalities.

Codes	Subcodes	Indicative quote(s)
Opinion	Gym membership	<i>"The membership also is, yeah, I think it's really good because you're literally getting free or, like, heavily subsidised workouts, so it's great. Really motivating as well because I think when you, like, have, you've paid for something, then you know you need to show up for it. Yeah, so it was good. I think it was good to get a taster and make sure that you're comfortable in the place that you're going and then decide to commit to it." (P14, age 24)</i> <i>"About the gym, I actually, yeah, I like the fact that you weren't insistent on the, you know, specifically for the gym, so for me I use the local leisure centre, which is much more convenient for me, it's five minutes away...it's helpful to have...I think that also motivated me to continue, like, as in hopefully continue the gym membership." (P18, age 37)</i> <i>"The gym membership was great. I think it really helped make me feel more comfortable in the gym, and I really liked the gym. I think it's a nice environment. It was just more, like,</i>

		<i>I would just get too lazy to leave the flat and then go to the gym, after I'd spent the whole day outside. So, what I would do is just wear my exercise clothes out, and then I would have to go to the gym." (P29, age 22)</i>
	Resistance bands	<i>"For me, it's brilliant because even in situations where you cannot use it (gym), well, you can always do something because you have it in the house, or you can take it with you. It's great. And then my feeling was oh, just resistance bands, but actually when you go, when you set for the higher bands, it's harder." (P06, age 43)</i> <i>"I thought the resistance bands were really good when it came to....so when I felt too lazy to go to the gym and I needed something at home, it was just really easy to just pick up and do a few bicep curls, and that was really good." (P29, age 22)</i> <i>"The resistance bands were very useful to use at home because I would have found it hard to go to the gym more than once a week. So, having something at home I could use because I could use body weight exercises, but then I could also have something else to help me. So, the resistance bands were useful and the gym, so to be honest, at the start, when I tried to go to just the gym itself, but it was always full." (P30, age 27)</i>
Suggestion	Additional information	<i>"I mean, like, I'm pretty happy with the way things are just now. But even just the studies, like, if you had studies that you liked, or that you were aware of, and just upping the reading, I guess. So that it kind of supports what we're doing in the gym." (P08, age 31)</i> <i>"I think just in general how to use the equipment and, like, again safety and then what makes it effective, these sort of things." (P19, age 20)</i> <i>"Maybe, like, some more information on, like, proper form and stuff like that." (P31, age 19)</i>
	Exercise progression	<i>"Well, so I'm doing Pilates, but then I'm also doing yoga as well, so I think I've been setting myself, like, strength goals, like how long can I hold this pose, or can I work up to this? And I think having that marker of progress makes me more motivated to keep going or to...I know I need to get stronger core strength or stronger mobility to be able to do different things." (P14, age 24)</i> <i>"Especially with the resistance bands. I feel like once you're at the top one, what do you do then?" (P31, age 19)</i>

5.6.3.6 Ratings of Knowledge and Satisfaction

Participants' ratings of knowledge and satisfaction are presented descriptively. Participants were asked to rate their knowledge of MSE on a scale of one to five (1= poor, 5 = excellent). The mean knowledge rating was 2.6 ± 0.7 at baseline and 4.2 ± 0.3 at 24 weeks. When asked about their overall satisfaction with the study on a scale of one to five (1= extremely dissatisfied, 5 = extremely satisfied), with a mean rating of 4.7 ± 0.4 .

5.6.4 Potential Effectiveness of the Co-Designed Intervention

5.6.4.1 Changes in body composition

Changes in body composition across four measurement points are presented in Table 5.10. For bodyweight, the repeated measure ANOVA revealed a significant effect of time ($p = 0.01$) but no significant interaction between time and group ($p = 0.837$). The post-hoc paired t-tests showed a significant decrease in bodyweight in the intervention group (-1.41 kg, -2.21% , $p = 0.022$) but not the control group (-0.98 kg, -1.35% , $p = 0.184$) from baseline to week 12. There were no significant changes in either group from baseline to week 24 (control group: -1.04 kg, -1.44% , $p = 0.859$; intervention: -1.36 kg, -2.13% , $p = 0.414$).

The repeated-measure ANOVA also revealed a significant effect of time ($p = 0.008$) but no significant interaction between time and group ($p = 0.849$) for body mass index. The post-hoc paired t-tests showed a significant decrease in body mass index in the intervention group (-0.54 kg/m², -2.25% , $p = 0.016$) but not for the control group (-0.36 kg/m², -1.39% , $p = 0.188$) from baseline to week 12. There was no significant change in either group from baseline to week 24 (control group: -0.37 kg/m², -1.42% , $p = 0.953$; intervention: -0.52 kg/m², -2.17% , $p = 0.324$).

For body fat percentage, there was a significant effect of time ($p < .001$), with no significant interaction between time and group ($p = 0.91$). The post-hoc paired t-tests showed a significant decrease in body fat percentages in both groups. When comparing body fat percentages from baseline to week 12, the control group showed a reduction of 2.31% (-6.92% , $p < .001$) and the intervention group showed a reduction of 2.11% (-6.82% , $p < .001$). From baseline to week 24, the control group showed a reduction of 1.99% (-5.96% , $p = 0.007$), and the intervention group showed a reduction of 2.14% (-6.92% , $p = 0.004$).

The analysis of fat-free mass revealed a significant effect of time ($p = 0.015$) but no significant interaction between time and group ($p = 0.485$). The post-hoc paired t-tests showed a significant increase in fat-free mass in the control group (+1.14 kg, +2.44%, $p = 0.018$) but not for the intervention group (+0.37 kg, +0.85%, $p = 1.000$) from baseline to week 12. There was no significant difference in either group from baseline to week 24 (control group: +0.82 kg, +1.76%, $p = 0.171$; intervention: +0.51 kg, +1.17%, $p = 1.000$).

Lastly, the analysis of vastus lateralis muscle thickness revealed a significant effect of time ($p = 0.028$) but no significant interaction between time and group ($p = 0.418$). No significant changes were seen in the post-hoc paired t-test from baseline to week 12 (control group: +0.56 mm, +2.40%, $p = 0.492$; intervention: +0.86 mm, +3.64%, $p = 0.054$) or from baseline to week 24 (control group: +0.36 mm, +1.54%, $p = 1.000$; intervention: +0.19 mm, +0.80%, $p = 1.000$).

Table 5.10: Changes in body composition across four time points according to group.

Outcome	Timepoint	Control (<i>n</i> = 16)			Intervention (<i>n</i> = 15)			<i>p</i> -value (time)	<i>p</i> -value (time* group)
		Mean ±SD	^a 12-week change (95%CI)	^b 24-week change (95%CI)	Mean ±SD	^a 12-week change (95%CI)	^b 24-week change (95%CI)		
Height (cm)		166.51 ± 6.28	-	-	163.27 ± 5.91	-	-	-	-
Bodyweight (kg)	Baseline	72.44 ± 18.14			63.85 ± 8.20			0.010	0.837
	Mid-Intervention	71.86 ± 17.64	-0.98 (-2.20, 0.24)	-1.04 (-3.01, 0.92)	63.22 ± 8.14	-1.41 (-2.67, -0.14)	-1.35 (-3.38, 0.68)		
	Post Intervention	71.46 ±17.72			62.44 ± 8.28				
	Follow-Up	71.40 ± 17.66			62.49 ± 6.95				
Body Mass Index (kg/m²)	Baseline	25.98 ± 5.89			23.99 ± 3.46			0.008	0.849
	Mid-Intervention	25.78 ± 5.75	-0.36 (-0.80, 0.09)	-0.36 (-1.07, 0.35)	3.75 ± 3.41	-0.53 (-0.99, -0.07)	-0.52 (-1.25, 0.21)		
	Post Intervention	25.62 ± 5.85			23.45 ± 3.37				
	Follow-Up	25.61 ± 5.80			23.47 ± 2.95				
Body Fat Percentages (%)	Baseline	33.40 ± 9.66			30.93 ± 6.22			<.001	0.910
	Mid-Intervention	32.27 ± 9.80	-2.31 (-3.39, -1.23)	-1.99 (-3.54, -0.43)	29.73 ± 6.35	-2.11 (-3.23, -1.00)	-2.14 (-3.75, -0.53)		
	Post Intervention	31.09 ± 9.25			28.82 ± 6.33				
	Follow-Up	31.41 ± 9.38			28.79 ± 5.71				
	Baseline	46.72 ± 5.48			43.65 ± 2.35			0.015	0.485

Fat Free Mass (kg)	Mid-Intervention	47.18 ± 5.50			43.97 ± 2.50				
	Post Intervention	47.86 ± 6.21	1.14 (0.14, 2.13)	0.82 (-0.19, 1.82)	44.02 ± 2.78	0.37 (-0.65, 1.40)	0.51 (-0.52, 1.55)		
	Follow-Up	47.54 ± 5.89			44.16 ± 2.22				
Vastus Lateralis Muscle Thickness (mm)	Baseline	23.37 ± 3.71			23.62 ± 3.21				
	Mid-Intervention	23.35 ± 3.30	0.55 (-0.32, 1.42)	0.35 (-0.90, 1.61)	24.41 ± 3.38	0.86 (-0.01, 1.73)	0.19 (-1.07, 1.44)	0.028	0.418
	Post Intervention	23.93 ± 3.48			24.48 ± 4.05				
	Follow-Up	23.73 ± 3.53			23.81 ± 2.54				

a. Mean changes baseline to 12 weeks

b. Mean changes from baseline to 24 weeks.

5.6.4.2 Changes in Muscular Strength

Handgrip strength data across the 24-week study period are presented in Figure 5.5. No significant effect of time ($p = 0.118$) or time*group interactions ($p = 0.628$) was noted.

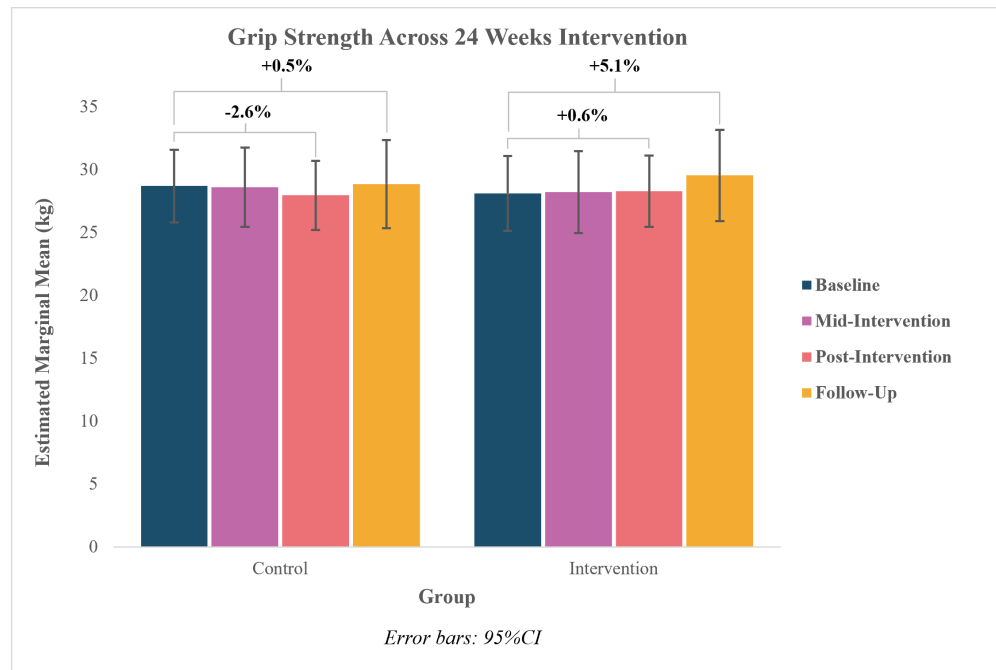


Figure 5.5: Handgrip strength at baseline, mid-intervention (week 6), post-intervention (week 12) and follow-up (week 24) in the control and intervention group. Data are presented as mean (95%CI).

Back strength data across the 24-week study period are presented in Figure 5.6. The repeated-measure ANOVA revealed a significant effect of time ($p = 0.039$), but no significant time*group interaction was found ($p = 0.424$). The post-hoc paired t-tests showed a significant increase in back strength in the intervention group (+9.8 kg, +14.11%, $p = 0.011$) but not in the control group (+3 kg, +4.12%, $p = 1.000$) from baseline to week 12. There was no significant change in either group from baseline to week 24 (control group: +2.94 kg, +4.04%, $p = 1.000$; intervention: +8.93 kg, +12.85%, $p = 0.197$).

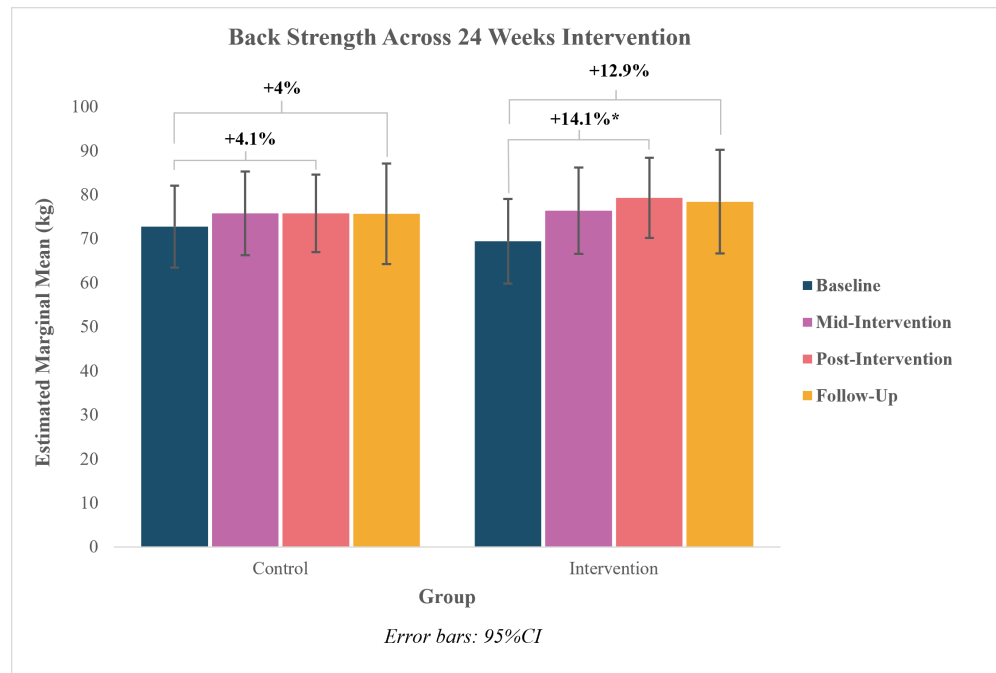


Figure 5.6: Back strength at baseline, mid-intervention (week 6), post-intervention (week 12) and follow-up (week 24) in the control and intervention group. Data are presented as mean (95%CI). * Denotes significant changes from baseline to post-intervention for the intervention group in the post-hoc t-test with Bonferroni correction ($p < .05$).

Knee extensor maximal isometric torque data across the 24-week study period are presented in Figure 5.7. The analysis torque revealed a significant effect of time ($p < .001$) but no significant interaction between time and group ($p = 0.072$). No significant changes were seen in the post-hoc paired t-test from baseline to week 12 (control group: -0.52 Nm, -0.35% , $p = 1.000$; intervention: $+10.89$ Nm, $+8.07\%$, $p = 0.381$) or from baseline to week 24 (control group: $+0.85$ Nm, $+0.58\%$, $p = 1.000$; intervention: $+15.42$ Nm, $+11.42\%$, $p = 0.051$).

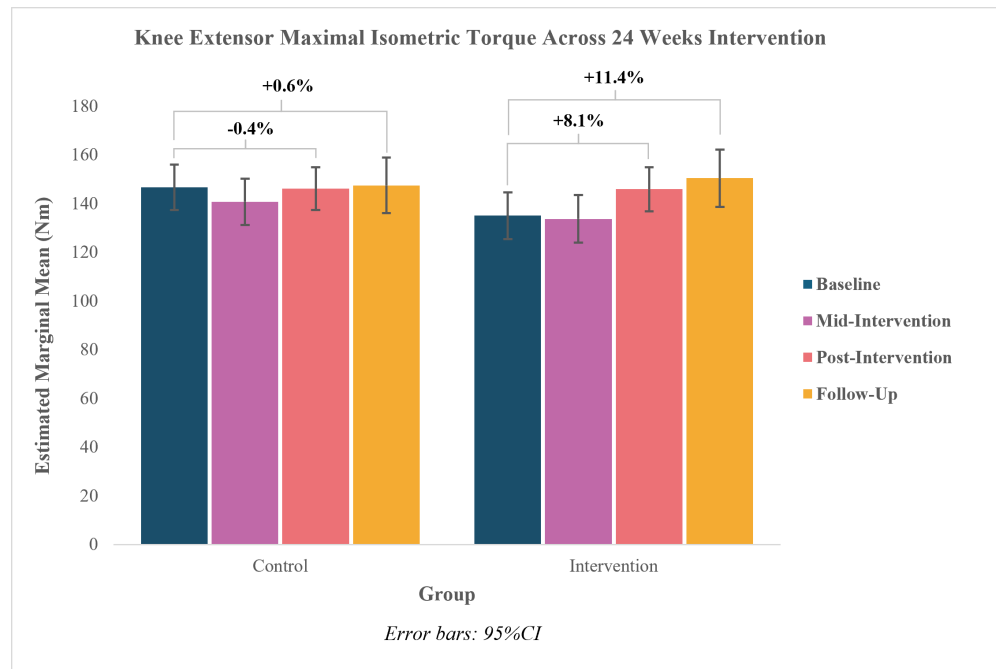


Figure 5.7: Knee extensor maximal isometric torque at baseline, mid-intervention (week 6), post-intervention (week 12) and follow-up (week 24) in the control and intervention group. Data are presented as mean (95%CI).

5.7 DISCUSSION

5.7.1 Principal Findings

The current chapter aimed to assess the feasibility and acceptability of a co-designed MSE intervention for women and to investigate its potential effectiveness on body composition and muscular strength. Participants found the intervention to be feasible, as demonstrated by the successful recruitment of 34 participants (100%) and a 91% retention rate during the 24-week study. Acceptability of the five intervention components varied, with trends indicating that the strength education sessions (with an attendance rate of 80-87% over four weeks) and access to various modalities were highly acceptable. In contrast, the optional group exercise sessions and online support group need further improvement. While a significant effect of time was observed, there is no significant interaction between time and group on any outcomes, and with the relatively low sample size, the conclusions drawn are tentative. Data show that the intervention group, but not the control group, experienced statistically significant improvements in body weight, body mass index, and back strength

from baseline to the post-intervention period. Other measures, such as vastus lateralis muscle thickness, grip strength, and knee extensor maximal isometric torque, showed trends toward improvement in the intervention group, though these did not reach statistical significance. These findings suggest that the co-designed intervention was feasible, acceptable, and may support improvements in body composition and muscular strength among women who previously did not participate in MSE, although further work with a larger sample size and longer study duration is needed, as no interaction effects were observed.

The co-designed intervention was found to be feasible, as shown by the successful recruitment and retention of participants. The paid advertising greatly helped with the recruitment of participants within the short one-month recruitment window. Recruitment reached the target sample size of 34 participants, and the study achieved a 91% retention rate. The retention rate for this current study is higher than other retention rates for physical activity interventions for women, including those involving cancer survivors. In a 12-week culturally tailored physical activity intervention by El Masri et al. (2021) on 22 Arab-Australian women, a 68% retention rate was reported. A 24-week physical activity intervention (ACCEPTANCE study) involving 30 cervical cancer survivors, with a similar study duration and several comparable intervention components, such as education sessions, diary entries, and online social interaction, reported a 77% retention rate (Millet et al., 2025). The Fit2Thrive study, involving a remotely delivered mobile health moderate to vigorous physical activity promotion study among 269 breast cancer survivors, reported a slightly higher retention rate of 94% at 12 weeks (Solk et al., 2025). The high retention rate in the current study may be attributed to the voucher offered upon completion of each lab visit, and the women recruited in this study may be more conscious of their health. Overall, the current study, which involved a co-designed MSE intervention, was highly feasible.

The acceptability of the intervention components varied with the education sessions, and access to various modalities was rated as highly acceptable. The

online support group and logging the training required further improvement. Similar findings were observed in the ACCEPTANCE study, which involved cancer survivors, despite differences in population characteristics with the current study focusing on healthy adults (Millet et al., 2025). The ACCEPTANCE study achieved a 100% attendance rate for its virtual intervention launch and education sessions (Millet et al., 2025), whereas the current study's attendance ranged from 80% to 87% over the four weeks of strength education sessions. The initial education session was crucial in both studies for increasing knowledge about the activities, discussing challenges and facilitators, and learning BCT (Millet et al., 2022). While the ACCEPTANCE study had a higher attendance rate for the coaching session (70%), as participants found it motivating and a chance for self-reflection (Millet et al., 2025), the group exercise sessions in the current study were optional, leading to lower participation due to scheduling conflicts. The ACCEPTANCE study also reported other similar issues to the current study, indicating that the online messaging group (the online support group in the current study) and diary (logging training in the current study) required further modification (Millet et al., 2025). Overall, these findings highlight the importance of educational sessions and access to various modalities, such as group exercise or resistance bands, in encouraging exercise participation among women.

The high feasibility and acceptability of the co-designed intervention suggest that participants in the current study were engaged with the intervention, as reflected in the preliminary findings on muscular strength. Although no significant between-group differences in muscular strength were observed over the study period, within-group analysis showed positive changes in the intervention group. Participants in the intervention group engaged in different types of MSE based on their preferences, and trends towards improvement in muscular strength were observed. Although these findings should be interpreted cautiously, they suggest that a variety of MSE modalities may have the potential to support strength development. In the current study, weight machines and free weights were the most frequently performed modalities, with an average of 98 and 102 sets completed, respectively. Previous studies have shown that the

strength gain effects from traditional MSE, such as weight machines and free weights, were often the largest. For example, in the network meta-analysis of 102 trials by Wiedenmann et al. (2025) on the effect of different resistance training modalities on muscle strength among older adults, it is reported that the largest effect for strength development was elicited from machine-based (SMD 1.34), followed by free weights (SMD 1.15), resistance bands (SMD 0.93), mixed (SMD 0.88) and bodyweight exercises (SMD 0.71). A systematic review and meta-analysis of 7 studies by Lopes et al. (2019) reported that similar strength gains can be achieved through resistance band training, which is comparable to training with machine-based and free weights. While different types of MSE contributed to muscular strength development, the flexibility (i.e., type, location, and timing) offered in the co-designed intervention likely enhanced adherence and engagement with MSE, as participants could choose the exercises they enjoyed. These findings suggest that a variety of accessible, preference-based MSE may support strength gains among women.

Similar to muscular strength, no significant between-group differences in body composition were observed over the study period. Within-group analysis showed reductions in body weight and body fat percentage in the intervention group, with comparable trends observed in the control group, suggesting that these changes cannot be attributed solely to the intervention. Changes in fat-free mass were minimal in both groups. Previous research demonstrated that MSE can reduce body fat and increase lean mass, particularly when the program involves sufficient training volume and longer duration (Wewege et al., 2022, Lopez et al., 2022). For example, a systematic review and meta-analysis of 54 studies by Wewege et al. (2022) reported that resistance training, averaging 20.5 weeks and 2.7 sessions per week, reduced body fat percentages by 1.4%. Similarly, a meta-analysis of 116 studies by Lopez et al. (2022) observed a significant increase in lean mass following resistance-based exercises across an average intervention duration of 14.6 weeks, with frequency ranging from one to five sessions per week. The absence of significant between-group effects in the present study may therefore reflect the relatively short intervention duration, flexible participation in MSE and limited statistical power. Nevertheless, the

observed within-group changes in the intervention group suggest that flexible participation in MSE may help support maintenance of lean mass and modest reduction in body fat among women although these findings require further testing in fully powered trial.

The absence of significant between-group effects in body composition and muscular strength may reflect insufficient exercise dose. In the current study, participants in the intervention group were encouraged to perform MSE of their choices for two or more days a week, and the training volume was not standardised. Consequently, physiological adaptations were likely dependent on individual engagement and total exposure to MSE. Previous research has demonstrated that higher training volumes generally lead to better hypertrophic adaptations (Schoenfeld et al., 2017). In a 12-week randomised parallel-group repeated-measures study on the effect of weekly set progression, Enes et al. (2025) reported that a progressive increase of 2 and 4 weekly sets every two weeks can yield greater improvements in muscular strength and muscle cross-sectional area. Furthermore, the relatively short active intervention period (12 weeks of active intervention with follow-up at 24 weeks) may also have limited the magnitude of detectable changes. However, it is important to note that the participants engaged with the co-designed intervention and reported participation in MSE throughout the study, suggesting its potential value as a behavioural entry point even when the physiological changes were modest.

5.7.2 Potential Intervention Improvement and Future Research

The feasibility, acceptability, and potential effectiveness explored in this chapter have revealed various ways to improve the co-designed intervention. The study highlights the importance of a more flexible and personalised physical activity intervention approach, allowing participants to tailor exercise preferences, location and timing while maintaining predefined activity targets. With each intervention component, several suggestions for improvement were made.

The strength education sessions and access to various modalities were received positively as a means of helping women participate in MSE. These sessions were seen as essential and should be expanded to include more topics on exercise techniques, nutrition, and training throughout the menstrual cycle and at different stages of life, such as pregnancy, postpartum, perimenopause, and menopause. The modalities given in the current study (resistance bands and gym membership) were helpful in getting women started in MSE, as they gave them an option, but they should be accompanied by further information on using the equipment and how to progress. These should be added as part of the education session topics.

While a training log is helpful, further refinement is needed, such as a digital or online format, likely to enhance the practicality for both participants and researchers, including during the follow-up period. Having an application-based training log would allow training to be logged in real time. Additional features, such as a progress monitor (e.g., percentage of improvement, physical and performance feedback), and a notification reminder if the user has not achieved at least two days a week of MSE, could also be added. Adding a leaderboard-like feature to the application that provides a score (e.g., experience points) based on their performance could enhance motivation to exercise and foster a sense of community.

The online support group and optional group exercise sessions were the intervention components that needed the most improvement. As the online support group was mainly researcher-led, future intervention could convert this component into access to an expert. This component could be used for participants to discuss any concerns they have, ask for guidance and suggestions, and for the researcher or appointed expert (e.g., a personal trainer) to share information such as an exercise plan, exercise videos, or the latest evidence on MSE. While the online support group had limited interactions among participants, future interventions could restore bi-weekly or monthly in-person meetings, with several group activities planned during each meeting. In-person meetings may help participants form meaningful friendships and establish a stronger community, which would then encourage communication

among participants. Although the group exercise sessions were optional, attendance could be improved by increasing the frequency and locations offered. Future interventions could consider joint collaboration with trainers at local gyms, fitness centres, and community centres to allow for more sessions and greater accessibility for participants.

Given the observed potential effectiveness, future research should evaluate this intervention across a broader age range, particularly among women over 45 years, including those who are menopausal or retired, as preferences and life contexts may differ. Extending the duration of both the intervention and follow-up period may help determine sustained engagement in MSE. Future studies should also explore how progressive overload can be implemented within a flexible co-design intervention, while monitoring other physical activity behaviours to better isolate the intervention effects. Expanding the outcome measures to include muscular endurance, such as a 30-second sit-to-stand test, would be beneficial for measuring other changes in muscle adaptations. While the current study uses qualitative outcomes from interviews on participants' perceptions of intervention components, future studies should consider a mixed-methods approach including quantitative measures, such as surveys or questions on participants' own numerical ratings, which would provide a more comparable interpretation between participants. Future studies could also explore the effect of the co-design intervention on mental health outcomes.

5.7.3 Strengths and Limitations

The strengths of this current study include the utilisation of a randomised controlled trial design and the co-design of the intervention with the target group, who responded to their needs. With the education sessions provided and access to various modalities given as part of the intervention, the intervention was designed to address common participation challenges, such as perceived time constraints and a lack of confidence in ability and knowledge. Participants in this study were not required to be entirely inactive to be eligible. While this may have influenced the outcomes based on their pre-existing activity levels, such as participation in other types of physical activity, it also enhances the

external validity of the findings, making them more generalisable and applicable in real-world settings. The flexibility and more personalised approach to the intervention have also led to better adherence to the study. However, this current study has several limitations. First, the current study is a pilot study with a small sample size and was not powered to detect between-group differences in study outcomes. Secondly, the assessment of functional outcomes was limited as the current study focused primarily on measures of muscular strength, with no direct assessment of broader functional performance. Additionally, the age range of participants (18 to 45 years old) limits the generalisability of findings to women in the older age group, especially those in the menopausal stage. Finally, the absence of training records from week 13 to week 24 makes it harder to be certain of the participation rate after the post-intervention visit.

5.8 CONCLUSION

In conclusion, this pilot randomised controlled trial found that a 12-week co-designed MSE intervention, with a 24-week follow-up, is feasible and acceptable among women who had not previously met the muscle-strengthening guidelines. Education sessions and access to various modalities, such as gym memberships and resistance bands, were highly favourable and considered crucial to helping women participate. Although changes in body composition and muscular strength outcomes were small and not consistently statistically significant, the findings suggest that a flexible, preference-based, co-designed approach may support women's engagement in MSE. Overall, these results highlight the potential of a co-designed intervention as a practical and adaptable strategy that may support women's participation in MSE. Future research should include a broader age range, a longer duration, progressive overload, and an exploration of nutritional aspects to determine how the co-designed intervention influences changes in body composition and muscular strength.

CHAPTER 6 – THEORY MAPPING

6.1 INTRODUCTION

When creating an intervention to change a behaviour, it is widely recommended to be grounded in a theoretical framework (Michie et al., 2008, Skivington et al., 2021). In this PhD work, the initial studies were exploratory and not intended to support intervention development. Rather, the earlier work (Chapter 2) was exploratory, and it was only after the completion and analysis of the survey that the research focus evolved towards improving women's participation in MSE. Consequently, theory mapping was undertaken retrospectively. The retrospective mapping was undertaken to enhance understanding of the behavioural mechanism underpinning the intervention and to strengthen its theoretical transparency. While the intervention was developed through sequential mixed-methods and co-design approaches, linking its components to behaviour change theory provides a clearer explanation of how it is expected to influence behaviour and facilitate future refinement and evaluation (Michie et al., 2018). This approach is consistent with the recommendations from the MRC framework, which emphasises the importance of understanding mechanisms of action within complex interventions (Skivington et al., 2021).

In the next section, the co-designed intervention is synthesised with the COM-B model Michie et al. (2011) and the BCTs Taxonomy by Michie et al. (2015) to show how it was linked to multiple mechanisms that support MSE behaviour. The COM-B model is a behaviour change framework by Michie et al. (2011) that highlights three key elements for understanding a behaviour. The elements are: (1) Capability: the physical and psychological ability to adopt the intended behaviour, (2) Opportunity: the physical and social factors that make intended behaviour possible or prompt it, and (3) Motivation: the reflective and automatic processes that energise and direct the intended behaviour (Michie et al., 2011). BCTs are evidence-based methods designed to change behaviour, allowing for observation and replicability in intervention design (Michie et al., 2015).

Several behaviour theories could have been considered, such as Social Cognitive Theory (Bandura, 1986) and Self-Determination Theory (Ryan and Deci, 2000). However, the COM-B model was selected because it provides a comprehensive yet pragmatic framework that integrates individual capability, environmental opportunities and motivational influences on behaviour. This was particularly relevant given the findings from Chapters 3 and 4, which identified barriers and facilitators that touched all three domains. Furthermore, the COM-B provides a direct link to the BCTs Taxonomy, allowing the intervention components to be systematically mapped to potential mechanism of action. Therefore, this chapter aims to retrospectively map the co-designed intervention components to the COM-B model and BCT Taxonomy to enhance theoretical transparency.

6.2 INTEGRATION OF COM-B MODEL AND BCTs TAXONOMY IN THE CO-DESIGNED INTERVENTION

Given the complexity of MSE behaviour, analysing the co-designed intervention through behaviour science frameworks can help clarify how and why the intervention is expected to change behaviour. To synthesise the development and implementation of the intervention, Table 6.1 outlines how each component of the co-designed intervention aligned with the COM-B model (Michie et al., 2011) and the BCTs Taxonomy (Michie et al., 2013), and how these elements were informed and shaped through the co-design process. This integration illustrates what is required for behaviour change to occur (COM-B) and the mechanisms through which it can occur (BCTs). It shows how these theoretical components were operationalised within the participatory approach (co-design).

6.2.1 Strength Education Session

The strength education sessions were designed to address the key barriers reported in Chapters 3 and 4, particularly women's lack of knowledge and confidence in their abilities, time constraints, and misconceptions about MSE. The co-design workshop highlighted what women need to improve their

knowledge and self-efficacy, which shaped the session content and delivery. This component primarily targeted capability (both physical and psychological) by improving knowledge and understanding of techniques, and reflective motivation by strengthening beliefs about the benefits and relevance of MSE. Several BCTs were operationalised in this component. Instruction on how to perform the behaviour (BCT 4.1) and information about health consequences (BCT 5.1) supported the psychological capability, whereas demonstration of behaviour (BCT 6.1) enhanced physical capability through skill acquisition and development. Credible sources (BCT 9.1) were employed by having a trained researcher (NR) deliver the sessions. Elements of self-regulation to help women initiate MSE were incorporated through goal setting (behaviour) (BCT 1.1), goal setting outcome (BCT 1.3), problem solving (BCT 1.2) and action planning (BCT 1.4). These techniques were included in the education session booklet. These BCTs were intended to support reflective motivation by helping women identify barriers, plan MSE according to their schedules and routines, and clarify their goals. Together, these inclusions were expected to increase women's knowledge and confidence in their ability to perform MSE and support the initiation of behaviour change.

Table 6.1: Integration of COM-B and BCTs Taxonomy in the co-designed intervention.

Intervention Component	COM-B Domain Targeted (Michie et al., 2011)	Key BCTs (v1 codes) (Michie et al., 2013)	Co-Design Contribution
Strength Education Session	• Capability – physical (<i>skills acquisition and development</i>) and psychological (<i>knowledge about exercise benefits and techniques</i>), • Motivation – reflective (<i>belief about the importance of MSE, intention formation</i>)	(1.1) Goal setting (behaviour) (1.2) Problem solving (1.3) Goal setting (outcome) (1.4) Action planning (4.1) Instruction on how to perform a behaviour (6.1) Demonstration of the behaviour (5.1) Information about health consequences. (9.1) Credible sources	Participants highlighted the need for education session at the start of the intervention and discussed the information and skills they think is needed to help women's participation in MSE.
Optional Group Exercise Session	• Capability – physical (<i>practical skills development</i>) and psychological (<i>knowledge on performing the exercises</i>) • Opportunity – social (<i>social influence, modelling, guided support</i>) • Motivation – reflective (<i>plans and commitment for exercising</i>) and automatic (<i>enjoyment, social reinforcement</i>)	(4.1) Instruction on how to perform a behaviour (6.1) Demonstration of behaviour (8.1) Behavioural practice/rehearsal	Participants highlighted the need for non-intimidating, women-only exercise session or class as this would help to overcome the fear of being watched and lack of confidence in abilities.

Online Support Group	• Opportunity – social (<i>peers/social influence</i>) • Motivation – reflective (<i>encouragement that reinforces commitment and intentions to do MSE</i>) and automatic (<i>emotional support, affective reinforcement</i>).	(3.1) Social support (unspecified) (6.2) Social comparison (7.1) Prompts/cues	Participants identified the need for accountability buddy or coach and sense of community to motivate women to do MSE.
Logging the Training	• Capability – psychological (<i>self-monitoring skills and awareness building</i>) • Motivation – reflective (<i>self-regulation, feedback and tracking progress</i>) and automatic (<i>habits formation cues, satisfaction after completion of exercise</i>)	(2.6) Biofeedback (2.3) Self-monitoring of behaviour (7.1) Prompts/cue	Participants suggested that having a log to track the exercise could help to reinforce consistency, act as reminders and visual progress of MSE. Training log in the finalised intervention include section on reflection and goal setting for the following week.
Access to Various Modalities	• Capability – physical (only when guidance/instruction included) • Opportunity - physical (<i>access, affordability</i>) • Motivation – reflective (<i>supports intention to do MSE</i>)	(12.1) Restructuring the physical environment (12.5) Adding objects to environment	Participants highlighted the need for various modalities (i.e., affordable gym membership, other exercise modality such as resistance bands) to allow women to choose the exercises they enjoyed and aligned with their live experience.

BCTs = Behaviour Change Techniques; MSE = muscle-strengthening exercises

6.2.2 Optional Group Exercise Session

The optional group exercise sessions were designed to address barriers related to cultural stigma and societal perceptions, fear of being watched, and a lack of confidence in abilities. While this was the least well-performed component of the co-designed intervention, some participants still found it helpful in building their confidence and providing proper guidance for exercise. Capability (both physical and psychological) is developed through knowledge and skill development. Exercising in a group setting with guided support allows for social Opportunity to take place. Motivation (both reflective and automatic) was targeted through planning to attend the session and social reinforcement. Several BCTs were employed in this component. Instruction on how to perform a behaviour (BCT 4.1), demonstration of the behaviour (BCT 6.1), and behavioural practice/rehearsal (BCT 8.1) were all used to target physical and psychological capability, social opportunity, and automatic motivation. This intervention component, although not fully utilised during the pilot testing, was expected to increase physical and psychological capability by providing a supervised, structured exercise and enhancing social opportunities through group participation. Observing others and receiving guidance were anticipated to reduce exercise anxiety and strengthen the automatic motivation as a result of increased confidence and comfort in doing MSE.

6.2.3 Online Support Group

The online support group was designed to facilitate communication with the researcher and social interaction among participants. It emerged from the co-designed workshop, where women expressed a need for encouragement, peers, and support. This component was created to target the social opportunity through social influence, a sense of community, and motivation (both reflective and automatic) driven by reinforcement, ongoing encouragement by the researcher and a sense of social presence within the group. Several BCTs were operationalised in this component. Although peer interactions did not fully develop, the group functioned primarily as a weekly reminder. Social support (unspecified) (BCT 3.1) and social comparison (BCT 6.2) were utilised through weekly polls, in which participants voted for the sessions they had completed. Prompts/cues (7.1) were delivered through the reminders to submit the training log to the researcher and reminders to exercise. Together, the weekly prompt and exposure to peers' MSE participation were expected to strengthen reflective motivation by sustaining the intention to perform MSE, reinforcing exercise planning and creating accountability.

6.2.4 Logging the Training

The insights from the co-design workshop regarding the need to track progress, remain consistent, act as reminders, and offer visual progress. This component targets psychological capability through self-monitoring skills and reflective motivation by reinforcing behaviour, self-regulation and tracking progress. Automatic motivation was supported by habit formation and a sense of satisfaction upon completing exercise. Several BCTs were employed in this component. Self-monitoring of behaviour (BCT 2.3) was the core technique participants used to monitor their exercise participation and progress. Recording the training also served as a prompt/cue (BCT 7.1) that helped to establish a behavioural routine. Logging the training done was complemented by biofeedback (BCT 2.6) during lab visits, where participants received feedback on their improvement and performance. This reinforced their sense of progress, thereby strengthening their reflective motivation and supporting continued participation in MSE. Together, the self-monitoring aspect was expected to reinforce reflective motivation by increasing participants' awareness of their progress and consistency with their MSE participation. Logging the training served as a behavioural cue, reinforcing the automatic motivation to include MSE in the participants' routine. The biofeedback received during lab visits provided evidence of improvements, which were expected to enhance the motivation to continue participating in MSE.

6.2.5 Access to Various Modalities

Access to various modalities (gym memberships and resistance bands) emerged from the co-design workshop, where participants discussed the importance of having more affordable options, such as cheaper modalities and gym memberships. Providing these modalities primarily targeted the physical opportunity to perform MSE by removing barriers related to cost, access, and equipment availability. When instruction on performing the exercises was provided during the strength education and optional group exercise sessions, this supported physical capability. The flexibility in choosing the MSE types, exercise location and time further influenced the reflective motivation by making MSE more feasible and aligned with individual life experiences. Key BCTs employed for this component were restructuring the physical environment (BCT 12.1), operationalised by enabling access to the gym space and adding objects to the environment (BCT 12.5), operationalised through the provision of resistance bands. Together, they helped reduce financial barriers, thereby increasing the

physical opportunity to engage in MSE. The offered modalities allowed participants to practice various types of MSE, strengthening their physical capabilities. The flexibility in choosing MSE types, location, and time was anticipated to enhance the reflective motivation by making MSE more feasible, acceptable and accessible.

Overall, the synthesis of these components showed how a co-designed intervention was linked to multiple mechanisms that support MSE behaviour. Each intervention component targeted a different configuration of capability, opportunity, and motivation and utilised BCTs suitable for those mechanisms. These intervention components formed a coherent behavioural system that could support the initiation of MSE behaviour, as participants were equipped with knowledge, supported and enabled to participate. This layered relationship highlighted the complexity of MSE behaviour and underscores the importance of co-design in shaping interventions that are feasible, acceptable and theoretically grounded.

While the intervention was not originally developed using a theory-led approach, retrospective COM-B and BCTs mapping enhance the conceptual clarity of the intervention, identified plausible mechanism of action, and provides a theoretical foundation for future optimisation and evaluation.

CHAPTER 7 – GENERAL DISCUSSION

7.1 INTRODUCTION

The 2019 UK physical activity guidelines recommend that adults engage in muscle-strengthening activities for two or more days a week, targeting the major muscle groups (Department of Health and Social Care, 2019). However, less than 35% of adults in the UK meet these guidelines, with even lower participation among women (Deakin et al., 2024a, Health Survey for England, 2023). Given the unique barriers to participation in MSE among women, it is essential to identify ways to increase women's involvement in MSE that are contextually relevant to their lived experiences. The gaps highlight three key areas requiring further investigation, which were:

- What activities are adults in the UK currently participating in to meet the muscle-strengthening guidelines?
- How do women who meet and do not meet these guidelines experience MSE?
- How can interventions be developed collaboratively with women to ensure they are acceptable, feasible, and aligned with their experiences?

Over four sequential studies, this thesis aimed to:

- **Chapter 2:** (1) To identify the types, frequency, intensity, and duration of activities adults participated in to meet the UK government's muscle-strengthening activities recommendations, and (2) to examine whether there are any differences between the sexes.
- **Chapter 3:** (1) To explore the barriers and facilitators to participation in MSE among women aged 18 to 64 who are currently meeting the muscle-strengthening guidelines, and (2) to identify strategies to improve involvement in these activities.
- **Chapter 4:** (1) To explore the barriers and potential facilitators to participation in MSE among women who did not meet the muscle-strengthening activities guidelines, and (2) to co-design a MSE intervention to assist women's participation.
- **Chapter 5:** (1) To assess the feasibility and acceptability of a co-designed MSE intervention for women, and (2) to investigate the effectiveness of the co-designed MSE intervention on body composition and muscular strength.
- **Chapter 6:** To retrospectively map the co-designed intervention components to the COM-B model and BCT Taxonomy to enhance theoretical transparency.

7.2 SUMMARY OF KEY FINDINGS

The infographic of the key findings is provided in Appendix 7 and has been used to communicate research findings to participants and wider audiences through social media. Chapter 2 presented adherence to muscle-strengthening guidelines based on the 2019 UK Physical Activity Guidelines among adults aged 18 to 64 years in the UK, for both MSE and daily living activities. Although the data did not represent the general population, this study provides data on the daily living muscle-strengthening activities listed in the physical activity guideline that were not captured by the national surveillance. 76% of participants self-reported meeting the guidelines, and among those who self-reported not meeting the guidelines, 95% met the two or more days a week recommendation, with the majority meeting this recommendation when daily living muscle-strengthening activities, such as carrying a shopping bag and climbing stairs, were included. In agreement with previous national surveillance, women in both groups reported doing fewer MSE and daily living muscle-strengthening activities than men. Sex differences were also seen in the types of MSEs participated in, where women were less likely to participate in the traditional MSE (i.e., weight machines or resistance) and were more inclined to participate in holistic exercises such as yoga and Pilates. The findings of Chapter 2 strengthened the rationale of refining the subsequent studies to focus on women and identify ways to improve women's participation in MSE.

Chapters 3 and 4 explored the barriers and facilitators to MSE participation among women who met and did not meet the muscle-strengthening guidelines, through follow-up interviews (Chapter 3) and co-design workshops (Chapter 4). Similar barriers and facilitators were identified in both groups of women. Main barriers include time constraint, lack of knowledge and ability, accessibility (cost, equipment and space availabilities) and cultural stigma and societal perception of women not needing to do MSE and MSE being more male dominated. Potential facilitators reported by women who did not meet muscle-strengthening guidelines (Chapter 4) were also similar to those reported by women who met the guidelines, including facilitators and strategies to improve women's participation in MSE (Chapter 3). This includes scheduling and prioritising MSE, using resources such as instructor help or exercise classes to increase knowledge and confidence, choosing exercises they enjoy, and using women-only spaces, according to their schedule.

Chapter 4 involved a co-design process to develop an intervention to help women participate in MSE through two co-design workshops. The findings in Chapter 4 informed a programme theory for MSE to summarise the mechanisms underlying changes in women's MSE behaviour. Three key elements were identified for inclusion in the co-designed intervention: (1) education (strength education session), (2) social (online support group and optional group exercise sessions), and (3) modalities (access to various modalities and logging the training). The finalised intervention aimed to have participants complete any MSE of their choice on two days a week, combined with several intervention components (strength education session, online support group, optional group exercise sessions, access to various modalities and logging the training), while also emphasising participants' autonomy in selecting the exercise logistics (type of MSE, timing, and location).

Chapter 5 evaluated the feasibility, acceptability, and effectiveness of the co-designed intervention and indicative change on outcomes of body composition and muscular strength. The intervention was feasible, achieved a 100% recruitment rate, and a 91% retention rate over a 24-week study duration. Strength education sessions (80-87% attendance rate) and access to various modalities (12-week gym membership and resistance bands) were rated as highly acceptable for improving women's participation in MSE. Logging training was reported to be helpful, but it was suggested that the log be digitised to improve practicality in recording and extracting data. While some find optional group exercise sessions and online support groups helpful, they still need further refinement in their delivery. The co-designed intervention showed potential improvement in body composition (body weight and body mass index), and muscular strength (back strength) from baseline to post-intervention in the intervention group, but there was no difference between the intervention and control. Other measures (vastus lateralis muscle thickness, grip strength, and knee extensor isometric torque) showed potential trends toward improvement following the intervention but no significance. Whilst the individual data showed that participants in the intervention group had potential improvements in body composition and muscular strength, this change was too small to reach statistical significance, and as the sample size is small, the conclusions drawn are tentative.

Chapter 6 involved retrospective mapping of the co-designed intervention to the COM-B and BCTs taxonomy to enhance the theoretical transparency. This mapping showed that the

key elements of the co-designed intervention involved education, social and modalities, collectively addressing multiple behavioural determinants of women's participation in MSE, including capability, opportunity and motivation. When each intervention component was linked to BCTs, it provided insight into the intervention's underlying behavioural mechanism and strengthened the conceptual understanding on how the co-designed intervention could support MSE participation.

7.3 INTERPRETATION OF THE FINDINGS

This PhD thesis has added new insights into women's participation in MSE. This thesis has outlined the multifactorial influence on women's engagement in MSE. In the first study (Chapter 2), the work extends understanding of adults' adherence to the UK muscle-strengthening guidelines (Health Survey for England, 2023, Deakin et al., 2024a), with new insights into how adherence differs when daily living activities such as stair climbing and carrying shopping bags are taken into account. This finding is important because it highlights inconsistencies between what is considered a muscle-strengthening activity in the national surveillance and in the physical activity guidelines. Notably, the observed sex differences in the activity type suggest that women were more likely than men to meet the muscle-strengthening activity guideline through holistic exercise and daily living activities at lower intensities. While including these activities in national surveillance may improve participation in muscle-strengthening behaviours, there is still limited evidence regarding whether daily living activities provide sufficient training stimulus to develop muscular strength. Therefore, future research is needed to determine whether daily living activity produce meaningful strength adaptation to justify their inclusion within the muscle-strengthening guidelines. Taken together, these findings suggest that women may be more likely to meet the muscle-strengthening through lifestyle-integrated and lower intensity activities that support behavioural adherence but may not consistently provide sufficient overload for physiological improvement.

The exploration of women's barriers and facilitators in the second study (Chapter 3) was consistent with prior literature that explores barriers and facilitators to women's participation in MSE (Vasudevan and Ford, 2022, Coen et al., 2018, Bopp et al., 2004). The current research extends this work by moving beyond problem identification to the development and preliminary evaluation of a tailored intervention to support women's engagement in MSE.

Importantly, strategies reported by women who already achieve 2 or more days a week of MSE provide actionable insight that might be transferable to women who did not meet the muscle-strengthening guidelines, highlighting the value of peer-informed approaches in the intervention design.

Although previous MSE interventions targeting women have been reported and discussed in Chapter 1 (Ashmead and Bocksnick, 2002, Arikawa et al., 2011, Seguin et al., 2012, Heiestad et al., 2016, Prieto-Prieto et al., 2022), this PhD thesis addresses the limitation of the inclusion of participants' voices during the intervention development. In the third study (Chapter 4), involving women in the co-design process produced an intervention perceived as relevant, acceptable and aligned with their experiences, contributing to higher participants' satisfaction, aligned with existing literature on participant-centred research (Durand et al., 2014, Martin et al., 2005, Frank et al., 2014). The suggestions generated through the co-designed process further refine the understanding of features that may enhance women's participation in MSE. The intervention components included were also aligned with previous literature as what could help women to participate in MSE (Petrov Fieril et al., 2014, Luckin et al., 2021, Hurley et al., 2018, Heiestad et al., 2016, Vasudevan and Ford, 2022).

In theory-driven intervention research, using a behavioural framework has been suggested to enhance clarity and replicability, as demonstrated by the Cycle Nation study, which utilised the 6SQuID model to guide the intervention development (Connell et al., 2022). Although theory was not explicitly applied during the initial development of the co-designed intervention, retrospective mapping to the COM-B model and BCTs taxonomy (Chapter 6) showed strong alignment with key behavioural components such as capability, opportunity, and motivation. This suggests that interventions developed through co-design, even without formal theoretical guidance, may target relevant behaviour mechanisms. Other studies also support the use of COM-B for behavioural change interventions. For example, a COM-B-based lifestyle intervention in overweight and obese adolescents in Vietnam showed improved outcomes related to metabolic syndrome (Nam et al., 2025). Similarly, a review of physical activity interventions for individuals with stroke by Paterson et al. (2024) found that interventions incorporating at least two COM-B elements were more likely to enhance physical activity behaviour. However, evidence on the application of COM-B in

interventions for MSE remains limited, highlighting the novel contribution of this post hoc mapping approach.

In the fourth study (Chapter 5), the co-designed intervention demonstrated that flexible, participant-centred approaches can successfully initiate women's engagement in MSE, as they prioritise autonomy and enjoyment. Adherence was high, with strong recruitment and retention, indicating that the intervention was both acceptable and feasible for the participants. While the study was not powered to detect statistically significant physiological changes, the trends observed in body composition and muscular strength suggests promising effects when participants engage consistently with the intervention. Importantly, the study has offered new insights showing that the co-designed intervention acted as an important behavioural entry point for women's participation in MSE. Future studies should build on this initial engagement and include adequate exercise dose and progression to observe physiological changes (Schoenfeld et al., 2017, Enes et al., 2025).

The findings also have implications for the implementation of MSE beyond a research setting. While the intervention is feasible in a real-world public health setting, it would benefit from streamlining and strategic partnership to support scalability and sustainability. The flexibility embedded within the intervention may support wider implementation, as women were able to select the type of MSE, location and timing for their participation according to their life circumstances. However, the real-world implementation would need greater consideration of the workforce capacity, training needed, affordability, and access to appropriate facilities and resources.

Among the intervention components, the strength education sessions are likely to be the most easily transferable beyond the research setting. These sessions were highly utilised by the participants and could be delivered in relatively low-cost settings such as community or leisure centres, workplace settings or through healthcare referral pathways. In contrast, access to various modalities, such as gym memberships and resistance bands, may pose greater cost challenges. However, this could potentially be addressed through partnerships with community organisations or subsidised access to facilities. Consistent with the recommendations from the MRC framework for developing and evaluating complex interventions (Skivington et al., 2021), future research should explore how the interventions

can be embedded within existing systems while maintaining the flexibility and autonomy valued by the participants.

This PhD thesis makes an original contribution by integrating evidence from survey data, qualitative exploration, co-design approach, and a pilot feasibility RCT to demonstrate the complex relationship between behavioural feasibility and physiological adequacy in women's participation in MSE. It contributes novel insights into how flexible and preference-based approaches can successfully initiate engagement in MSE, while also highlighting such approach may not consistently provide sufficient training dosage for optimal physiological adaptation. Collectively, this PhD thesis extends the current literature by highlighting the complex relationship between behavioural feasibility and physiological adequacy in women's participation in MSE. While preference-based and lifestyle-integrated approaches may support the initiation of MSE, they may not consistently deliver sufficient exercise dosage to improve physiological changes. Therefore, future promotion strategies for women should adopt the staged approach by supporting behaviour initiation through flexible and context-sensitive programming, then progress towards an adequate training dose.

Although the findings provide important insight into women's participation in MSE, consideration should also be given to women who remain disengaged from MSE and who may not actively seek opportunities to participate. While Chapter 4 and 5 specifically involved women who did not meet the MSE guidelines, participants who volunteered for the co-design workshops and the intervention testing may still have been more receptive to behaviour change than the wider population. Consequently, additional barriers experienced and potential facilitators by women who are uninterested in or actively avoiding MSE may not have been fully captured. Nevertheless, the emphasis on flexibility, autonomy, social support, and accessibility in MSE participation suggests that the intervention components may provide a useful foundation for initiating MSE among women with little to no prior experience. Embedding participants' perspectives into the intervention design remains essential to improve relevance, engagement, and sustainability of MSE behaviour, while broader environmental and sociocultural constraints on women's participation, particularly time availability, access to spaces and gendered exercise norms, such as women not needing MSE, should be explicitly addressed in future interventions and policy development.

7.4 IMPLICATION FOR PRACTICE AND RESEARCH

The findings in the thesis highlights the implications for researchers, practitioners, and policy development. From a research perspective, future intervention studies should move beyond behaviour initiation and incorporate progressive overload and sufficient training dosage to ensure physiological adaptations are achieved alongside behavioural engagement. From a practice perspective, MSE promotion should prioritise flexibility and preference-based delivery models that lower the entry barriers for women who are not currently engaged in structured exercise, while embedding mechanisms for progression over time. Practitioners delivering physical activity interventions should consider integrating education-based components as a low-cost, scalable entry point, alongside partnerships with community and healthcare settings, to improve access and opportunities to participate. From a policy perspective, clearer guidance may be required on the role of lifestyle-integrated muscle-strengthening activities within surveillance systems, particularly in relation to whether they are intended to reflect behaviour participation or physiological adequacy. The findings from the thesis suggest that effective promotion for MSE requires a staged approach that support the initiation through flexibility and autonomy, followed by structured progression in order to achieve meaningful health outcomes.

7.5 STRENGTHS AND LIMITATIONS OF THE THESIS

7.5.1 Strengths of the thesis

The main strength of the thesis is its mixed-methods design, which combines qualitative and quantitative approaches to yield richer, more in-depth results. Integrating these methods with a co-design approach allowed the study to quantify patterns of MSE participation, identify barriers and facilitators to participation, and inform the development of an intervention relevant to women's real-life experiences. Given that women participate in MSE less than men do, this approach demonstrates the potential to develop strategies and interventions to improve women's participation in MSE. The inclusion of daily living muscle-strengthening activities, as outlined in the 2019 UK Physical Activity Guidelines, captured the variation of activities that were often not reported in surveillance data. The feasibility and acceptability of the co-designed intervention, assessed alongside body composition and muscular strength, provided a clear understanding of its potential effects. Finally, the co-designed intervention was highly relevant to participants, as it was informed directly by women who did and did not meet the muscle-strengthening guidelines, addressing the barriers to participation.

7.5.2 Limitations of the thesis

The main limitation of the thesis lies in its study population and representativeness, as all participants were based in the United Kingdom. Across four sequential studies, participants predominantly lived in the least deprived area, were employed full-time, and had a university degree or higher, which limits generalisability to women from more deprived areas or with lower educational backgrounds. The lack of ethnicity data further limits understanding of the barriers and facilitators for women of diverse backgrounds. Both the quantitative survey and the qualitative interview relied on self-report data and were more prone to recall and social desirability bias. While the co-designed intervention was tested using a randomised controlled trial, it was not powered to assess effectiveness due to its pilot nature. It also only explored the feasibility, acceptability, and effects on body composition and muscular strength among women aged 18 to 45 years. The short study duration limits the insights into long-term adherence to MSE, and several intervention components also need further refinement. Finally, the theoretical framework for behaviour change was applied post hoc, rather than guiding the study design.

7.6 FUTURE WORK DIRECTIONS

Building on the findings and limitations of this thesis, several suggestions for future work can be identified as follows:

7.6.1 Diversify Background

Future studies should explore the pattern of MSE and the barriers and facilitators for participation in MSE across women with different socio-economic backgrounds, ethnicities, and life stages, to allow for the co-design of a more contextually relevant intervention for each group. Collecting income data in addition to the deprivation category for participants' demographic background allows for a better understanding of participants' economic stance.

7.6.2 Larger Scale Randomised Controlled Trial

Given the small sample size and shorter study duration (24 weeks) of the pilot randomised control trial, there is a need to scale up the trial. Further refinement of the co-designed intervention is needed, as outlined in Chapter 5, Section 5.7.5. Following demonstration of

the feasibility and acceptability, a power calculation should guide the recruitment for a larger trial to determine the intervention's effectiveness. A longitudinal study would provide insight into the sustainability of MSE engagement and its long-term health effects.

7.6.3 Behaviour Change Mapping

As the current thesis applied the theoretical frameworks post hoc, future studies should incorporate them from the start to strengthen the intervention's design and evaluation. The COM-B model can be used to systematically map the barriers and facilitators identified to guide BCT selection. Future work should also explore whether the intended behaviour change mechanisms are achieved and investigate which BCTs are most effective in increasing women's participation in MSE across different subgroups. Considering the Ecological Model in co-designing intervention development could further enhance its scalability and relevance across various contexts. This would enable a better understanding of how environmental and sociocultural constraints on women's MSE participation can be effectively addressed.

7.7 CONCLUSION

In conclusion, this PhD thesis provides a comprehensive investigation of participation in MSE among women by integrating quantitative, qualitative and intervention-based approaches. Across four sequential studies, it quantified the pattern of MSE participation, explored the types, frequency, intensity, and duration of muscle-strengthening activity, the barriers and facilitators experienced by women who did and did not engage in MSE, and developed a co-designed intervention to improve participation. This mixed-method design, combined with a co-design approach, ensured that the intervention and findings were relevant to women's life experiences. While the thesis has limitations, the findings offer a clear direction for future research and intervention development. The thesis lays the foundation for a scalable intervention to improve women's participation in MSE and their health outcomes by addressing persistent barriers to MSE participation and incorporating participants' insights into the intervention.

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APPENDICES

Appendix 2-A: Ethics Approval: Muscle-Strengthening Activity Survey



Dr Gemma Ryde

MVLS College Ethics Committee

200220454

Muscle Strengthening Activity Survey: An Assessment of UK Adults' Participation in the Muscle Strengthening Component of the Physical Activity Guidelines

The College Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the proposed study. We are happy therefore to approve the project, subject to the following conditions

- Project end date as stipulated in original application.
- The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research:
(http://www.gla.ac.uk/media/media_227599_en.pdf)
- The research should be carried out only on the sites, and/or groups defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment, except when it is necessary to change the protocol to eliminate hazard to the subjects or where the change involves only the administrative aspects of the project. The Ethics Committee should be informed of any such changes.
- For projects requiring the use of an online questionnaire, the University has an Online Surveys account for research. To request access, see the University's application procedure at <https://www.gla.ac.uk/research/strategy/ourpolicies/useofonlinesurveystoolforresearch/>.
- You should submit a short end of study report within 3 months of completion.

Yours sincerely

Dr Terry Quinn

Terry Quinn
FWSO, FESO, MD, FRCP, BSc (hons), MBChB (hons)
Reader / Honorary Consultant

College of Medicine, Veterinary & Life Sciences
School of Cardiovascular and Metabolic Health
terry.quinn@glasgow.gla.ac.uk

The University of Glasgow, charity number SC004401

Appendix 2-B: Participant's Information Sheet

Participant Information Sheet

- 1. Title:** Muscle Strengthening Activity Survey: An Assessment of Adults' Participation in the Muscle Strengthening Component of the Physical Activity Guidelines

You are being invited to take part in this study about your participation in muscle strengthening activities. Before you decide, it is important for you to understand why the survey is being done and what it will involve. Please take time to read the following information and ask us if there is anything that is not clear or if you would like more information.

- 2. What is the purpose of the study?**

Muscles play an important role in the human body including not only in allowing us to move but also in our wider health. For example, low muscle strength has been associated with an increase in risk of heart disease and diabetes. Our current physical activity guidelines state that adults should perform two or more days of muscle strengthening activity, but current levels of participation are low. The guidelines state that doing daily activities, such as gardening and cleaning, can help to strengthen our muscles. Currently we have very little information in people who meet the physical activity guidelines on what kind of activities they carry out.

Therefore, the purpose of this study is to identify what activities adults in the United Kingdom do to meet the muscle strength component of the physical activity guidelines of two or more days a week of muscle.

- 3. Why have I been invited to participate?**

You have been invited to take part in this study because you are an adult. You can only participate in this survey if you are: 1) between the age of 18 to 64 years old, and 2) currently living in the United Kingdom, and 3) not limited in taking part in muscle strengthening activities by health issues.

- 4. Do I have to take part?**

No, it is up to you to decide whether to take part as the participation in this survey is completely voluntary. If you do decide to take part, you are still free to withdraw at any time without giving any reason. Participating in this survey will not affect your employment or standing.

- 5. What will happen to me if I take part?**

The survey will be conducted across all adults in the United Kingdom. If you decided to take part, you will have to complete one anonymous online survey that would take not more than 15 minutes.

- 6. What do I have to do?**

Participants that decided to take part in this survey will complete a 30-item survey that consist of questions about their demographic, participation in muscle strengthening exercises and activities, and occupational physical activity.

- 7. What are the possible risks of taking part?**

There are no known risks to you. the participation in this survey is based on your voluntary decision in allowing your anonymised data to be analysed for the research

purpose. It is acknowledged that participants will take not more than 15 minutes time burden by completing this survey.

8. What are the possible benefits of taking part?

You will receive no direct benefit from taking part in this survey. The information that is collected in this survey will give us a better understanding of the current level of participation in muscle strengthening and what do adults in the United Kingdom do to meet the guideline.

9. Will my taking part in this study be kept confidential?

All the information and responses collected from you will be kept strictly confidential and anonymous. All data in electronic format will be stored on secure password-protected computers. No one outside of the research team, the University-approved transcription company and appropriate governance staff will be able to find out your name and any other information that could identify you.

10. What will happen to my data?

We may collect and store identifiable information from you (email address) only if you decide to participate in further follow-up research to design the muscle strengthening intervention with the researchers at the end of the survey. Email addresses (optional) will be in the same survey for those who provide them until download. After download, the online data will be deleted, and the emails and data will be kept in separate files. Email addresses will also not be linked to participant numbers. Researchers from the University of Glasgow collect, store, and process all personal information in accordance with The General Data Protection Regulation (2018). The data will be stored in archiving facilities in line with the University of Glasgow retention policy of up to 10 years. After this period, further retention may be agreed, or your data will be securely destroyed in accordance with the relevant standard procedures. Your rights to access, change, or move the information we store may be limited, as we need to manage your information in specific ways for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we already obtained. To safeguard your rights, we will use the minimum personally identifiable information possible. You can find out more about how we use your information from the researcher (n.rosaini.1@research.gla.ac.uk).

11. What will happen to the results of the research study?

The findings from this research project will contribute to the principal researcher's (Nur Dania Rosaini) PhD project. The research team would also seek to publish the findings in journals and present the data at conferences. You will not be identified by name in any publications. Please let the research team know if you would like a copy of the published results.

12. Who is organising and funding the research?

The work is organised by Ms Nur Dania Rosaini, Professor Stuart Gray and Dr Gemma Ryde in the School of Cardiovascular and Metabolic Health at the University of Glasgow. This work is funded by Majlis Amanah Rakyat Malaysia (MARA), a studentship to Ms Nur Dania Rosaini.

13. Who has reviewed the study?

This study has been reviewed and approved by the College of Medical, Veterinary and Life Sciences Ethics Committee at the University of Glasgow.

14. Contacts for further information.

If you have any doubts or questions, please contact one of the investigators below:

Principal Researcher

Nur Dania Rosaini

Email: n.rosaini.1@research.gla.ac.uk

Supervisor

Professor Stuart Gray

Email: stuart.gray@glasgow.ac.uk

Dr Gemma Ryde

Email: gemma.ryde@glasgow.ac.uk

Appendix 2-C: Consent Form



THIS FORM WILL BE CONVERTED INTO AN ONLINE SURVEY – if they do not consent, they will be directed to close their browser

Title of Project: Muscle Strengthening Activity Survey: An Assessment of UK Adults' Participation in the Muscle Strengthening Component of the Physical Activity Guideline

Name of Researcher(s): Nur Dania Rosaini, Professor Stuart Gray, Dr Gemma Ryde

CONSENT FORM

Please
initial box

I confirm that I have read and understood the Participant Information Sheet version V.0.1 dated 27/07/2023.

☐

I confirm that I have read and understood the Privacy Notice version 00001 dated 27/07/2023.

☐

I have had the opportunity to think about the information and ask questions and understand the answers I have been given.

☐

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

☐

I confirm that I agree to the way my data will be collected and processed and that data will be stored for up to 10 years in University archiving facilities in accordance with relevant Data Protection policies and regulations.

☐

I understand that all data and information I provide will be kept confidential and will be seen only by study researchers and regulators whose job it is to check the work of researchers.

☐

I agree that my name, contact details and data described in the information sheet will be kept for the purposes of this research project.

☐

I understand that if I withdraw from the study, my data collected up to that point will be retained and used for the remainder of the study.

☐

I agree to take part in the study.

☐

I do not agree to take part in the study.

☐



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Veterinary & Life Sciences

VOLUNTEERS NEEDED!

Are you curious about what activities you do that meet the physical activity guidelines for muscle strengthening? Take part in our survey to find out.

You can answer this survey if you are:

- Aged between 18 to 64 years old
- Currently living in the United Kingdom

**SCAN HERE TO ANSWER
THE SURVEY**



or follow this link:

https://uofg.qualtrics.com/jfe/form/SV_ePpFLTGFuYK0Edw

For more information, please contact:

Nur Dania Rosaini
n.rosaini.1@research.gla.ac.uk



Appendix 2-E: Muscle-Strengthening Activity Survey

MUSCLE STRENGTHENING PARTICIPATION SURVEY

PRE-SCREENING QUESTION

Are you aged between 18-64 years old?

- ☐ Yes (continues to the next pre-screening question)
- ☐ No (thank you and exit the questionnaire)

Do you currently have any health conditions that stop or limit you being as active (physically, mentally, socially) as you would like, e.g., something that leaves you tired or in pain, anxious or depressed, or needing to be near a toilet?

- ☐ Yes (thank you and exit the survey)
- ☐ No (continue to survey)

PART A – DEMOGRAPHIC SECTION

What is your date of birth (month and year)?

- ☐ MM/YYYY

What is your sex?

- ☐ Male
- ☐ Female
- ☐ Non-Binary
- ☐ Other
- ☐ Prefer not to say

Postcode

- ☐ Insert postcode.

Which of the following descriptions best describes your usual 'work' situation?

- ☐ Going to school or university full time.
- ☐ Employed or self-employed.
- ☐ Doing unpaid work for your own business, or family owned.
- ☐ Permanently unable to work because of long-term illness or disability.
- ☐ Retired from paid employment.
- ☐ Looking after family or home.
- ☐ Other.

What is the highest qualification you have completed?

- ☐ No formal qualification after school
- ☐ Trade, Technical certificate, Apprenticeship or Diploma
- ☐ University degree or higher
- ☐ Prefer not to say

What is your marital status?

- ☐ Single (never been married)
- ☐ Single (with children)
- ☐ Married (without children)
- ☐ Married (with children)
- ☐ Divorced/Separated (without children)
- ☐ Divorced/Separated (with children)
- ☐ Widowed (without children)
- ☐ Widowed (with children)
- ☐ Prefer not to say

Are you a care giver? (if no, skip to next question: Are you on wheelchair?)

- ☐ Yes
- ☐ No

Who do you care for?

- ☐ Child or children
- ☐ Older adults
- ☐ Someone with a disability
- ☐ Other

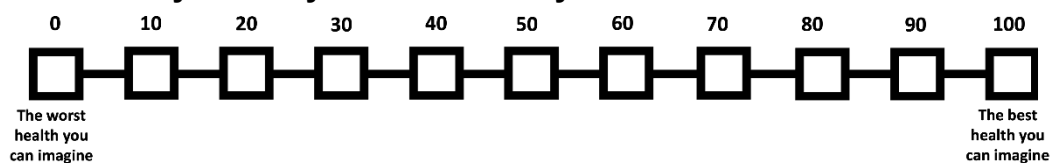
How long do you spend caring for them?

- ☐ Full time
- ☐ Part time

Are you a wheelchair user?

- ☐ Yes
- ☐ No

How would you rate your health today on a scale of 0-100?



The infographic above provides details about the 2019 UK Physical Activity Guidelines for adults and older adults. We are particularly interested in the “build strength” part of the guidelines. It is recommended that adults build strength on at least two days a week to keep the muscles, bones, and joints strong. This can include activities such as using bodyweight, free weights, resistance machines or elastic bands, as well as activities of daily living such as stair climbing, wheeling your wheelchair, carrying shopping bags, lifting, and carrying children, and gardening.

Do you think you meet these “build strength” guidelines by taking part in muscle strengthening activities twice a week, or more, during a typical week?

- ☐ Yes

○ No

Next, we are going to look at what kind of muscle strengthening activities you do, please fill this in even if you said no to the previous question.

PART B: MUSCLE STRENGTHENING EXERCISE (Adapted from Shakespear-Druery et al., 2022)

The next set of questions are about your participation in muscle strengthening exercise. In this section, we are interested in muscle strengthening exercise that you do during your leisure time. The type of exercises we are interested in in this section are:

- Weight machines: at home, in a gym or fitness centre.
- Bodyweight exercises: such as push ups, sit ups or planking.
- Resistance exercises: using free weights such as dumbbells or resistance bands.
- Holistic exercises: including Pilates, Yoga and Tai-Chi.

Do you do any of these kinds of muscle strengthening activity in a usual week? (Tick those that are applicable. If none, skip to part C)

Yes

No

Weight machines

Bodyweight exercises

Resistance exercises

Holistic exercises

How many days, in a usual week, do you do these activities?

Weight machines

none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐	☐	☐	☐	☐	☐	☐	☐

Bodyweight exercises

none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐	☐	☐	☐	☐	☐	☐	☐

Resistance exercises

none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐	☐	☐	☐	☐	☐	☐	☐

Holistic exercises

none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐	☐	☐	☐	☐	☐	☐	☐

How long do you usual spend doing these activities (minutes spent in a usual session)?

0 minutes Less than 10 minutes 10-20 minutes 21-30 minutes 31-40 minutes 41-50 minutes 51-60 minutes More than 60 minutes

Bodyweight exercises

0 minutes Less than 10 minutes 10-20 minutes 21-30 minutes 31-40 minutes 41-50 minutes 51-60 minutes More than 60 minutes

Resistance exercises

0 minutes Less than 10 minutes 10-20 minutes 21-30 minutes 31-40 minutes 41-50 minutes 51-60 minutes More than 60 minutes

Holistic exercises

0 minutes Less than 10 minutes 10-20 minutes 21-30 minutes 31-40 minutes 41-50 minutes 51-60 minutes More than 60 minutes

On the scale of 0-10, how hard do you feel when you are doing these activities? '0' being 'extremely easy' and '10' being 'extremely hard'

Weight machines

0 1 2 3 4 5 6 7 8 9 10

Not Applicable Extremely Easy Easy Somewhat Easy Somewhat Hard Hard Extremely Hard

Bodyweight exercises

Figure 1 shows a 10-point Likert scale. The scale is represented by a horizontal line with 11 square boxes. Below each box is a label: 0: Not Applicable, 1: Extremely Easy, 2: Easy, 3: Somewhat Easy, 4: Somewhat Hard, 5: Somewhat Hard, 6: Hard, 7: Hard, 8: Hard, 9: Hard, 10: Extremely Hard.

Resistance exercises

Figure 1 shows a 10-point semantic differential scale. The scale is represented by a horizontal line with 11 boxes, numbered 0 to 10. Below each box is a descriptive label. The labels are: 0: Not Applicable, 1: Extremely Easy, 2: Easy, 3: Somewhat Easy, 4: Somewhat Hard, 5: Hard, 6: Extremely Hard, 7: (blank), 8: (blank), 9: (blank), 10: (blank).

Holistic exercises

Which part of your body or muscle group do you exercise (tick as many as you do)?

Weight machines

Not applicable Shoulder Arms Chest Back Abdomen Hips Legs

Bodyweight exercises

Not applicable Shoulder Arms Chest Back Abdomen Hips Legs

[illegible]

Stairs climbing	none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
	☐	☐	☐	☐	☐	☐	☐	☐
Lifting and carrying children	none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
	☐	☐	☐	☐	☐	☐	☐	☐
Wheeling a wheelchair	none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
	☐	☐	☐	☐	☐	☐	☐	☐

How long did you spend doing these activities (minutes spent in a usual session)?

Gardening	0 minutes	Less than 10 minutes	10-20 minutes	21-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes	More than 60 minutes
	☐	☐	☐	☐	☐	☐	☐	☐
Carrying shopping bags	0 minutes	Less than 10 minutes	10-20 minutes	21-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes	More than 60 minutes
	☐	☐	☐	☐	☐	☐	☐	☐
Stairs climbing	0 minutes	Less than 10 minutes	10-20 minutes	21-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes	More than 60 minutes
	☐	☐	☐	☐	☐	☐	☐	☐
Lifting and carrying children	0 minutes	Less than 10 minutes	10-20 minutes	21-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes	More than 60 minutes
	☐	☐	☐	☐	☐	☐	☐	☐
Wheeling a wheelchair	0 minutes	Less than 10 minutes	10-20 minutes	21-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes	More than 60 minutes
	☐	☐	☐	☐	☐	☐	☐	☐

On the scale of 0-10, how hard do you feel when you are doing these activities? '0' being 'extremely easy' and '10' being 'extremely hard'

Gardening	0	1	2	3	4	5	6	7	8	9	10
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Not Applicable	Extremely Easy	Easy		Somewhat Easy		Somewhat Hard		Hard		Extremely Hard
Carrying shopping bags	0	1	2	3	4	5	6	7	8	9	10
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Not Applicable	Extremely Easy	Easy		Somewhat Easy		Somewhat Hard		Hard		Extremely Hard

Stairs climbing

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not Applicable	Extremely Easy	Easy		Somewhat Easy		Somewhat Hard		Hard		Extremely Hard

Lifting and carrying children

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not Applicable	Extremely Easy	Easy		Somewhat Easy		Somewhat Hard		Hard		Extremely Hard

Wheeling a wheelchair

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not Applicable	Extremely Easy	Easy		Somewhat Easy		Somewhat Hard		Hard		Extremely Hard

What kind of task or tasks do you do when doing this activity?

Gardening (for example shovelling, chopping, watering, digging, weeding and more.)

PART D: OCCUPATIONAL MUSCLE STRENGTHENING PHYSICAL ACTIVITY

The next set of questions will be about your participation in occupational physical activities. In this section, we are interested in occupations that have high physical exertion, and movement involved such as individuals working in healthcare and construction, or those who work as warehouse workers, delivery drivers, gardeners, or similar occupations.

Does your occupation have high physical exertion and movement involved? (If yes, specify what do you work as. If no, skip to the end.)

- ☐ Yes, as _____
- ☐ No

How many days, in a usual week, do you do occupational physical activity?

none	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐	☐	☐	☐	☐	☐	☐	☐

When you do occupational physical activity, how long did you spend doing this activity (minutes spent in a usual session)?

0 minutes	Less than 10 minutes	10-20 minutes	21-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes	More than 60 minutes
☐	☐	☐	☐	☐	☐	☐	☐

On the scale of 0-10, how hard do you feel when you are doing occupational physical activity. '0' being 'extremely easy' and '10' being 'extremely hard'.

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not Applicable	Extremely Easy	Easy		Somewhat Easy		Somewhat Hard		Hard		Extremely Hard

**What is the muscle strengthening activity or activities that you do at work?
(For example, carrying heavy boxes, moving patients, or installing buildings
structures.)**

FOLLOW-UP

**Thank you for participating in this survey. If you would like to participate in
further follow-up research to design the muscle strengthening intervention
with the researchers, please leave your email address below.**

- ☐ Yes, email address: _____
- ☐ No

**This is the end of the questionnaire. Your response is very much
appreciated.**

Appendix 2-F: CHERRIES Checklist

Checklist for Reporting Results of Internet E-Survey (CHERRIES)

In accordance with Eysenbach G. Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). J Med Internet Res. 2004 Sep 29;6(3):e34. doi: 10.2196/jmir.6.3.e34. Erratum in: doi:10.2196/jmir.2042. PMID: 15471760; PMCID: PMC1550605.

Item Category	Checklist Item	Page number	Description
Design	Describe survey design	27	- Adults aged 18-64, living in the UK - Data collected from October 2023 to December 2023
IRB approval and informed consent process	Approval	26	Approved by MVLS Ethic Committee University of Glasgow (Ethic ID: 200220454)
	Inform Consent	26	- Participants were provided the privacy notice and information sheet on the landing page of the survey. - Participants give consent by clicking "I agree /disagree". - Participants are free to withdraw consent at any stage during survey completion but won't be able to do so after the survey is submitted.
	Data protection	Not in report	- Data stored according to the GDPR requirements. - Data is stored anonymously, and the file is password protected.
Developing and pre-testing	Development and testing	27-29	Survey developed with guidance from the 2019 UK CMO Physical Activity Guidelines, Muscle Strengthening Exercise Questionnaire (MSEQ) (Shakespeare-Druery et al., 2022) by lead researcher NDR, and

			edited by supervisors SRG and GCR. Pilot testing was done on 9 participants for the readability and comprehension of the questions.
Recruitment process and description of the sample having access to the questionnaire	Open survey vs closed survey	27	Open survey on Qualtrics (Qualtrics Ltd). No password is required to answer the survey.
	Contact mode	26	No initial contact was made with potential participants before participating in the survey.
	Advertising the survey	26	- Offline (poster advertisement) - Online (through professional network; Microsoft Viva Engage, LinkedIn and social media; Nextdoor, X and Facebook advertising)
Survey administration	Web/Email	27	Web survey on Qualtrics (Qualtrics Ltd)
	Context	27	- Qualtrics is used for collecting responses for various types of surveys/studies. - Participants are often brought to this website by following the link provided in the study announcement.
	Mandatory/voluntary	26	Voluntary
	Incentives	N/A	None
	Time/Date	26	The survey was active 24 hours a day between October 2023 to December 2023
	Randomization of items or questionnaire	27-29, Appendix 2-E	No. The survey was structured into 5 sections: pre-screening and demographic, muscle strengthening exercise, daily living muscle strengthening

			activity and occupational muscle strengthening activity and information on registering interest to participate in follow-up study.
	Adaptive questioning	Not in report	• Yes, for Part B (MSE), Part C (DLMSA) and Part D (OMSPA).^{**} Questions will only appear based on the participant's answer choice. (Refer supplementary material I)
	Number of items	Not in report	• 26 items
	Number of screens	Not in report	• 7 blocks
	Completeness check	Not in report	• None provided to the participants. The submit button appears on the last page and once participant submit their response, it is considered complete.
	Review step	Not in report	• Participants can review and change their answers while completing the survey but are unable to do so once they submit it.
Response rate	Unique site visitor	Not in report	• The participant's response type (IP address) is recorded but the participant's exact IP address is not recorded. • reCAPTCHA is used to detect bot
	View rate	N/A	• N/A
	Participation rate	Not in report	• 90% agree to participate
	Completeness rate	Not in report	• 74% completed out of the total response received. • Response quality is 100% (based on Qualtrics responses quality check).

Preventing multiple entries from the same individual	Cookies used	N/A	None. The survey is set to prevent multiple submissions on the Qualtrics setting. If a participant submits multiple entries, it will be flagged.
	IP Check	Not in report	Qualtrics collected IP addresses to ensure no duplication in submission. However, the IP address data was not used for any other purpose and was permanently deleted by the researcher.
	Log file analysis	Not in report	Qualtrics recorded the log file to ensure there were no duplicates.
	Registration	N/A	N/A
Analysis	Handling of incomplete questionnaires	30	Only responses with completeness above 80% are included in the analysis of muscle strengthening participation.
	Questionnaire submitted with an atypical timestamp	Not in report	- The questionnaire will take about 4 to 15 minutes to answer depending on the participant's responses to certain questions. - No cut-off point decided.
	Statistical correction	N/A	N/A

**MSE = muscle strengthening exercises, DLMSA = daily living muscle strengthening activities, OMSPA = occupational muscle strengthening physical activity

Appendix 3-A: Ethics Approval WISH Study (Interview and Co-Design Workshops)



Dr Gemma Ryde

MVLS College Ethics Committee

Co-Designing an Intervention to Improve Participation of Women in Muscle Strengthening Exercise
200230238

The College Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the proposed study. We are happy therefore to approve the project, subject to the following conditions

- Project end date as stipulated in original application.
- The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research:
(http://www.gla.ac.uk/media/media_227599_en.pdf)
- The research should be carried out only on the sites, and/or groups defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment, except when it is necessary to change the protocol to eliminate hazard to the subjects or where the change involves only the administrative aspects of the project. The Ethics Committee should be informed of any such changes.
- For projects requiring the use of an online questionnaire, the University has an Online Surveys account for research. To request access, see the University's application procedure at <https://www.gla.ac.uk/research/strategy/ourpolicies/useofonlinesurveystoolforresearch/>.
- You should submit a short end of study report within 3 months of completion.

Yours sincerely

Dr Terry Quinn

Terry Quinn
FWSO, FESO, MD, FRCP, BSc (hons), MBChB (hons)
College of Medicine, Veterinary & Life Sciences
School of Cardiovascular and Metabolic Health
New Lister Building, Glasgow Royal Infirmary
Glasgow G3 7ER
terry.quinn@glasgow.ac.uk
Tel – 0141 201 8519

The University of Glasgow, charity number SC004401



University of Glasgow | College of Medical,
Veterinary & Life Sciences

PARTICIPANT INFORMATION SHEET

1. **Study title:** Co-designing an intervention to improve participation of women in muscle strengthening exercise (Part 1)

You are being invited to take part in this follow-up interview to further discuss your participation in muscle strengthening exercises. Before you decide, you need to understand why this interview is being done and what it will involve. Please take time to read the following information and ask us if there is anything that is not clear or if you would like more information.

2. **What is the purpose of the study?**

We previously surveyed participation in muscle strengthening activities as described in the 2019 UK Physical Activity Guidelines and investigated the different way people meet the guidelines. The survey data revealed that women that do muscle strengthening exercise tend to favour bodyweight exercises and holistic exercises, such as Pilates and yoga, as opposed to weight machine-based exercise which were more common in men. We have little information on why women prefer these specific types of exercises or what barriers they face in participating in other types of muscle-strengthening activities. This is particularly important as we know from previous research that women are less likely to meet the UK physical activity guidelines for muscle strengthening (Strain et al., 2016).

Therefore, the aim for this current research is:

- To explore the barriers and facilitators for muscle strengthening participation among women who self-reported meeting the build strength guideline.

Reference:

Strain, T., Fitzsimons, C., Kelly, P., & Mutrie, N. (2016). The forgotten guidelines: cross-sectional analysis of participation in muscle strengthening and balance & co-ordination activities by adults and older adults in Scotland. *BMC Public Health*, 16(1), 1108.
<https://doi.org/10.1186/s12889-016-3774-6>

3. **Why have I been invited to participate?**

You have been invited to take part in this study because you have expressed your interest in participating in a follow up study when completing the Muscle Strengthening Participation Survey and reported that you currently do muscle strengthening exercise on two or more days per week.

4. Do I have to take part?

No, it is up to you to decide whether to take part as participation in this study is completely voluntary. If you do decide to take part, you are still free to withdraw at any time without giving any reason. Participating in this study will not affect your employment or standing.

5. What will happen to me if I take part?

In this follow-up interview, we want to explore in more detail how you manage to achieve the guidelines, barriers you faced and things that help to facilitate this. This interview will last less than one hour and will be conducted online (Microsoft Teams) or onsite at the University of Glasgow if you prefer.

Microsoft Teams interviews will be recorded through the software and the file saves in Microsoft Stream (via University of Glasgow SharePoint). Onsite interviews will be recorded using a digital voice recorder. In all cases, only audio will be recorded. Once all recordings have been transcribed by the researchers and checked against the original recordings, the audio files will be deleted.

6. What do I have to do?

If you decided to take part in the follow up interview, we will ask you questions based on the Muscle Strengthening Participation Survey in more detail considering the barriers you faced and facilitators in your participation in muscle strengthening exercise. Some of the barriers to taking part in exercise may be personal and sensitive therefore participants will be provided with resources and contact details of organisations who might be able to help with this as appropriate (Samaritans, financial advice services, mental health charities). However, if anything is raised that suggests illegality or risk status, then the researcher is obligated to report as appropriate.

7. What are the possible disadvantages and risks of taking part?

There are no possible disadvantages and risk of taking part in this study.

8. What are the possible benefits of taking part?

Participating in muscle strengthening exercise is important for our health. The information will help us develop interventions to increase participation in muscle strengthening exercise. A £20 Amazon voucher will be provided upon completion.

9. Will my taking part in this study be kept confidential?

Participant's name and contact information (phone number/email) will be collected only if they agree to take part in the study. The researchers will only use this information to get in touch with the participants and it will not be linked to their responses in the interview. Non-sensitive personal data (date of birth, postcode, work situation, highest qualification completed, marital status) will be obtained. The data will be stored in archiving facilities in line with the University of Glasgow retention policy of up to 10 years. After this period, further retention may be agreed, or the data will be securely destroyed in accordance with the relevant standard procedures. All the information and responses collected will be kept strictly confidential and anonymous. All data in electronic format will be stored on secure password-protected computers.

10. What will happen to my data?

Researchers from the University of Glasgow collect, store, and process all personal information in accordance with The General Data Protection Regulation (2018). The data will be stored in archiving facilities in line with the University of Glasgow retention policy of up to 10 years. After this period, further retention may be agreed, or your data will be securely destroyed in accordance with the relevant standard procedures. Your rights to access, change, or move the information we store may be limited, as we need to manage your information in specific ways for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we already obtained. To safeguard your rights, we will use the minimum personally identifiable information possible. You can find out more about how we use your information from the researcher (n.rosaini.1@research.gla.ac.uk).

11. What will happen to the results of the research study?

The findings from this research project will contribute to the principal researcher's (Nur Dania Rosaini) PhD project. The research team would also seek to publish the findings in journals and present the data at conferences. You will not be identified by name in any publications. Please let the research team know if you would like a copy of the published results.

12. Who is organising and funding the research?

The work is organised by Ms Nur Dania Rosaini, Professor Stuart Gray and Dr Gemma Ryde in the School of Cardiovascular and Metabolic Health at the

University of Glasgow. This work is funded by Majlis Amanah Rakyat Malaysia (MARA), a studentship to Ms Nur Dania Rosaini.

13. Who has reviewed the study?

This study has been reviewed and approved by the College of Medical, Veterinary and Life Sciences Ethics Committee at the University of Glasgow.

14. Contact for Further Information

If you have any doubts or questions, please contact one of the investigators below:

Principal Researcher
Nur Dania Rosaini
Email: n.rosaini.1@research.gla.ac.uk

Supervisor
Professor Stuart Gray
Email: stuart.gray@glasgow.ac.uk
Dr Gemma Ryde
Email: gemma.ryde@glasgow.ac.uk

Thank you for reading the Information Sheet

Appendix 3-C: Consent Form (Interview)



University of Glasgow | College of Medical,
Veterinary & Life Sciences

Title of Project: Co-designing an intervention to improve participation of women in muscle strengthening exercise (Part 1)

Name of Researcher(s): Nur Dania Rosaini, Professor Stuart Gray, Dr Gemma Ryde

CONSENT FORM

Please
initial
box

I confirm that I have read and understood the Participant Information Sheet version V.0.1 dated 18/01/2024.

I confirm that I have read and understood the Privacy Notice version 00001 dated 18/01/2024.

I have had the opportunity to think about the information and ask questions and understand the answers I have been given.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

I confirm that I agree to the way my data will be collected and processed and that data will be stored for up to 10 years in University archiving facilities in accordance with relevant Data Protection policies and regulations.

I understand that all data and information I provide will be kept confidential and will be seen only by study researchers and regulators whose job it is to check the work of researchers.

I agree that my name, contact details and data described in the information sheet will be kept for the purposes of this research project.

I understand that if I withdraw from the study, my data collected up to that point will be retained and used for the remainder of the study.

I agree to my interview being audio-recorded.

I understand that the recorded interview will be transcribed word by word and the transcription stored for up to 10 years in

University archiving facilities in accordance with Data Protection policies and regulations.

I understand that my information and things that I say in an interview may be quoted in reports and articles that are published about the study, but my name or anything else that could tell people who I am will not be revealed

☐

I agree to take part in the study.

☐

I do not agree to take part in the study.

☐

Name of participant

Date

Signature

Name of Person taking consent
(if different from researcher)

Date

Signature

Researcher

Date

Signature

(1 copy for participant; 1 copy for researcher)

Appendix 3-D: Recruitment Poster

 **University of Glasgow** | College of Medical, Veterinary & Life Sciences 

FOLLOW-UP INTERVIEW

You previously participated in our Muscle Strengthening Participation Survey, and we would like to hear more from you in an online or onsite interview about your:

- ✓ Barriers and facilitators for muscle strengthening exercise participation

 **£20**
Amazon voucher upon completion



To register, please contact:
Nur Dania Rosaini
n.rosaini.1@research.gla.ac.uk

Appendix 3-E: WISH Study Interview Topic Guide

Introduction

- Hi, I am (name), from the University of Glasgow.
- Before we begin, I would like to check if you agree with the terms and conditions and privacy notice that I sent previously?
- I would also like to remind you that this meeting is audio recorded.
- First of all, thank you for volunteering to participate in this interview. So, the purpose of this interview is to identify barriers and facilitators you faced when participating in muscle strengthening.
- We will ask you some questions covering the knowledge, challenges, motivation, and facilitators for your participation in muscle strengthening and on your demographics.
- The whole interview will range from about 30 to 60 minutes. Are you okay to proceed?

DEMOGRAPHIC (D)

D1. Month and year of birth

D2. Postcode *(to determine the quintile of IMD – you can also give me your IMD quintile if you know it)*

D3. Work situation *(FT student/employed/doing unpaid work - own/volunteer/care for family, retired)*

D4. Highest academic qualification *(no formal qualification after school/trade technical apprenticeship diploma/ university)*

D5. Marital status *(single/married/divorced separated/widowed) - with/without children*

KNOWLEDGE (K)

K1. How many days per week do you participate in muscle strengthening exercises?

K1.1 How would you rate overall familiarity with different types of muscle strengthening activities?

K2. What exercise do you prefer to do when participating in muscle strengthening exercises?

K2.1 Are there any specific muscle groups or areas of focus that you prioritise during your workouts?

K2.2 What aspect of muscle strengthening exercises do you enjoy the most?

K3. Do you work out at home or the gym? Do you work out alone, with friends or join classes?

K3.1 How do your choice of workout environment and companionship influence your motivation and enjoyment of doing muscle strengthening activities?

K3.2 Are there any specific aspects of your environment that either facilitate or impede your ability to adhere to regular muscle strengthening participation?

CHALLENGES (C)

C1. Can you tell me what challenges you face when you are participating in muscle strengthening?

C1.1 How do these challenges impact your motivation and consistency in maintaining your muscle strengthening routine?

C1.2 How do you overcome those challenges? / How do you incorporate muscle strengthening exercise in your daily routine? / Have you developed any strategies or habits that help you maintain a consistent muscle strengthening participation? *(depending on participant response to C1)*

C2. Have you experienced any physical limitations or health concerns that hinder your ability to engage in muscle strengthening?

MOTIVATION (M)

M1. What initially inspired or motivated you to start participating in muscle strengthening?

M1.1 How has your motivation evolved or changed over time?

M2. How do you think muscle strengthening benefits you, physically and mentally?

M2.1 Do you notice any specific changes in your overall well-being, confidence and self-esteem as a result of your muscle strengthening effort? *(not necessary to ask if participants already answer this when answering QM2)*

M2.2 How do you perceive yourself in terms of your strength and fitness level?

M3. Can you discuss the role of social support (e.g. family, friends, workout partners) in your muscle strengthening journey? / How do people around you response to your muscle strengthening participation?

M3.1 Have you found that having a support system or workout buddy positively impacts your motivation and consistency in participating in muscle strengthening?

M4. Can you describe any specific goals or aspirations that you have relating to your muscle strengthening journey?

M4.1 How do you envision your participation in muscle strengthening exercise evolving or continuing in the future?

FACILITATORS (F)

F1. What makes participating in muscle strengthening easier for you?

F1.1 Can you identify any external factors or internal motivators that support your adherence to regular participation in muscle strengthening?

F2. How can participation in muscle strengthening be improved, based on your own experiences and preferences?

F2.2 Are there any specific resources, tools or support systems that you believe would enhance the accessibility and effectiveness of muscle strengthening activities?

F3. Looking back on your experiences, what have you learned about yourself or your capabilities?

F4. What would be your top advice for other women who haven't thought about strength/strength training/wanting to start?

Conclusion

- Do you have any questions that you would like to ask us?
- Thank you for your input. We will email you the voucher code to the email address you provided before. Once again thank you for participating in our study.

Reminder: if they answer more on sport specific side as part of their muscle-strengthening participation, divert it to MSE participation. If they have kids, ask them more on the age, childcare responsibilities. Ask about time constraints and how they include it in their schedule.

Appendix 3-F: COREQ Checklist

COREQ (Consolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
<i>Personal characteristics</i>			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	46
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	46
Occupation	3	What was their occupation at the time of the study?	46
Gender	4	Was the researcher male or female?	46
Experience and training	5	What experience or training did the researcher have?	46
<i>Relationship with participants</i>			
Relationship established	6	Was a relationship established prior to study commencement?	46
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	46
Interviewer characteristics	8	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	46
Domain 2: Study design			
<i>Theoretical framework</i>			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	45-46
<i>Participant selection</i>			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	45
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	45
Sample size	12	How many participants were in the study?	48
Non-participation	13	How many people refused to participate or dropped out? Reasons?	n/a
<i>Setting</i>			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	46
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	46
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	46, 48, 49
<i>Data collection</i>			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	45-46
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	46-47
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	46
Field notes	20	Were field notes made during and/or after the inter view or focus group?	n/a
Duration	21	What was the duration of the inter views or focus group?	46
Data saturation	22	Was data saturation discussed?	47
Transcripts returned	23	Were transcripts returned to participants for comment and/or	47

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
<i>Data analysis</i>			
Number of data coders	24	How many data coders coded the data?	47
Description of the coding tree	25	Did authors provide a description of the coding tree?	47
Derivation of themes	26	Were themes identified in advance or derived from the data?	47
Software	27	What software, if applicable, was used to manage the data?	47
Participant checking	28	Did participants provide feedback on the findings?	47
<i>Reporting</i>			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	51-69
Data and findings consistent	30	Was there consistency between the data presented and the findings?	51-69
Clarity of major themes	31	Were major themes clearly presented in the findings?	51-69
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	51-69

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.



University of Glasgow | College of Medical,
Veterinary & Life Sciences

PARTICIPANT INFORMATION SHEET

- 1. Study title:** Co-designing an intervention to improve participation of women in muscle strengthening exercise (Part 2)

You are being invited to take part in this co-design muscle strengthening intervention workshop to discuss about your participation in muscle strengthening exercises. Before you decide, you need to understand why this workshop is being done and what it will involve. Please take time to read the following information and ask us if there is anything that is not clear or if you would like more information.

- 2. What is the purpose of the study?**

We previously surveyed participation in muscle strengthening activities as described in the 2019 UK Physical Activity Guidelines and investigated the different way people meet the guidelines. The survey data revealed that women that do muscle strengthening exercise tend to favour bodyweight exercises and holistic exercises, such as Pilates and yoga, as opposed to weight machine-based exercise which were more common in men. We have little information on why women prefer these specific types of exercises or what barriers they face in participating in other types of muscle-strengthening activities. This is particularly important as we know from previous research that women are less likely to meet the UK physical activity guidelines for muscle strengthening (Strain et al., 2016).

Therefore, the aims for this current research are:

- To explore the barriers and facilitators for muscle strengthening participation among women who self-reported not meeting the build strength guideline.
- To co-design an intervention to assist women in meeting the build strength guideline.

Reference:

Strain, T., Fitzsimons, C., Kelly, P., & Mutrie, N. (2016). The forgotten guidelines: cross-sectional analysis of participation in muscle strengthening and balance & co-ordination activities by adults and older adults in Scotland. *BMC Public Health*, 16(1), 1108. <https://doi.org/10.1186/s12889-016-3774-6>

3. Why have I been invited to participate?

You have been invited to take part in this study because you are woman, aged 18 to 64 years old, currently did not do muscle strengthening exercise on two or more days per week and lived in Glasgow.

4. Do I have to take part?

No, it is up to you to decide whether to take part as participation in this study is completely voluntary. If you do decide to take part, you are still free to withdraw at any time without giving any reason. Participating in this study will not affect your employment or standing.

5. What will happen to me if I take part?

In this workshop, we will discuss barriers and facilitators for participation in muscle strengthening exercise and then, with your help, design an intervention to help you achieve the muscle strengthening exercise guidelines. This workshop will take place at the University of Glasgow and last two hours. Some of the barriers to taking part in exercise may be personal and sensitive therefore participants will be provided with resources and contact details of organisations who might be able to help with this as appropriate (Samaritans, financial advice services, mental health charities). However, if anything is raised that suggests illegality or risk status, then the researcher is obligated to report as appropriate.

6. What do I have to do?

If you decided to take part in the workshop, we will ask you questions on the barriers you faced and facilitators in your participation in muscle strengthening exercise. Then, you will be invited to design an intervention together with the researchers. There are four parts in this 2-hour workshop which are knowledge sharing session, discussion of barriers and facilitators for participation in muscle strengthening exercise, demonstration of muscle strengthening exercises and lastly, creation of muscle strengthening intervention.

7. What are the possible disadvantages and risks of taking part?

There are no possible disadvantages and risk of taking part in this study.

8. What are the possible benefits of taking part?

Participating in muscle strengthening exercise is important for our health. The information will help us develop interventions to increase participation in

muscle strengthening exercise. A £20 Amazon voucher will be provided upon completion.

9. Will my taking part in this study be kept confidential?

Participant's name and contact information (phone number/email) will be collected only if they agree to take part in the study. The researchers will only use this information to get in touch with the participants and it will not be linked to their responses during the workshop. Non-sensitive personal data (date of birth, postcode, work situation, highest qualification completed, marital status) will be obtained. The data will be stored in archiving facilities in line with the University of Glasgow retention policy of up to 10 years. After this period, further retention may be agreed, or the data will be securely destroyed in accordance with the relevant standard procedures. All the information and responses collected will be kept strictly confidential and anonymous. All data in electronic format will be stored on secure password-protected computers.

10. What will happen to my data?

Researchers from the University of Glasgow collect, store, and process all personal information in accordance with The General Data Protection Regulation (2018). The data will be stored in archiving facilities in line with the University of Glasgow retention policy of up to 10 years. After this period, further retention may be agreed, or your data will be securely destroyed in accordance with the relevant standard procedures. Your rights to access, change, or move the information we store may be limited, as we need to manage your information in specific ways for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we already obtained. To safeguard your rights, we will use the minimum personally identifiable information possible. You can find out more about how we use your information from the researcher (n.rosaini.1@research.gla.ac.uk).

11. What will happen to the results of the research study?

The findings from this research project will contribute to the principal researcher's (Nur Dania Rosaini) PhD project. The research team would also seek to publish the findings in journals and present the data at conferences. You will not be identified by name in any publications. Please let the research team know if you would like a copy of the published results.

12. Who is organising and funding the research?

The work is organised by Ms Nur Dania Rosaini, Professor Stuart Gray and Dr Gemma Ryde in the School of Cardiovascular and Metabolic Health at the University of Glasgow. This work is funded by Majlis Amanah Rakyat Malaysia (MARA), a studentship to Ms Nur Dania Rosaini.

13. Who has reviewed the study?

This study has been reviewed and approved by the College of Medical, Veterinary and Life Sciences Ethics Committee at the University of Glasgow.

14. Contact for Further Information

If you have any doubts or questions, please contact one of the investigators below:

Principal Researcher

Nur Dania Rosaini

Email: n.rosaini.1@research.gla.ac.uk

Supervisor

Professor Stuart Gray

Email: stuart.gray@glasgow.ac.uk

Dr Gemma Ryde

Email: gemma.ryde@glasgow.ac.uk

Thank you for reading the Information Sheet

Appendix 4-B: Consent Form (Workshop)



University of Glasgow | College of Medical,
Veterinary & Life Sciences

Title of Project: Co-designing an intervention to improve participation of women in muscle strengthening exercise (Part 2)

Name of Researcher(s): Nur Dania Rosaini, Professor Stuart Gray, Dr Gemma Ryde

CONSENT FORM

Please
initial
box

I confirm that I have read and understood the Participant Information Sheet version V.0.1 dated 18/01/2024.

I confirm that I have read and understood the Privacy Notice version 00001 dated 18/01/2024.

I have had the opportunity to think about the information and ask questions and understand the answers I have been given.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

I confirm that I agree to the way my data will be collected and processed and that data will be stored for up to 10 years in University archiving facilities in accordance with relevant Data Protection policies and regulations.

I understand that all data and information I provide will be kept confidential and will be seen only by study researchers and regulators whose job it is to check the work of researchers.

I agree that my name, contact details and data described in the information sheet will be kept for the purposes of this research project.

I understand that if I withdraw from the study, my data collected up to that point will be retained and used for the remainder of the study.

I understand that my information and things that I say during the workshop may be quoted in reports and articles that are published about the study, but my name or anything else that could tell people who I am will not be revealed

I agree to take part in the study.

☐

I do not agree to take part in the study.

☐

Name of participant

Date

Signature

Name of Person taking consent
(if different from researcher)

Date

Signature

Researcher

Date

Signature

(1 copy for participant; 1 copy for researcher)

Appendix 4-C: Recruitment Poster

University of Glasgow | College of Medical, Veterinary & Life Sciences

the strengthUK project

WOMEN IN STRENGTH

Co-Design Muscle Strengthening Workshop

Ever wanted to have your say on how muscle strengthening should be designed for women? Join our workshop to begin your muscle strengthening adventure!

open to women aged 18-64 who aren't yet engaging in twice-weekly muscle strengthening.

Where and When?

Date and Time:

- 11.06.2024 (10 AM - 12 PM)
- 13.06.2024 (6 PM - 8 PM)

Venue: BHF Glasgow
Cardiovascular Research Center,
University of Glasgow

Activities

- **Knowledge Sharing Session:** Women and Strength
- **Group Discussion:** Challenges and Barriers to Muscle Strengthening Participation
- **Strength Exercise Demonstration**
- **Build Your Strength Exercise Plan**

Interested? Scan to register

£20
Amazon voucher upon completion

For more information, please contact:
Nur Dania Rosaini
n.rosaini.1@research.gla.ac.uk

Appendix 4-D: Post Workshop Survey Questions

POST WORKSHOP SURVEY (via Qualtrics Ltd.)

Thank you for joining our **Women in Strength: Co-Design Muscle Strengthening Intervention Workshop**. Your insights and experiences are incredibly valuable to us. We'd love to hear about your experiences attending the workshop and gather your feedback. Your voice matters—let us know what you think!

Q1. Session attended

- ☐ Tuesday, 10 am – 12 pm
- ☐ Thursday, 6 pm – 8 pm

Q2. How would you rate your overall experience with the workshop?

- ☐ Extremely satisfied
- ☐ Somewhat satisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Somewhat dissatisfied
- ☐ Extremely dissatisfied

Q3. What do you like most about your experience?

Q4. What do you like least about your experience?

Q5. Do you find this workshop useful?

- ☐ Definitely yes
- ☐ Probably yes
- ☐ May or may not
- ☐ Probably not
- ☐ Definitely not

Q6. How would you rate your understanding of muscle-strengthening exercises before the workshop?

- ☐ Excellent
- ☐ Good
- ☐ Average
- ☐ Poor
- ☐ Terrible

Q7. How would you rate your understanding of muscle-strengthening exercises after the workshop?

- ☐ Excellent
- ☐ Good
- ☐ Average
- ☐ Poor
- ☐ Terrible

Q8. Were there any issues or problems you encountered? If so, please describe them.

☐

Q9. Over the past 7 days, have you attempted to incorporate muscle-strengthening exercises into your routine?

☐ Yes

☐ No

Q10. How many days did you do muscle-strengthening exercises?

☐ _____ days per week

Q11. What type of muscle-strengthening exercises do you do?

	Yes	No
Weight Machines (at home, in a gym or fitness centre)		
Resistance Exercises (using free weights such as dumbbells or resistance bands.)		
Bodyweight Exercises (such as push-ups, sit ups or planking)		
Holistic Exercises (such as Pilates, Yoga, Tai Chi)		

Q12. Please provide any suggestions you have for improving our workshop.

**We appreciate the time you took to complete this survey.
Your response has been recorded.**

Appendix 4-E: PRODUCES Checklist

Checklist for reporting intervention co-creation (PRODUCES)

In accordance with Leask, C.F., Sandlund, M., Skelton, D.A. *et al.* Framework, principles and recommendations for utilising participatory methodologies in the co-creation and evaluation of public health interventions. *Res Involv Engagem* 5, 2 (2019). <https://doi.org/10.1186/s40900-018-0136-9>

Item	Checklist Item	Page Number	Description
Planning			
How was the aim of the study framed?	1) Use each element of the PRODUCES framework.	80-81	Using PAAR (<i>Design</i>) to develop (<i>Objective</i>) and test (<i>Evaluation</i>) with academic researchers and adult women (<i>Co-creators</i>), an iterative (<i>Scalability</i>) intervention to increase participation in muscle-strengthening exercises among women (<i>end-Users</i>).
Explain the sampling procedure	2) Explain the criteria used for sampling.	81	Purposive sampling. End-users aged between 18 to 64 years old, community-dwelling, able to ambulate independently, able to give informed consent and attend the workshop.
	3) In what settings did the sampling occur?	81	End-users' co-creators were recruited from survey responses, and additional participant recruitment was done through promotional posters.
	4) How many individuals engaged as co-creator? (academic/non-academic stakeholder)	81-82	3 university researchers and 21 adult women.
	5) Describe the co-creators (demographic/groups/demographic/groups/other characteristic).	80	Females, living in Glasgow, aged between 18 to 64 years old and currently not achieving the government recommendations of 2 days a week of muscle-strengthening activities.
Conducting			
How was ownership manifested?	6) Explain the methods used to manifest ownership (branding, rights and responsibility).	80-83	Co-creators branded as Women in Strength (WISH) Team. All co-creators are told of their rights or equal status within the group and responsibilities to contribute ideas.

Procedures Component	7) What level of participation was there from the co-creators?	80-83	Equal participation from both academic researchers and end-users and all co-creators will be asked for their inputs in each discussion point.
	8) How was the overall aim presented?	80-85	The overall aim will be highlighted at the beginning of the process and at the beginning of the workshop.
	9) How was the purpose of each meeting presented?	80-85	The purpose of the workshop was highlighted at the beginning.
	10) What were the rules and responsibilities of participation agreed upon?	80-85	Individuals were told of their right to equal status within the group and to contribute their ideas.
Procedures Methods	11) In which areas did the co-creators require up-skilling?	80-85	End-users will be upskilled regarding behavioural change theory and research methods. Academic researchers will be upskilled regarding adults' reasons and preferences for muscle-strengthening exercise participation.
	12) What previous evidence was reviewed, and how?	80-85	Presentation of the context for muscle strength throughout the age, adults' participation in muscle-strengthening exercises, behavioural assets that can be done to increase muscle-strengthening exercise participation and behavioural change theory.
	13) If a prototype was developed, describe the prototype and the prototyping process.	80-85	A full intervention prototype will be created from several key elements discussed.
	14) Describe the frequency and the duration of meetings.	81	2 independent co-creation workshops (morning or evening sessions) were conducted with each group of stakeholders, including community members and the research team. Each session lasted 2 hours.
	15) Give examples of interactive techniques or methods used.	80-85	Scenarios (where it may be easy / difficult to increase participation in muscle-strengthening exercises) /

			Brainstorming (how/what can be done)
	16) Give examples of fieldwork techniques or methods used.	88-95	Testing the created prototype with end-users who are not involved in the process.
	17) Give an example of how iteration occurred during the process.	86	The initial prototype will be developed, tested externally and after discussion, refined and then tested again.
Evaluating			
Process	18) Explain how co-creator satisfaction and contribution are evaluated (attendance rate, questionnaire, interview).	95	The satisfaction level is evaluated through a post-workshop questionnaire.
	How were the results reported back to stakeholders and the public?	Chapter 7	Written report will be done to explain the results of the process, and the findings will be disseminated through the journal publication and conference.
Outcome	19) Explain how the validity of the outcome and the process were evaluated (face validation, member checking).	86	Data was collected using individual worksheets, sticky notes with comments and images, written notes from whole group discussions, and reflective notes from the research team. After each workshop, a 1-hour debrief was held to discuss the data, add comments and thoughts to the reflective notes, and create a consensus summary of key points.
	20) Explain plans for formal testing of the effectiveness/scalability of the co-created outcome.	86, Chapter 5	Plan to embed the intervention into a randomised control trial involving two arms (control and intervention) to assess the feasibility and acceptability.
	21) Explain the outcome of the evaluation (if tested).	Chapter 5	If step 20 is deployed, outcomes that will be measured include experiences with muscle-strengthening exercise participation, changes in body composition, and muscular strength.

Appendix 4-F: Workshop Worksheets



ACTIVITY 1: DRAW WHAT MUSCLE STRENGTHENING EXERCISES LOOK LIKE TO YOU

STICK THE POST IT BELOW:



ACTIVITY 1: DRAW WHAT MUSCLE STRENGTHENING EXERCISES LOOK LIKE TO YOU

STICK THE POST IT BELOW:



ACTIVITY 2: HOW DO YOU THINK MUSCLE STRENGTHENING EXERCISES BENEFIT WOMEN?

STICK THE POST-IT / WRITE BELOW:

Feeling better
about doing
something
GOOD FOR YOU!

GOOD FOR
MENTAL
HEALTH

GIVING
SELF
SATISFACTION

FEEL BETTER
IN YOUR
BODY
CONFIDENCE

Improve
your overall
health
(fat metabolism,
...)

To get
resistance to
do more
activities
(hiking, playing
with my son)

Increase
stamina

HELP WOMEN
AGE BETTER
AVOID BREAKING
BONES

EXERCISE
CLASSES MAY
ALSO HELP
YOUR MENTAL
HEALTH

IF YOU FEEL
FIT YOU
FEEL BETTER

ACTIVITY 2: HOW DO YOU THINK MUSCLE STRENGTHENING EXERCISES BENEFIT WOMEN?

STICK THE POST-IT / WRITE BELOW:

Better posture
stronger spine
Greater
General independence
Locomotion

Don't make anything
difficult, build custom
• Improved mental health
• Be more energetic and
healthy
• Perform daily tasks and take
home with more energy
• Independent body care
• Age gracefully

• Women have more
fat than muscle
So they need to
strengthen their core
• Pregnancy
• Holding baby etc
• Core muscles
• They let your muscles
into working posture

Women & Strength
• Higher blood circulation
and confidence
• Helps feel more energized
and purpose
• Helps feel strong (not)
• Helps build endurance

ACTIVITY 2: HOW DO YOU THINK MUSCLE STRENGTHENING EXERCISES BENEFIT WOMEN?

STICK THE POST IT / WRITE BELOW:

increase dopamine
to keep a good mood.

mental health.

bone density.

- helps carry weight
- helps lift things
- builds stronger muscles.

Prevents muscle loss

ACTIVITY 2: HOW DO YOU THINK MUSCLE STRENGTHENING EXERCISES BENEFIT WOMEN?

STICK THE POST IT / WRITE BELOW:

Muscle strengthening exercise
improves metabolism ~~improves~~
which may help us keep fit & healthy

Strength training exercises
would help me carry
weight via strong
hips so carry around
that weight with

Muscle training can
combat age-related
muscle loss

Endurance
to keep going through
the day +
while when
working hard

Burn more
calories if
muscles are
strong.

Over 50+
lose muscle
mass so need
extra work
(menopause)

Feeling
strong and
powered

1. Full energy
2. More healthy
3. More beautiful
4. More confident

ACTIVITY 3

STICK THE POST-IT / WRITE BELOW

CHALLENGES AND BARRIERS THAT YOU FACE IN YOUR MUSCLE STRENGTHENING EXERCISES PARTICIPATION	THE WAYS THAT YOU THINK WOULD HELP YOU OVERCOME THESE CHALLENGES AND BARRIERS
in being consistent DONT HAVE ACCESS TO A GYM (COST) Phone distraction! Feel embarrassed when compared with other people Lack of motivation Lack of time ...? Stigma for women "exercising is not important for girls!"	TRY TO GET A REDUCED GYM MEMBERSHIP IF POSSIBLE Better time management NEED TO MAKE TIME CALL IT SELF HELP put away phone! -do a time-blocking NEED TO ENJOY WHAT EXERCISE YOU CHOOSE. Knowing the benefits of muscle strengthening Find an <u>accountable</u> exercising partner

ACTIVITY 3

STICK THE POST-IT / WRITE BELOW

CHALLENGES AND BARRIERS THAT YOU FACE IN YOUR MUSCLE STRENGTHENING EXERCISES PARTICIPATION	THE WAYS THAT YOU THINK WOULD HELP YOU OVERCOME THESE CHALLENGES AND BARRIERS
Not knowing the right ones Fear of injury or strain if I'm doing the exercise correctly Being watched Too many options... where to begin... ACCESS TO THE GYM Fear of making things worse Not out of the sport at all some of the beginners clothes Embarrassment Changing clothes -Showering -having to pee CORRECT POSTURE? Expense of gym membership/at home equipment	USE RESISTANCE BANDS OR EASILY AVAILABLE START SOMEWHERE! Free community classes to help learn some basics (after @ the gym or @ home) Listen to music/podcast Distract PEER SUPPORT - DISCUSS/GET HELP FROM FRIENDS WHO DO ME. Get your friends to go @ you.

ACTIVITY 3

STICK THE POST IT / WRITE BELOW

CHALLENGES AND BARRIERS THAT YOU FACE IN YOUR MUSCLE STRENGTHENING EXERCISES PARTICIPATION

Time (Schedule)

&
Motivation

Culture Difference

Accountability
with a
Gym Partner/Buddy

Cultural Difference
Men & Women

Not enough
to
Beach Sport

Clothing
(Compare)

Finance
/
Affordability

THE WAYS THAT YOU THINK WOULD HELP YOU OVERCOME THESE CHALLENGES AND BARRIERS

Gym
buddy
(motivations)

Be honest
with
yourself

A Routine
to create a
habit
to miss none

ACTIVITY 3

STICK THE POST IT / WRITE BELOW

Knowledge
→ it always seems
worse than it is
→ all muscle strength is a process
→ it's a very progressive
process

With partner and
make an intention for
exercise sports
About people, motivation
and others

CHALLENGES AND BARRIERS THAT YOU FACE IN YOUR EXERCISES PARTICIPATION

Motivation
if exercising
alone - have
to self-motivate

For people only
gym
Because like gym
have a lot of rules
and a culture that's
difficult to pick up if
you're new to it

Too
Because gym is expensive
the design is not good

I didn't find the gym
comfortable. I had
to train for 1 hour a week
until I had to stop
or rescheduling it
all.

It's
Boring

I have a very busy
job. It's difficult to
find time to energy
to do muscle exercises
It's also difficult to
have time to other
things around
periods

Not sure
what to do
in the gym
on the machine
or free weights

I am scared I
will injure myself
with weights

Group
Strength
Classes on gym
floor. Beginners
level

1. Make a timetable
schedule
2. Pick a partner
3. Find new way to
exercise our muscle

A reasonably good time that
women only gym in a
convenient location with
a supportive, no judgment
space of instruction that
will take you from basics

Female focused
resources and
created by a diverse
demographic
of experienced
personal fitness
trainers

Classes for
50+
menopausal
women
classes

Accountability
coach / even
if just online
to check in +
see you are
doing exercises

Women only
weight lifting
strength classes
(Female
coach)

try to use different
plan

Being the one who
- looking out for others and
motivate

• Greater variety of exercise
- functional strength training
- strength training
- strength training
- strength training
- strength training

lack of knowledge

ACTIVITY 3

CHECK THE POST IT / WRITE BELOW:

CHALLENGES AND BARRIERS THAT YOU FACE IN
YOUR MUSCLE STRENGTHENING EXERCISES

lack of visible results,
depression / mental health -
fatigue
work / study priorities
discomfort / pain from exercise.
injury / illness.
male bias / culture / safety
being looked at / stared at.
smells / sweat.
weather.
laziness.
cost / equipment.
time.
childcare.

THE WAYS THAT YOU THINK WOULD HELP YOU
OVERCOME THESE CHALLENGES AND BARRIERS

accountability buddy ✓
class / timetable ✓
paying for a session / course
women's club / group. (doesn't always work)
instructor help.
non-competitive activity.
tracker
"non-negotiable".
visible / measurable results.
getting 'the buzz'.
remove friction (put out clothes etc).

ACTIVITY 4: LET'S CREATE AN ALTERNATIVE ROUTINE

5:00 - 6:00 AM:	Dream 1	3:00 - 4:00 PM:	Tea Break
6:00 - 7:00 AM:	Dream 1 (agreed one)	4:00 - 5:00 PM:	work
7:00 - 8:00 AM:	wake up + freshen up	5:00 - 6:00 PM:	go home
8:00 - 9:00 AM:	Go strength train!	6:00 - 7:00 PM:	Dinner & Digs
9:00 - 10:00 AM:	Shower, prepare & eat breakfast	7:00 - 8:00 PM:	Movie time
10:00 - 11:00 AM:	Work / uni	8:00 - 9:00 PM:	chill
11:00 - 12:00 PM:	—	9:00 - 10:00 PM:	Chat logs
12:00 - 1:00 PM:	—	10:00 - 11:00 PM:	Sleep
1:00 - 2:00 PM:	lunch	11:00 - 12:00 AM:	
2:00 - 3:00 PM:	work / uni / class		

OTHER THOUGHTS?

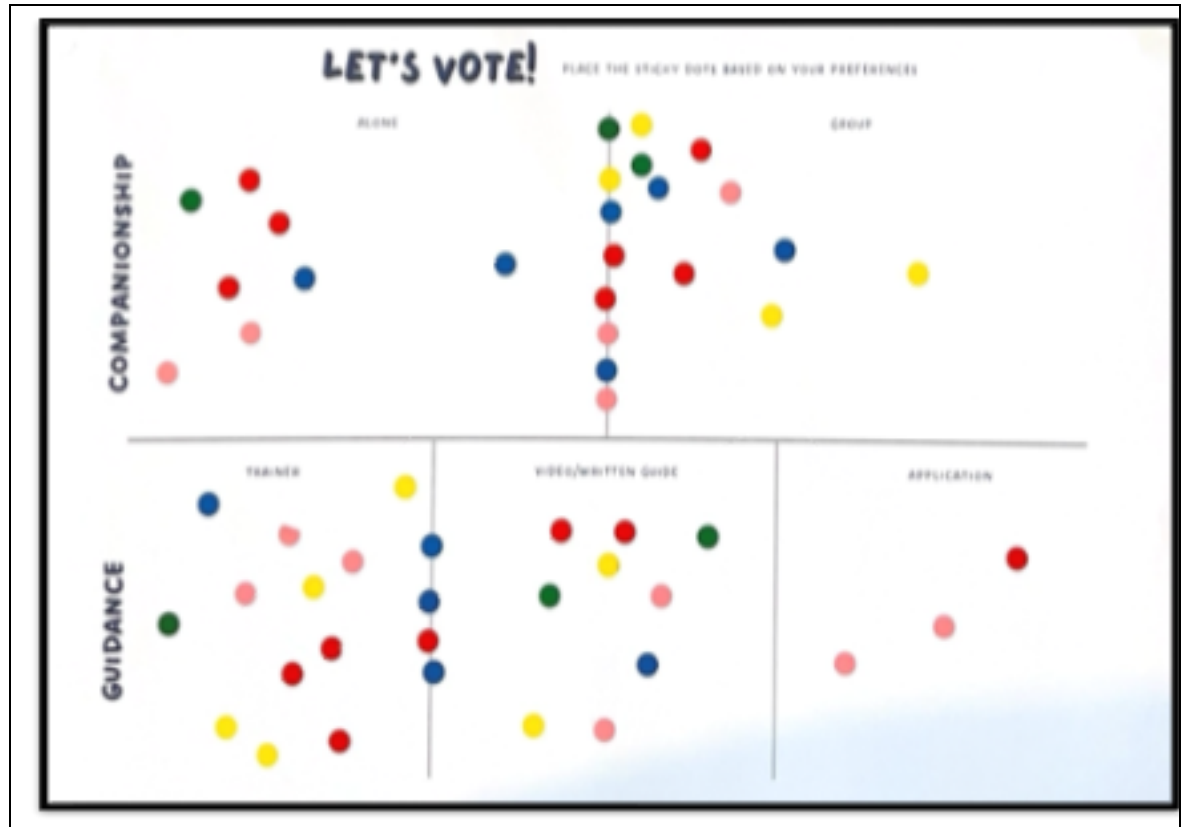
ACTIVITY 4: LET'S CREATE AN ALTERNATIVE ROUTINE

5:00 - 6:00 AM:	ASLEEP	5:00 - 6:00 PM:	// // //
6:00 - 7:00 AM:	BREAKFAST + GYM OR HOME WORK OUT	6:00 - 7:00 PM:	// // //
7:00 - 8:00 AM:	GET READY FOR WORK OR UNI.	7:00 - 8:00 PM:	HOMETIME
8:00 - 9:00 AM:	WORK OR UNI	8:00 - 9:00 PM:	COOK DINNER
9:00 - 10:00 AM:	// // //	9:00 - 10:00 PM:	POSSIBLE GYM OR HOME EXERCISE
10:00 - 11:00 AM:	// // //	10:00 - 11:00 PM:	SPEND TIME WITH FAMILY.
11:00 - 12:00 PM:	// // //	11:00 - 12:00 PM:	WIND DOWN FOR THE DAY
12:00 - 1:00 PM:	LUNCH BREAK AND POSSIBLY GYM	12:00 - 1:00 PM:	// // // //
1:00 - 2:00 PM:	WORK OR UNI	1:00 - 2:00 PM:	GET READY FOR BED
2:00 - 3:00 PM:	// // //	OTHER THOUGHTS:	

LET'S VOTE!

PLACE THE STICKY DOTS BASED ON YOUR PREFERENCES





Appendix 4-G: Participants' Experiences with the Co-Design Process

Participants' Experience with the Co-Creation Process	
How would you rate your overall experience with the workshop?	Extremely satisfied (N=8) Somewhat satisfied (N=2)
What did you like most about your experience?	• Meeting ladies who are also interested in building up muscle • Friendly attitude of the researcher • The interactive style of the workshop and the snacks. • The speaker and approach • The group work was well facilitated • Talking about different ways to exercise without incurring huge costs • The information provided by the research group and meeting other women with similar situations to mine • Everyone is very friendly and engaging. • Being able to have my voice heard • I liked hearing from people who knew what they were talking about.
What did you like least about your experience?	• Only spoke to the people at my table • What I liked least was that there wasn't much teaching of skills during the workshop. I also found it a bit challenging doing the group projects (such as making the ideal routine) because my schedule was very different from those in my group, and my preferred work out methods were also different from those in my group. • Women making unreasonable excuses about using the gym • The session was quite long. • I think all the whole session was well planned. I would maybe just adjust the time planning to make it more efficient, but even though I believe it was really good. • The activity with the photographs was confusing, and we couldn't really come to a consensus
Do you find this workshop useful?	Definitely yes (N=6) Probably yes (N=1) May or may not (N=3)
How would you rate your understanding of muscle strengthening exercises before the workshop?	Good (N=4) Average (N=3) Poor (N=3)
How would you rate your understanding	Excellent (N=1) Good (N=7)

of muscle-strengthening exercises after the workshop?	Average (N=2)
In the past 7 days, have you tried to include muscle-strengthening exercises in your schedule?	Yes (N=8) No (N=2)
How many days did you do muscle-strengthening exercises?	1 day (N=1) 2 days (N=1) 3 days (N=4) 4 days (N=1)
What type of muscle-strengthening exercises that you do? (select which is applicable to you)	Bodyweight Exercises (<i>such as push-ups, sit-ups or planking</i>) (N=6) Holistic Exercises (<i>such as Pilates, Yoga, Tai Chi</i>) (N=2) Resistance Exercises (<i>using free weights such as dumbbells or resistance bands</i>) (N=5) Weight Machines (<i>at home, in a gym or fitness centre</i>) (N=3)
Please provide any suggestions you have for improving our workshop.	• Including a section on how to determine what your own workout goals should be and knowing how much weight/reps to start with would be really helpful. • Bringing a professional fitness person possibly to explain the background to working with PT or gym culture. My experience is good and possibly could change some of the thought processes I heard. • The people who attended were scared of the gym. Arranging a voucher or optional date for a walk around as a group might have helped them as a follow-up. • Just as a clarification. Since attending the workshop, I got a gym membership and plan to do at least 2 sessions/day of strengthening per week (initially through classes: resistance, bodyweight exercises; and later using weight machines). Regarding the workshop, I believe it was fabulous, and I will only suggest that it last longer, so there is more time for the activities/discussion (although I know there could be time constraints from participants or organisers).

Appendix 5-A: Ethics Approval: WISH Trial



Professor Stuart Gray

MVLS College Ethics Committee

A randomised pilot feasibility trial of a muscle strengthening exercise intervention for women
200240060

The College Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the study.

We are happy therefore to approve the project, subject to the following conditions

- Project end date as stipulated in original application.
- The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research:
(http://www.gla.ac.uk/media/media_227599_en.pdf)
- The research should be carried out only on the sites, and/or groups or datasets as defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment, except when it is necessary to change the protocol to eliminate hazard to the subjects or where the change involves only the administrative aspects of the project. The Ethics Committee should be informed of any such changes.
- You should submit a short end of study report within 3 months of completion.

Yours sincerely

Dr Terry Quinn

Terry Quinn
FWSO, FESO, MD, FRCP, BSc (hons), MBChB (hons)
College of Medicine, Veterinary & Life Sciences
School of Cardiovascular and Metabolic Health
New Lister Building, Glasgow Royal Infirmary
Glasgow G3 7 2ER
terry.quinn@glasgow.gla.ac.uk
Tel – 0141 201 8519

The University of Glasgow, charity number SC004401

Appendix 5-B: Participant's Information Sheet

University of Glasgow | College of Medical,
Veterinary & Life Sciences

1. Study title

A randomised pilot feasibility trial of a muscle strengthening exercise intervention for women

We are a group of researchers from the University of Glasgow who are interested in helping women to participate in muscle strengthening exercises. We invite you to participate in our study to explore the acceptability and effectiveness of our intervention. Before you decide, you need to understand why this study is being done and what it will involve. Please take time to read the following information and ask us if there is anything that is not clear or if you would like more information.

2. What is the purpose of the study?

We previously explored the barriers and facilitators for women participating in muscle strengthening exercises. Based on the information we gather, we have created an intervention that we hope women find acceptable and something they can do in the long term. Therefore, the study aims to see if you find the intervention created acceptable and can fit into your daily schedule. We also would like to investigate how the intervention can influence your body composition and strength.

3. Why have I been invited to participate?

You have been invited to participate as you have indicated that you are woman, aged between 18 to 45 years old, living in the Glasgow area and currently not meeting the current government muscle strengthening activities guidelines of 2 days a week.

4. Do I have to take part?

No, it is up to you to decide whether to take part as participation in this study is completely voluntary. If you do decide to take part, you are still free to withdraw at any time without giving any reason. Participating in this study will not affect your employment or standing.

5. What will happen to me if I take part?

This study will utilise the Randomised Controlled Trial (RCT) design. Following completion of the baseline measurements, you will be randomly assigned to either the control group or the intervention group.

Control

If you are in the control group, we will ask you to maintain your normal activity levels for 24 weeks. On completion of the 24 weeks, we will give you a 12-week University of Glasgow Sports gym membership.

*Group**Intervention**Group*

The overall aim of the intervention is for you to participate in muscle strengthening exercises, of your choice, two days a week. These exercises can include weight machine, resistance band and body weight resistance exercises, alongside strength training classes such as yoga and body pump. The intervention will begin with weekly education sessions over the first 4 weeks, to help make sure you are confident and competent in performing exercises. You will be given a gym membership for the 12-week intervention period and asked to log all muscle strengthening exercises that you participate in. Throughout the intervention, you will receive weekly support reminder messages via WhatsApp from the research team, and we will also set up a social support group on WhatsApp for the participants. Weekly group-based exercise sessions with the researcher will also be offered to you; these will be optional.

The following data will be collected from all participants. All measures will be collected at baseline, mid-intervention measurement (week 6), post-intervention (week 12), and follow-up (week 24) except for follow-up interview and you will be given an Amazon voucher worth £25 for every measurement period you attend. Each test/measure is detailed further below.

During baseline measurement, we will ask you your age, postcode, ethnic background, work situation, highest qualification completed, marital status, if you are a caregiver and the rating of your health. Following this we will measure your body composition where we will record your weight, height, fat mass, fat percentages, muscle mass and muscle size.

Then, we will measure your strength using three strength tests which are the grip strength test, back strength test and maximal voluntary contraction. You will be shown how to perform the test by the research team before performing it. You will be asked to do each test 3 times with rest in between each attempt. The body composition and strength test will be conducted again in week 6, 12 and 24.

If you are in the intervention group, there will be a follow-up interview during the measurement visit on week 12 and 24 to discuss your experiences and feedback on the intervention.

6. What do I have to do?

Data will be collected from the strength test and body composition test (both groups), interview and training log (intervention group only). You will be asked to attend 4 measurement sessions throughout the 24 weeks study duration and each measurement session is about 2 hours. Each test/measure is detailed further below.

Body Composition: Your height and body mass will be collected using a stadiometer and digital weight scale. Your body mass index (BMI) will be calculated using the BMI formula ($BMI = kg/m^2$). Your lean muscle mass, fat

mass, muscle mass and body fat percentages will be taken using a segmental body composition analyser. Your vastus lateralis muscle thickness will be measured using a small handheld ultrasound device.

Strength Tests.

- *Grip strength:* This test will be conducted using a handgrip dynamometer where you will be asked to squeeze the handgrip dynamometer with as much force as possible. You will be asked to perform this test 3 times for each hand and with rest in between each attempt.
- *Back strength:* This test will be conducted using a back dynamometer. You will be asked to stand on the base with your feet shoulder feet apart, bending your knee slightly and hold the handle with both hands. You will have to keep your back straight and pull upwards. This test will be repeated 3 times with rest in between each attempt.
- *Maximal voluntary contraction (MVC):* You will be asked to sit in a chair with your legs at 90-degree angle. A strap around will be placed around the right ankle which will be connected to a force transducer. You will be asked to contract maximally with the leg fixed in position and record force for 10 seconds. You will perform 3 contractions, with 1 minute rest between contraction.

Training Log: If you are in the intervention group, you will be provided with a training log where we will ask you to record every muscle strengthening exercise that you do. The log will contain sections on the day, date, time, type of activity, perceived exertion, set, repetitions and load where required. You will be asked to complete this in as much detail as possible throughout the 24 weeks.

Follow-up Interview: if you are in the intervention group, you will have a follow-up interview at post-intervention and follow-up visits. The interview will last around 60 minutes and will further explore the acceptability and feasibility of the intervention and testing protocols, asking questions about barriers to participation. The interview will include people who completed the whole intervention and also those who dropped out of the intervention (where possible). These interview sessions will be audio-recorded for analysis purposes and be transcribed word by word. All transcripts will be checked against the original recording. Once this is complete, audio files will be deleted.

7. What are the possible disadvantages and risks of taking part?

Exercises will be at a submaximal level at most points in the study depending on the type of exercises participated but there is the possibility the participants in the intervention group will suffer from acute muscle soreness a day or two after performing the exercises. This condition is called Delay Onset Muscle Soreness and is a normal and short-lived feeling. There is also the potential for

musculoskeletal injury, although this risk is small and will be minimized by performing a warm up and cool down. If you experience any unusual sensations in your chest, feel unwell or do not want to continue for any other reason during exercise you should cease exercising immediately.

8. What are the possible benefits of taking part?

Participating in muscle strengthening exercises is beneficial for our health. The results from this study will provide evidence of the benefits of this sort of intervention for women's participation in muscle strengthening exercises which is essential given that women are still participating in less muscle strengthening exercises compared to men. A £25 Amazon voucher will be provided for every measurement visit that you attend.

9. Will my taking part in this study be kept confidential?

Yes. All information which is collected about you during the course of the research will be kept strictly confidential. Your data will be anonymised in any outputs produce with a number allocated to the data and not your name or contact details.

10. What will happen to my data?

Researchers from the University of Glasgow collect, store, and process all personal information in accordance with The General Data Protection Regulation (2018). The data will be stored in archiving facilities in line with the University of Glasgow retention policy of up to 10 years. After this period, further retention may be agreed, or your data will be securely destroyed in accordance with the relevant standard procedures. Your rights to access, change, or move the information we store may be limited, as we need to manage your information in specific ways for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we already obtained. To safeguard your rights, we will use the minimum personally identifiable information possible. You can find out more about how we use your information from the researcher (n.rosaini.1@research.gla.ac.uk).

11. What will happen to the results of the research study?

The findings from this research project will contribute to the principal researcher's (Nur Dania Rosaini) PhD project. The research team would also seek to publish the findings in journals and present the data at conferences. You will not be identified by name in any publications. Please let the research team know if you would like a copy of the published results.

12. Who is organising and funding the research?

The work is organised by Ms Nur Dania Rosaini, Dr Gemma Ryde, Professor Stuart Gray and in the School of Cardiovascular and Metabolic Health at the University of Glasgow. This work is funded by Majlis Amanah Rakyat Malaysia (MARA), a studentship to Ms Nur Dania Rosaini.

13. Who has reviewed the study?

This study has been reviewed and approved by the College of Medical, Veterinary and Life Sciences Ethics Committee at the University of Glasgow.

14. Contact for Further Information

If you have any doubts or questions, please contact one of the investigators below:

Principal Researcher

Nur Dania Rosaini

Email: n.rosaini.1@research.gla.ac.uk

Supervisor

Professor Stuart Gray

Email: stuart.gray@glasgow.ac.uk

Dr Gemma Ryde

Email: gemma.ryde@glasgow.ac.uk

Thank you for reading the Information Sheet

Appendix 5-C: Consent Form



University of Glasgow | College of Medical,
Veterinary & Life Sciences

**Participant
Number:**

Identification

Title of Project:

A randomised pilot feasibility trial of a muscle strengthening
exercise intervention for women

**Name
Researcher(s):**

of Nur Dania Rosaini, Dr Gemma Ryde, Professor Stuart
Gray

CONSENT FORM

Please
initial
box

**I confirm that I have read and understood the Participant
Information Sheet version V.0.2 dated 19/11/2024.**

☐

**I confirm that I have read and understood the Privacy Notice
version 00002 dated 19/11/2024.**

☐

**I have had the opportunity to think about the information and ask
questions and understand the answers I have been given.**

☐

**I understand that my participation is voluntary and that I am free
to withdraw at any time, without giving any reason, without my
legal rights being affected.**

☐

**I confirm that I agree to the way my data will be collected and
processed and that data will be stored for up to 10 years in
University archiving facilities in accordance with relevant Data
Protection policies and regulations.**

☐

**I understand that all data and information I provide will be kept
confidential and will be seen only by study researchers and
regulators whose job it is to check the work of researchers.**

☐

**I agree that my name, contact details and data described in the
information sheet will be kept for the purposes of this research
project.**

☐

**I understand that if I withdraw from the study, my data collected
up to that point will be retained and used for the remainder of the
study.**

☐

I agree to my interview being audio-recorded.

☐

I understand that the recorded interview will be transcribed word by word and will be checked against the original recording and deleted once it's done and the transcription will be stored for up to 10 years in University archiving facilities in accordance with Data Protection policies and regulations.

☐

I understand that the information and things that I say in an interview may be quoted in reports and articles that are published about the study, but my name or anything else that could tell people who I am will not be revealed.

☐

I agree to take part in the study.

☐

Name of participant

Date

Signature

Name of Person taking consent
(if different from researcher)

Date

Signature

Researcher

Date

Signature

(1 copy for participant; 1 copy for researcher)

Appendix 5-D: Recruitment Poster

University of Glasgow | College of Medical, Veterinary & Life Sciences

WOMEN IN STRENGTH *GIRL POWER*

A randomised pilot feasibility trial of a muscle strengthening exercise intervention for women

Have you ever wanted to participate in muscle strengthening but don't know how or where to start? Join our 24 weeks study to begin your muscle strengthening adventure!

open to women aged 18-45 who are living in Glasgow and aren't yet engaging in twice-weekly muscle strengthening.

What is offered in this study?

- FREE 12-weeks gym membership
- £25 Amazon vouchers for attending each measurement visits (4 visits to the lab)
- Body composition analysis
- Strength measurements
- and many more...

Interested? Scan here:

made by WOMEN FOR WOMEN

For more information, please contact:
Nur Dania Rosaini
n.rosaini@research.gla.ac.uk

Appendix 5-E: PAR-Q+

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 are currently experiencing a temporary illness, such as a cold or fever. It is best to wait until you feel better.
-  You are pregnant. In this case, talk with your health care practitioner, physician, 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 health care practitioner, physician, or qualified exercise professional before proceeding with any physical activity program.

PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. **Do you have Arthritis, Osteoporosis, or Back Problems?**
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?**
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 chemotherapy 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**
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?**
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**
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 ☐

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.

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 are currently experiencing a temporary illness, such as a cold or fever. It is best to wait until you feel better.
- You are pregnant. In this case, talk to your health care practitioner, physician, qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes. Talk to your health care practitioner, physician, 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 D.E., Jamnik V.K., Bredin T.D., 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* 42(1):20-2011.

Key References

1. Jamnik V.K., Warburton D.E., McKenzie D.C., Shephard R.J., Stone J., and Gledhill N. Enhancing the effectiveness of clearance for physical activity participation, background and overall process. *APMIR* 3(6):513-513, 2011.
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3. Chakrabarti D., Gledhill N., Kozak L., Dwyer P.W., and Gruber N. Physical activity readiness. *British Columbia Medical Journal*, 16(5):17-17S-17S.
4. Thomas S., Reading L., and Shephard R.J. Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Canadian Journal of Sport Science* 19(1):174-186.

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.

Appendix 5-F: Trial Registration



ClinicalTrials.gov Protocol Registration and Results System (PRS) Receipt Release Date: July 23, 2025

ClinicalTrials.gov ID: NCT07095322

Study Identification

Unique Protocol ID: WISH

Brief Title: Investigating the Feasibility and Acceptability of Co-created Intervention to Improve Women's Participation in Muscle-strengthening Exercises (WISH)

Official Title: Women in Strength: A Randomised Pilot Feasibility Trial of a Muscle Strengthening Exercise Intervention for Women

Secondary IDs:

Study Status

Record Verification: July 2025

Overall Status: Completed

Study Start: December 4, 2024 [Actual]

Primary Completion: July 7, 2025 [Actual]

Study Completion: July 7, 2025 [Actual]

Sponsor/Collaborators

Sponsor: University of Glasgow

Responsible Party: Principal Investigator

Investigator: Stuart Gray [SGray]

Official Title: Professor Stuart Gray

Affiliation: University of Glasgow

Collaborators:

Oversight

U.S. FDA-regulated Drug: No

U.S. FDA-regulated Device: No

U.S. FDA IND/IDE: No

Human Subjects Review: Board Status: Approved

Approval Number: 200240060

Board Name: College of Medical, Veterinary and Life Sciences

Board Affiliation: University of Glasgow

Phone:

Email: ResearchEthicSystem@glasgow.ac.uk

Address:

University of Glasgow, G12 8QQ

Data Monitoring: Yes

Study Description

Brief Summary: This study will utilise the Randomised Controlled Trial (RCT) design. Following completion of the baseline measurements, participants will be randomly assigned to either the control group or the intervention group.

Control Group Control group will be asked to maintain normal activity levels for 24 weeks. On completion of the 24 weeks, 12-week University of Glasgow Sports gym membership will be given.

Intervention Group The overall aim of the intervention is for participants to participate in muscle strengthening exercises, of choice, two days a week. These exercises can include weight machine, resistance band and body weight resistance exercises, alongside strength training classes such as yoga and body pump. The intervention will begin with weekly education sessions over the first 4 weeks, to help make sure participants are confident and competent in performing exercises. Participants will be given a gym membership for the 12-week intervention period and asked to log all muscle strengthening exercises that participants participate in. Throughout the intervention, participants will receive weekly support reminder messages via WhatsApp from the research team, and researcher will also set up a social support group on WhatsApp for the participants. Weekly group-based exercise sessions with the researcher will also be offered to the participants; these will be optional.

The following data will be collected from all participants. All measures will be collected at baseline, mid-intervention measurement (week 6), post-intervention (week 12), and follow-up (week 24) except for follow-up interview and participants will be given an Amazon voucher worth £25 for every measurement period attend. Each test/measure is detailed further below.

During baseline measurement, researcher will ask the participants on their age, postcode, ethnic background, work situation, highest qualification completed, marital status, caregiver or not and the rating of health. Following this researcher will measure participants' body composition where the weight, height, fat mass, fat percentages, muscle mass and muscle size will be recorded.

Muscular strength will be measured using three strength tests which are the grip strength test, back strength test and maximal voluntary contraction. Participants will be shown how to perform the test by the research team before performing it. Participants will be asked to do each test 3 times with rest in between each attempt. The body composition and strength test will be conducted again in week 6, 12 and 24.

Intervention group will be involved in a follow-up interview during the measurement visit on week 12 and 24 to discuss the experiences and feedback on the intervention with the researchers.

Detailed Description:

Conditions

Conditions: Physical Activities
Exercise
Muscular Strength
Healthy Women

Keywords: Exercise
Muscle-strengthening
Women
Co-creation
co-design intervention
WISH study

Study Design

Study Type: Interventional
Primary Purpose: Prevention
Study Phase: N/A
Interventional Study Model: Parallel Assignment
Number of Arms: 2
Masking: None (Open Label)
Allocation: Randomized
Enrollment: 31 [Actual]

Arms and Interventions

Arms	Assigned Interventions
No Intervention: Control Remain usual activity level	
Experimental: Intervention Participated in the co-created intervention	Behavioral: Strength Education Session Strength education session given at the first 4 weeks of intervention to educate women on muscle-strengthening exercises Other Names: • Education Behavioral: Gym Membership 12 weeks gym membership to allow participant to go to the gym on their own Other Names: • Gym Membership Behavioral: Group Exercise Session Optional exercise sessions from week 4 to week 12 of the intervention if the participants want to join Other Names: • Exercise session Behavioral: Training Log To record the exercise done for 24 weeks duration. Consist of date, day, exercise, set, repetitions, load, RPE Other Names: • Log Behavioral: Support group For reminders and support for the participant for the first 12 weeks of intervention Other Names:

Arms	Assigned Interventions
	• Support group

Outcome Measures

Primary Outcome Measure:

1. Interview with researcher on the feasibility and acceptability of the co-created intervention.
Participants is invited to an interview with the researcher to discuss their opinion of the intervention component and if it has helps them to start and continue participating in muscle-strengthening exercises. Interview conducted at two time point week 12 and week 24. Interview will be conducted either in-person or online through Microsoft Teams and will be audio recorded for analysis purpose.

[Time Frame: Week 12 (post intervention) - how they find the intervention Week 24 (follow up) - to see if they still continue participating in muscle-strengthening exercises, were there any challenges and what has helped them]

Secondary Outcome Measure:

2. Knee Extensor Strength
Knee extensor maximal torque during isometric MVC
[Time Frame: changes from baseline to week 6, 12 and 24]
3. Grip Strength
measured via handgrip dynamometer
[Time Frame: Changes from baseline to week 6, 12 and 24]
4. Back Strength
measured via back strength dynamometer
[Time Frame: Changes from baseline to week 6, 12 and 24]
5. Vastus lateralis muscle thickness
measured via ultrasound
[Time Frame: Changes from baseline to week 6, 12 and 24]
6. Height
Height recorded using a stadiometer in centimetre at the beginning of the study.
[Time Frame: Recorded at baseline (Week 0)]
7. Bodyweight
Changes in bodyweight, recorded in kilogram. Measured via body composition analyser
[Time Frame: Changes from baseline to week 6, and 24.]
8. Body Mass Index (BMI)
Will be calculated from the bodyweight (in kilogram) and height (in meter) according to the BMI formula (kg/m^2).
[Time Frame: Changes from baseline to week 6, 12, and 24]
9. Body Fat Mass
Changes in body fat mass, recorded in kilogram. Measured via body composition analyser
[Time Frame: Changes from baseline to week 6, 12 and 24.]
10. Body Fat Percentages
Changes in body fat percentage, recorded in percentage. Measured via body composition analyser
[Time Frame: Changes from baseline to week 6, 12, and 24]
11. Fat Free Mass
Changes in fat free mass, recorded in kilogram. Measured via body composition analyser
[Time Frame: Changes from baseline to week 6, 12, and 24]

Eligibility

Minimum Age: 18 Years

Maximum Age: 45 Years

Sex: Female

Gender Based: Yes
Female

Accepts Healthy Volunteers: Yes

Criteria: Inclusion Criteria:

- female
- between 18-45 years old
- living in Glasgow area
- not currently achieving the government recommendation of 2 days a week of muscle-strengthening activities

Exclusion Criteria:

- did not pass the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+)
- have blood pressure > 150/90 mmHg
- currently pregnant, planning to get pregnant within the next 6 months or in post-partum period in the past 6 months
- have intellectual disabilities

Contacts/Locations

Central Contact Person: Stuart Gray
 Telephone: [REDACTED]
 Email: Stuart.Gray@glasgow.ac.uk

Central Contact Backup:

Study Officials:

Locations: **United Kingdom**
 University of Glasgow
 Glasgow, United Kingdom, G12 8QQ
 Contact: Stuart Gray [REDACTED] Stuart.Gray@glasgow.ac.uk

IPDSharing

Plan to Share IPD: No

References

Citations:

Links:

Available IPD/Information:

Appendix 5-G: WISH Strength Education Session Booklet

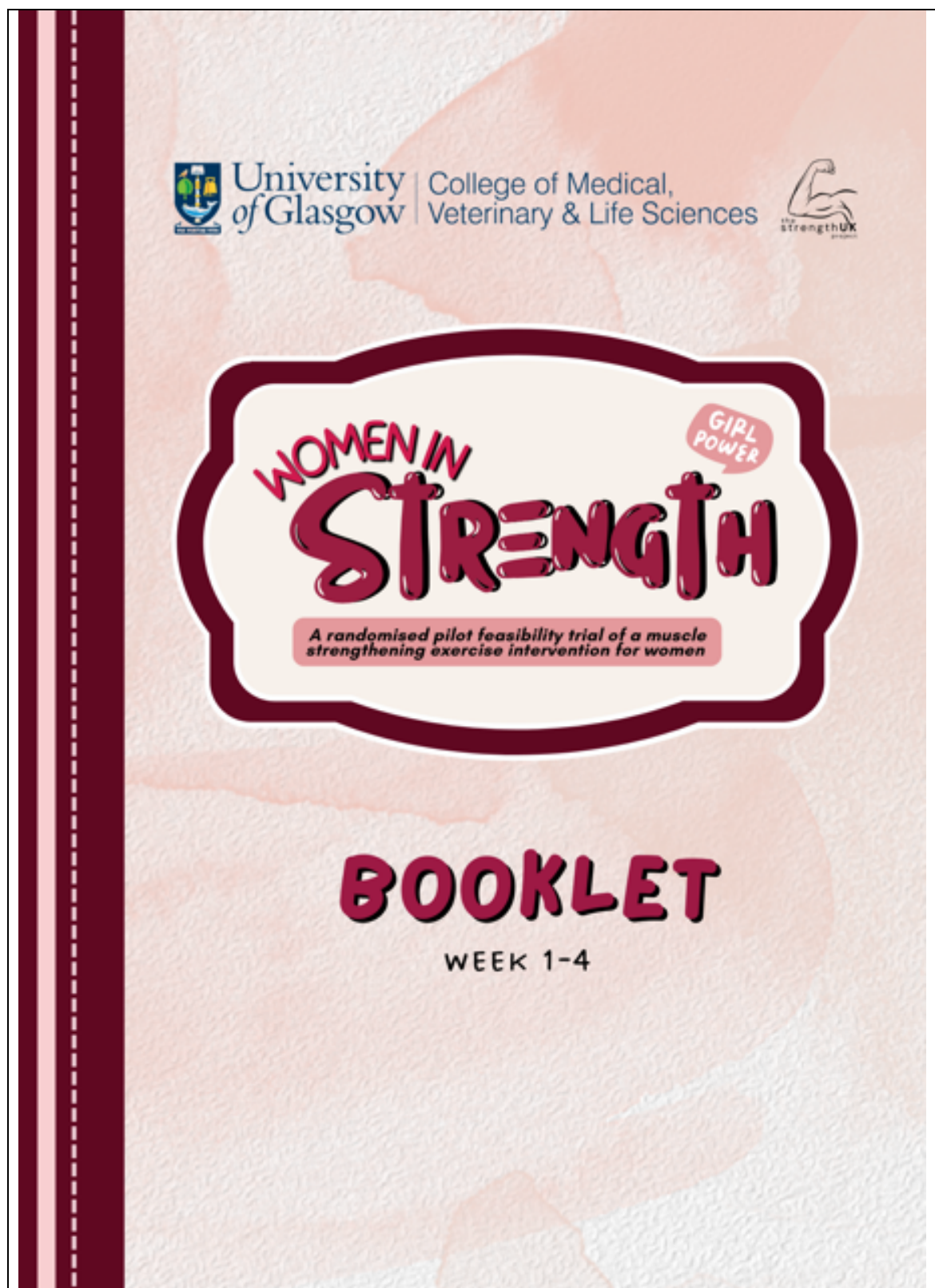
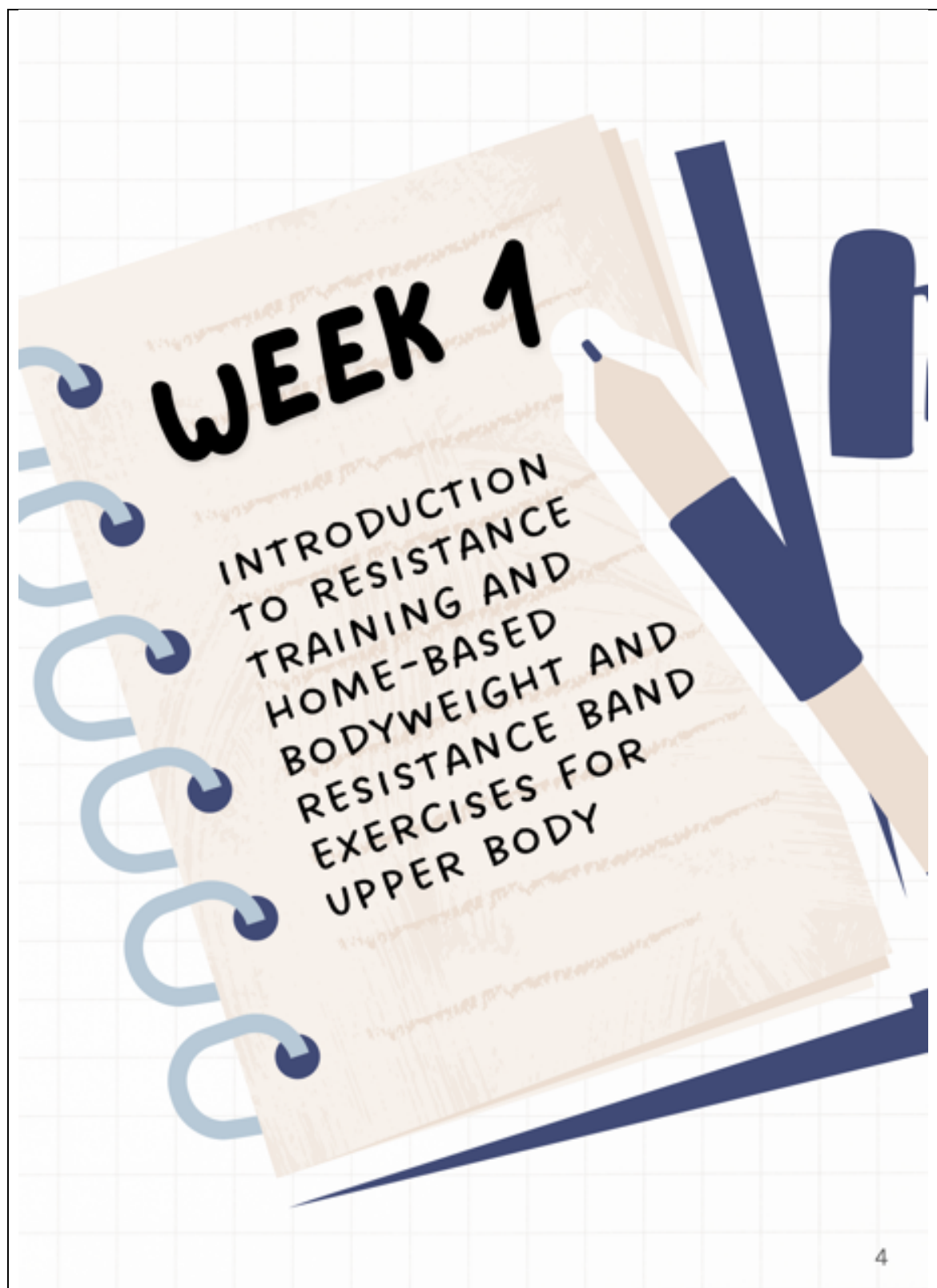


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WHAT IS RESISTANCE TRAINING?

Resistance training is a form of exercise where you use your muscles to push, pull, or lift against something heavier, like weights or your body weight. When this is performed regularly, your muscles get stronger over time.

WHAT ARE THE BENEFITS OF RESISTANCE TRAINING?

It is well established that resistance training offers numerous benefits for our health. Here is some scientific evidence supporting the effects of resistance training:

REDUCE THE RISK OF MORTALITY

↓ 20% risk of all causes of death
32% risk of death from cancer
(Stamatakis et al., 2018)

REDUCE THE RISK OF FRAILTY AND FALLING

✓ sufficient muscle strengthening exercises = good muscle aging
(Skelton et al., 2018)

REDUCE RISK OF T2DM AND CVD

↓ 30% risk of type 2 diabetes mellitus
17% risk of cardiovascular diseases
(Shicoma et al., 2017)

IMPROVE MENTAL HEALTH

↓ anxiety and depression symptoms
(Shannon et al., 2023)

IMPROVE METABOLIC BIOMARKERS

↓ blood pressures, resting heart rate, fasted glucose and insulin, total cholesterol & triglycerides
(Ashton et al., 2018)

IMPROVE MENOPAUSE SYMPTOMS

✓ improvement in pelvic floor and leg strength, bone density, metabolism and hormone changes & hot flushes
(Capei-Alcoraz et al., 2023)

MYTH BUSTING TIME!

MYTH:

"If you do this, you will be big, bulky, like the male bodybuilder!"



ANSWER:

This is a myth! Women will not get bulky when they do strength training unless they specifically train to be bodybuilders! Women's bodies produce, on average, 15 to 20 times less testosterone than men's, and as one of the functions of testosterone is for muscle growth, women's muscles will not grow as big as men's.



MYTH:

"You will get injured and even worse you can break a bone!"

ANSWER:

This is a myth. As explained in the benefits section, resistance training can reduce the risk of frailty and falls. It also improves your bone mineral density. As we age, we naturally lose bone mass, which can lead to conditions such as osteoporosis. Incorporating strength training into your routine can stimulate bone growth and slow down this loss, ultimately leading to stronger and healthier bones.

WHAT TERMS ARE USUALLY ASSOCIATED WITH RESISTANCE TRAINING?

FREQUENCY

Number of days per week for an exercise.

INTENSITY

How hard your body works during exercise or how heavy a load you carry. This is usually measured by self-reporting your perceived exertion (see more below) for exercises using bodyweight and resistance bands, and as a percentage of the maximum weight you can lift for exercise using weights.

TIME

Duration or length of time spent doing an exercise.

TYPE

The type of exercise done.

VOLUME

The amount of work done in a session (set x reps x intensity or load).

PROGRESSION OVERLOAD

Gradually increasing the volume of an exercise. There are different ways to do this: increase load (resistance), increase repetitions or adjust speed or rest period.

EXAMPLE OF DOING PROGRESSION OVERLOAD



SET

The number of times repeating a particular number of repetitions of the exercise.

REPETITIONS

The number of times a single exercise is performed in one set.

LOAD

The amount of weight or resistance used.

REST

The time taken to recover between sets or exercises.

RATE OF PERCEIVED EXERTION

The Rate of Perceived Exertion scale refers to how you feel about your level of effort, strain, discomfort, and/or fatigue during an exercise. You can use the scale below to describe how your body feels during each of the exercises that you do. If you feel that the exercise is:

- **Extremely Easy:** rate this as number 0.
- **Extremely Hard:** rate this as number 10.
- **Somewhere between extremely easy (0) and extremely hard (10):** rate this as any number between 0 and 10.

There are no right or wrong numbers. Use the words below to help select the numbers to describe how you feel when performing an exercise, this is often use during bodyweight or resistance band exercises to make sure you are working hard enough.



RESISTANCE TRAINING SYSTEM

TYPE	DEFINITION
Single set	Performing one set of each exercise.
Multiple set	Performing multiple sets for each exercise.
Circuit training	Performing a series of exercises, one after the other, with minimal rest.
Split routine	A resistance training routine that trains different body parts on separate days (i.e., upper/lower body split, push/pull split).

WARMING UP

Warm-up is done for 5 to 10 minutes before exercising to prepare you mentally and physically for the exercise that you are about to do. It will increase your body temperature, heart rate, and circulation and prepare the muscles for the movement. For resistance training, the usual warm-up activities include light cardio, active or dynamic stretches and mobility exercises.

Active stretching	This stretch involves moving the joint into a range of motion.	1 to 3 sets, hold each stretch for about 1 to 2 seconds and repeat for 5 to 10 repetitions.
Dynamic stretching	This stretch usually mimic the movement used during the exercise.	1 set, 10 to 15 repetitions, 3 to 10 exercises.

COOL DOWN

Cool down is done for around 5 minutes after completing your exercise session to help relax, improve your flexibility and slow down your heart rate. The usual cool-down activity is static stretching.

Static stretching	This stretch involves passively stretch the muscle to the point of tension.	1 to 3 sets, and hold each stretch for about 30 seconds.
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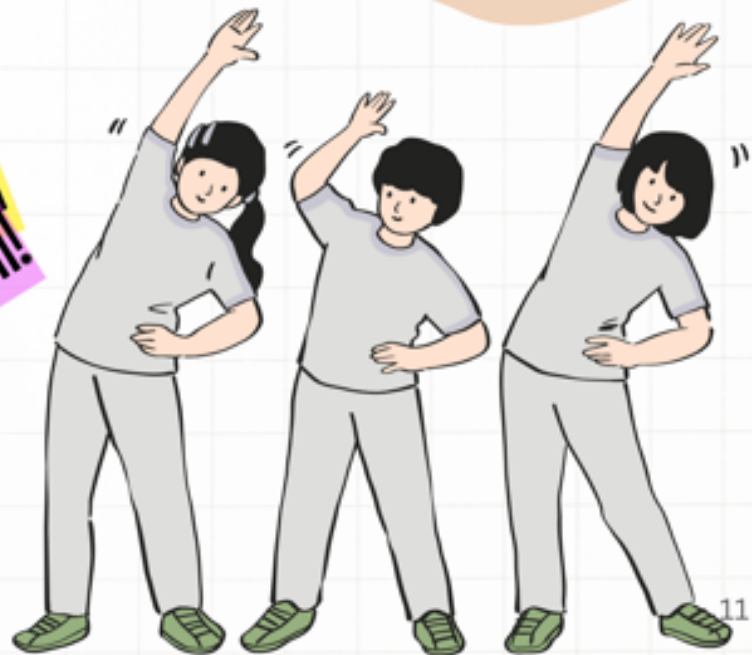
DELAYED ONSET MUSCLE SORENESS

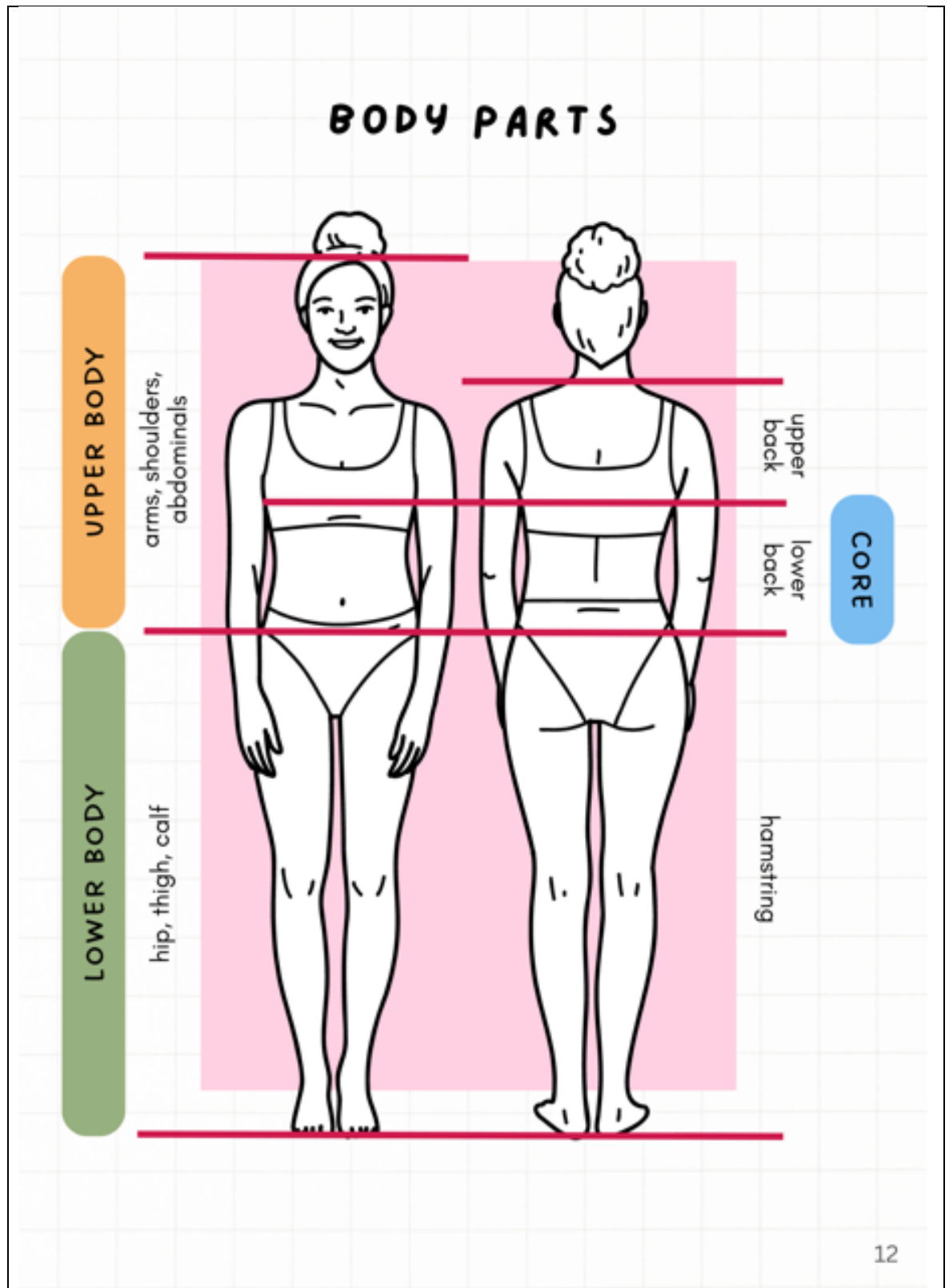
Proper preparation of your body can help reduce muscle soreness after exercise. The term commonly used for this soreness in the context of exercise is delayed onset muscle soreness. This refers to the muscle ache or pain that typically occurs 24 to 72 hours after exercise. Even experienced exercisers can experience soreness, though the intensity of the soreness often decreases over time as their bodies adapt.

To minimise the severity of any soreness, it's important to progress slowly when starting a new exercise program or routine. Allowing your muscles time to adapt to the stress and ensuring sufficient recovery time (2 to 3 days) reduces the severity of soreness.



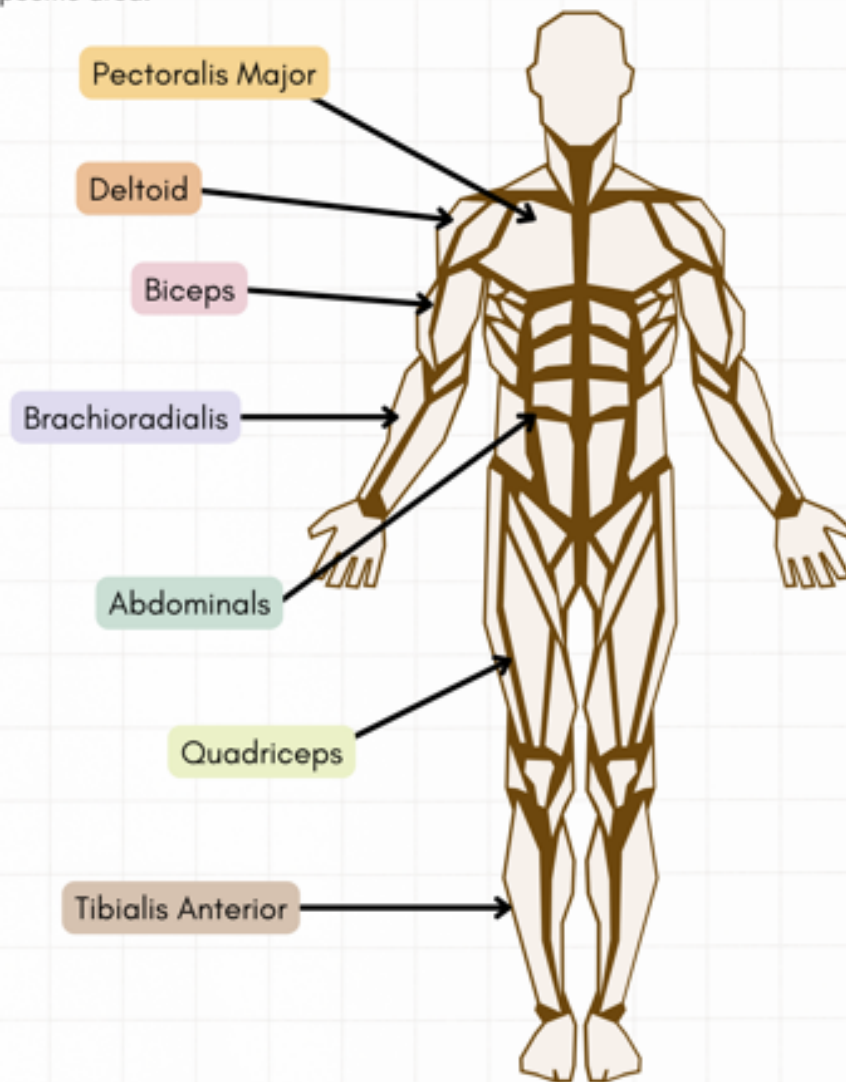
**DON'T FORGET
to STRETCH!**





MUSCLE NAMES

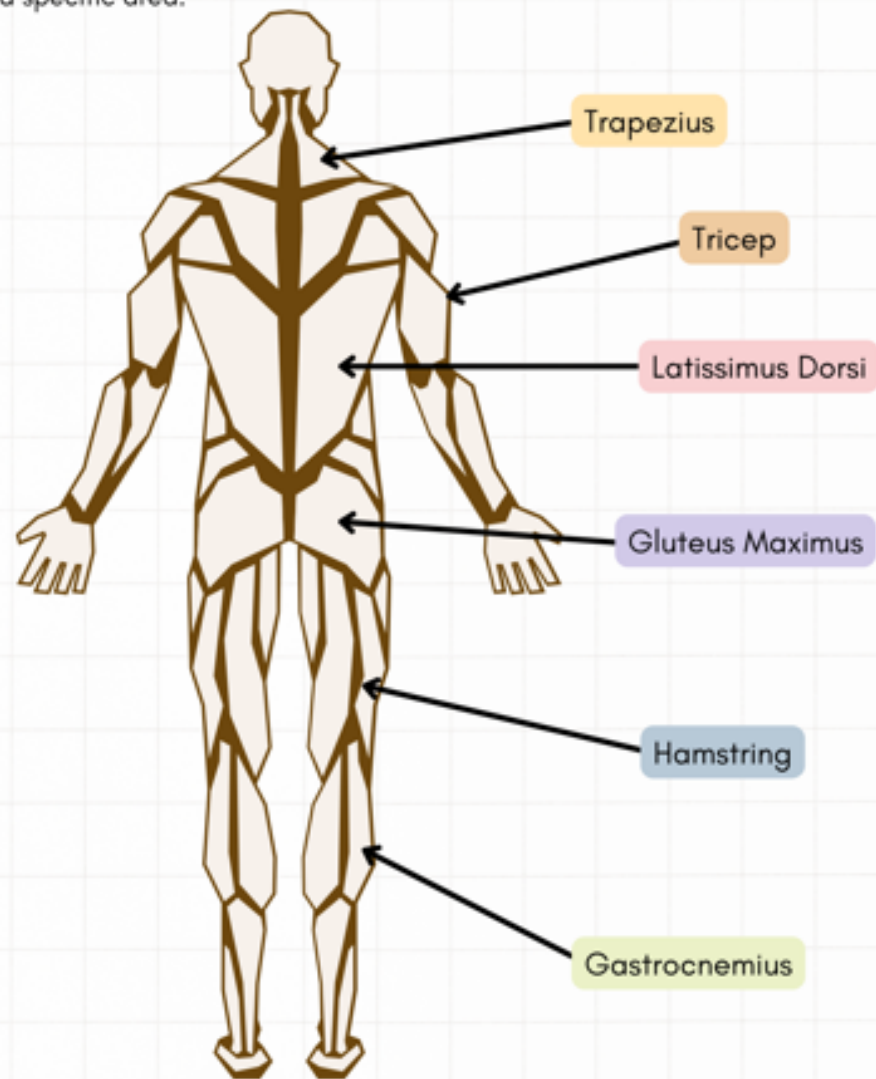
The muscular system consists of more intricate names, as muscles are organized in layers. The terms provided represent the general classifications of the muscles in a specific area.



ANTERIOR (FRONT) VIEW

MUSCLE NAMES

The muscular system consists of more intricate names, as muscles are organized in layers. The terms provided represent the general classifications of the muscles in a specific area.



POSTERIOR (BACK) VIEW

COMMON MODALITIES FOR RESISTANCE TRAINING



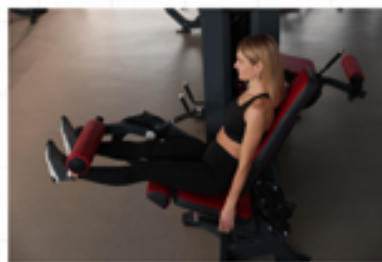
RESISTANCE BANDS



FREE WEIGHTS



BODYWEIGHT EXERCISES



WEIGHT MACHINES

UPPER BODY EXERCISES EXAMPLES

Here are some examples of upper body exercises that you can do at home using your body weight, resistance bands, or even household items like cans of beans or water bottles. You can increase the difficulty of the exercises by adjusting the weight of the objects you use or by choosing stronger resistance bands. We will explore this in more detail during the in-person session.

Arm Raises

Stand straight and hold household items, one in each hand (household items) or stand on the band with both feet and hold the end in each hand (resistance bands).

For lateral raise:

1. Start with arms straight down
2. Raise both arms to the side, pause and then return to the starting position.

For front raise:

1. Start with arms straight down
2. Raise both arms to the front, pause and then return to the starting position

Lateral Raise



Start

End

Front Raise



Start

End

UPPER BODY EXERCISES EXAMPLES

Arm Curls

For biceps curl

1. Start with the arm straight down
2. Raise both arms towards your shoulder, pause and then return to the starting position.

For triceps extension

1. Start with the arm at the side of your head.
2. Extend upward, pause and then return to the starting position.

Biceps Curl



Start

End

Tricep Extension



Start

End

Seated Row

Steps:

1. Hold each end of the resistance band in both hands.
2. Step in the middle of the band with both feet.
3. Start with the arm extended forward.
4. Pull arms back towards the waist, pause and slowly return to the starting position.

You can also do this exercise using household items. Simply hold the item in each hand.



Start

End

UPPER BODY EXERCISES EXAMPLES

Chest Press

There are several options to do this exercise. You can start by doing the chest press on a wall (*option 1*) and work your way up to a full push-up (*option 4*).

Steps:

1. Start with the arms extended on shoulder height, just a bit wider than your shoulder width.
2. Bend your elbow slowly to bring your body closer towards the surface.
3. Then push yourself back until you are back to the starting position but don't lock your elbow.

Option 1



Start

End

Option 2



Start

End

Option 3



Start

End

Option 4



Start

End

TRY IT OUT!

The first week...

Do each exercise for one set (**single set**) until you reach around **4 to 6 on the RPE scale**. You can do these exercises using your body weight, resistance bands or household items.

The following weeks...

Do each exercise for one set (**single set**) until you reach around **8 to 10 on the RPE scale**.

How many repetitions should I do?

We suggest you to do the exercises within the range of **8 to 15 repetitions**.

What should I do once I am doing more than 15 repetitions?

Once you are doing **more than 15 repetitions**, here are some of the things you could do:

- Add weights (if you are using body weight) or increase the weight (if you use household items).
- Move up a level of the resistance bands

You can also do more sets for each exercise (**multiset**)





COMMON BARRIERS AND FACILITATORS TO RESISTANCE TRAINING PARTICIPATION

These are some barriers and facilitators discussed during the Women in Strength (WISH) interviews and workshops with women who met and did not meet the guidelines of muscle strengthening at least twice a week.

TIME CONSTRAINTS

Most participants find time challenging because as women, we always share our time with others (as mothers, daughters, colleagues or friends!). Participants found that forming a routine, creating an activity planner and blocking time for exercising works best for them.

Accessability is also one of the biggest barriers, be it location or cost. Some participants chose gyms or fitness centres that are closer to the place their house or workplace. Some participants use free online resources and do exercises at home to help ease the cost barriers.

ACCESSIBILITY

SELF-CONSCIOUS AND LACK OF CONFIDENCE



The participants found that going to the gym felt scary when they first started. Some of the things that they did to overcome this feeling were by going with friends and signing up for personal trainers or exercise classes. From there, they built their confidence and knowledge until they are ready to go on their own.

BEHAVIOUR CHANGE TECHNIQUE #1

GOAL SETTING

Goal setting is a method for creating an action plan that helps you achieve your objectives. A well-defined goal directs your efforts and provides a clear timeline for accomplishment. However, your goal must remain adaptable and flexible to accommodate changes as needed.

S.M.A.R.T GOAL

S

SPECIFIC

The goal must be clearly defined with precise detail. **Example:** "I want to do resistance training at least twice a week."

M

MEASUREABLE

The goal that is set can be objectively measured and tracked over time. **Example:** "I will track my progress by recording the session I did the exercise each week."

A

ATTAINABLE

The goal must be challenging yet can be achieved. **Example:** "I will start off by doing at least one session and gradually increase the frequency I exercise."

R

REALISTIC

The goal must be relevant to your lifestyle. **Example:** "I can do a 10-minutes session in the morning and evening."

T

TIMELY

Set a specific timeframe to achieve the goal. **Example:** "I will accomplish this goal within 4 weeks."

Therefore, the **full SMART goal** is:

"I will do at least twice a week of resistance training in 4 weeks and track my training weekly"



**SMALL STEPS
ARE BETTER
THAN NO STEPS**

BEHAVIOUR CHANGE TECHNIQUE #2

SELF-MONITORING

Self-monitoring is a method where you track your behaviour over time. You can do this by observing, recording and evaluating what you did in your day-to-day life.

You can record your daily activities in a diary or journal. In the WISH workshop, we introduced participants to a time planner, and we asked them to list their typical daily activities hourly. Then, we asked them to find possible ways to include resistance training in their routine.

Common exercise time suggested:

- Early morning
- Lunch break
- After work

Even a short session of just 10 minutes of resistance training a day can be beneficial!



Examples of routines where participants incorporate resistance training into their routine.

ACTIVITY 4: LET'S CREATE AN ALTERNATIVE ROUTINE

5:00 - 6:00 AM	ASLEEP	5:00 - 6:00 PM	11 11 11
6:00 - 7:00 AM	BREAKFAST + GYM OR HOME WORK OUT	6:00 - 7:00 PM	11 11 11
7:00 - 8:00 AM	GET READY FOR WORK OR UNI.	7:00 - 8:00 PM	HOMETIME
8:00 - 9:00 AM	WORK OR UNI	8:00 - 9:00 PM	COOK DINNER
9:00 - 10:00 AM	11 11 11	9:00 - 10:00 PM	POSSIBLE GYM OR HOME EXERCISE
10:00 - 11:00 AM	11 11 11	10:00 - 11:00 PM	SPEND TIME WITH FAMILY
11:00 - 12:00 PM	11 11 11	11:00 - 12:00 PM	WIND DOWN FOR THE DAY
12:00 - 1:00 PM	LUNCH BREAK AND POSSIBLY GYM	12:00 - 1:00 PM	11 11 11 11 11
1:00 - 2:00 PM	WORK OR UNI	1:00 - 2:00 PM	GET READY FOR BED
2:00 - 3:00 PM	11 11 11		

OTHER THOUGHTS?

ACTIVITY 4: LET'S CREATE AN ALTERNATIVE ROUTINE

5:00 - 6:00 AM	Wakeup!	5:00 - 6:00 PM	Tea Break
6:00 - 7:00 AM	Dinner! (Lunch time)	6:00 - 7:00 PM	Work
7:00 - 8:00 AM	Wakeup + Freshen up	7:00 - 8:00 PM	Go home
8:00 - 9:00 AM	Go strength train!	8:00 - 9:00 PM	Dinner & Baby
9:00 - 10:00 AM	Dinner - popcorn & eat breakfast	9:00 - 10:00 PM	Movie time
10:00 - 11:00 AM	Work / uni	10:00 - 11:00 PM	Chill
11:00 - 12:00 PM	11 11 11	11:00 - 12:00 PM	Get Cogg
12:00 - 1:00 PM	11 11 11	12:00 - 1:00 PM	Sleep
1:00 - 2:00 PM	Lunch	1:00 - 2:00 PM	
2:00 - 3:00 PM	Work / uni / class		

OTHER THOUGHTS?

BEHAVIOUR CHANGE TECHNIQUE #3

ACTION PLANNING

Action planning is a strategy for determining and concentrating on the steps needed to achieve your goals. By utilizing the implementation intention method, you can break down your goals into specific actions, clearly defining what you will do, where, when, and how you will do it. Additionally, by incorporating if-then planning, you can develop alternative strategies to overcome potential obstacles to your plan.

A simple to-do list may look something like this:

- Do bodyweight exercise
- Go to the gym

But by including the implementation intention and if-then planning, you can create a contingency plan in case your initial action plan can't be conducted. For example,

Implementation Intention	I will do my bodyweight exercises at/in my office during my lunch break.
If-Then Planning	If my meeting exceeds to my lunch hour, then I will do my bodyweight exercise before I leave the office in the evening.

LOWER BODY EXERCISES EXAMPLES

Here are some examples of lower body exercises that you can do at home using your body weight, resistance bands, or even household items like cans of beans or water bottles. You can increase the difficulty of the exercises by adjusting the weight of the objects you use or by choosing stronger resistance bands.

Squat

Steps:

1. Hold each end of the resistance band in both hands.
2. Step in the middle of the band with both feet shoulder-width apart.
3. Squat down as far as you can and keep your leg parallel to the ground, pause and slowly return to the starting position.

You can progress in your squat by starting with rising up and down from a chair, then doing the squat without chairs or resistance bands and lastly doing it with additional weight.



Start

End

Leg Raise

Steps:

1. Lie down on the floor. You can place your hands below your hips for more stability.
2. Start with your leg extended upwards and brace your core.
3. Slowly lower your leg as close as you can get to the ground without actually touching it then raise it back up to the starting position.



Start

End

LOWER BODY EXERCISES EXAMPLES

Lunges

For bodyweight lunges

1. Start with standing straight with your feet shoulder-width apart. You can place your hand on your hip for stability.
2. Step forward with one foot as far as you feel comfortable while keeping your back straight, pause and then return to the starting position.
3. Repeat step 2 with the opposite leg.

For weighted lunges

1. Do the same steps as bodyweight lunges but this time by holding the items on each hand.

Bodyweight Lunges



Start

End

Weighted Lunges



Start

End

LOWER BODY EXERCISES EXAMPLES

Calf Raise

For calf raise

1. Start with standing straight with your feet shoulder-width apart. You can place your hand on your hip, wall or a chair for stability.
2. Push the ball of your feet to raise your heels until you stand on your toes.
3. Pause and then return to the starting position and repeat.

For single-leg calf raise

1. Start straight on one foot. You can place your hand on your hip, wall or a chair for stability.
2. Push the ball of your foot to raise your heels until you stand on your toes.
3. Pause and then return to the starting position and repeat.
4. Once you completed your repetitions on one foot, repeat with the other foot.

Calf raise



Start

End

Single-Leg Calf Raise



Start

End

TRY IT OUT!

The first week...

As with the upper body exercise, do each exercise for one set (**single set**) until you reach around **4 to 6 on the RPE scale**. You can exercise using your body weight, resistance bands or household items.

The following weeks...

Do each exercise for one set (**single set**) until you reach around **8 to 10 on the RPE scale**.

How many repetitions should I do?

We suggest you to do the exercises within the range of **8 to 15 repetitions**.

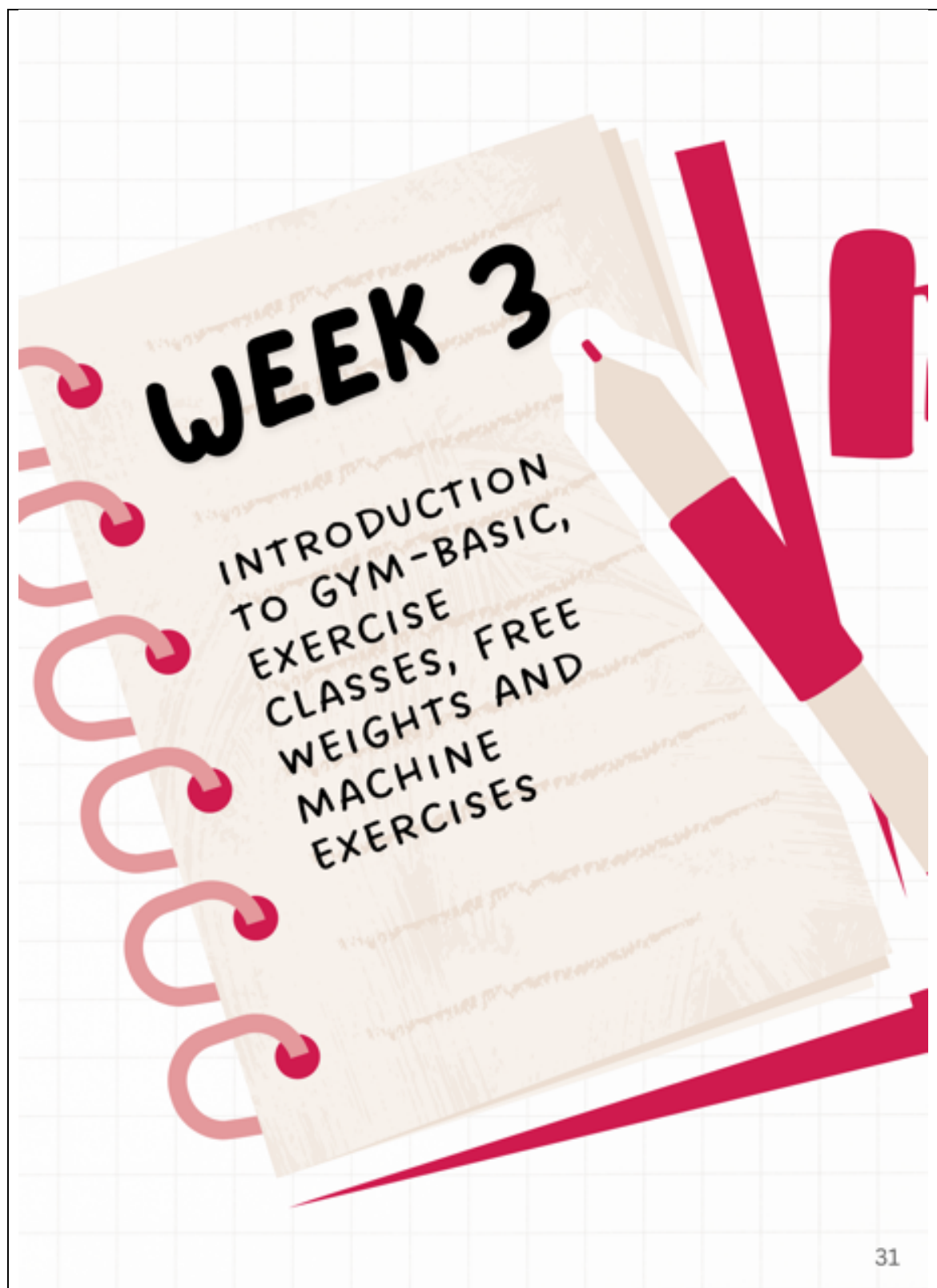
What should I do once I am doing more than 15 repetitions?

Once you are doing **more than 15 repetitions**, here are some of the things you could do:

- Add weights (if you are using body weight) or increase the weight (if you use household items).
- Move up a level of the resistance bands

You can also do more sets for each exercise (**multiset**)





SAFETY CONSIDERATIONS

Gym-based exercises include exercises that use free weights such as dumbbells, barbells or kettlebells, as well as resistance machines. When doing an exercise involving additional weights, it is important to pay attention to some safety considerations when doing the exercises.

HOW HEAVY DO I GO?

If you are new to exercising with weights or additional loads, it might be unclear which weight to start with. Begin with a light weight that you can lift for 12 to 15 repetitions. If it feels too easy, increase the weight; if it's too hard to complete the repetitions, reduce the weight. Gradually increase the weight as you continue training and become stronger.

KEEP BREATHING!

When lifting heavier objects, you may be tempted to hold your breath, known as the Valsalva Manoeuvre. This can be dangerous, as it may cause dizziness, increase blood pressure, and even lead to fainting. The proper breathing technique is to inhale when lowering the weight and exhale when lifting it.

PROPER FORM.

It's essential to learn the correct way to perform each exercise. This will help you avoid injuries. Training with proper form allows you to move through the entire range of motion required for the exercise. If you find that you cannot perform the exercise with proper form while increasing the load, you should reduce the weight or the number of repetitions.

AM I STABLE OR NOT?

Ensure that when performing any exercise, you are on a stable surface with your feet (or just one foot for single-leg exercises) firmly planted on the ground. For standing exercises, your feet should generally be shoulder-width apart. For single-leg exercises, focus on improving your balance. You can progress slowly by doing the exercise with assistance, such as holding onto a wall or any stationary object nearby. Once you build the necessary strength and stability, you can gradually reduce the assistance.

DO I NEED A SPOTTER?

Although it is not necessary, it's often wise to have a spotter when exercising with heavier weight. A spotter is someone who can assist you during your workout, helping to prevent injuries. They can offer support when you struggle to lift the weight, especially towards the end of your set. If you are lifting near your maximum weight, having a spotter becomes even more crucial.



EXERCISE CLASSES

There are various classes available that focus on developing or maintaining muscle strength. Some examples of strength exercise classes include Body Pump, Legs, Bums, Tums, and kettlebell classes. Additionally, there are holistic exercise options like Pilates, Yoga, and Tai Chi.



Participating in exercise classes offers several benefits, including support, companionship, and an opportunity to build your confidence.

FREE WEIGHTS & MACHINE EXERCISES EXAMPLES

UPPER BODY

Biceps Curl

Steps:

1. Hold the weights in each hand.
2. Start with the arm straight down
3. Raise both arms towards your shoulder, pause and then return to the starting position.



Start

End

Triceps Extension

Steps:

1. Hold the handle with both hands.
2. Start with the arm at a 90-degrees angle.
3. Extend downward, pause and then return to the starting position.



Start

End

Chest Press

Steps:

1. Hold the weights in each hand.
2. Start with the arm extended.
3. Slowly lower the weight to 90-degrees angle, pause and then return to the starting position.



Start

End

Other than dumbbells, you can also do chest press using a barbell or a Smith machine. For beginners, using a Smith machine is highly recommended!

FREE WEIGHTS & MACHINE EXERCISES EXAMPLES

Lateral Raise

Steps:

1. Hold the weights on each hand.
2. Start with the arm straight down.
3. Raise both arms to the side, pause and then return to the starting position.



Start

End

Front Raise

Steps:

1. Hold the weights on each hand.
2. Start with the arm straight down.
3. Raise both arms to the front, pause and then return to the starting position.



Start

End

Lat Pull Down

Steps:

1. Hold the handle with both hands, slightly wider than shoulder width.
2. Pull down the handle down while keeping your elbow in line with your torso.
3. Pause and then return to the starting position.



Start

End

FREE WEIGHTS & MACHINE EXERCISES EXAMPLES

Seated Row

Steps:

1. Hold the handle with both hands, while your chest is against the chest pad.
2. Start with the arm extended forward.
3. Pull arms back towards the waist, pause and slowly return to the starting position.



Start

End

LOWER BODY

Squat

Steps:

1. Hold the weights on each hand.
2. Stand straight with both feet shoulder-width apart.
3. Squat down as far as you can and keep your leg parallel to the ground, pause and slowly return to the starting position.



Start

End

Other than dumbbells, you can also do squats using a barbell or a Smith machine. It is important to move in controlled motion while bracing your core.

FREE WEIGHTS & MACHINES EXERCISES EXAMPLES

Calf Raise

Steps:

1. Hold the weights on each hand and stand straight with your feet shoulder-width apart.
2. Push the ball of your feet to raise your heels until you stand on your toes.
3. Pause and then return to the starting position and repeat.



Start

End

Lunges

Steps:

1. Hold the weights on each hand and stand straight with your feet shoulder-width apart.
2. Step forward with one foot as far as you feel comfortable while keeping your back straight, pause and then return to the starting position and repeat.



Start

End

Leg Press

Steps:

1. Sit on the machine with your leg at 90 degrees and back flat against the seat.
2. Your feet should be placed on the footplate, shoulder-width apart.
3. Brace your core and extend your leg to push the footplate but don't lock your knee.
4. Return to starting position and repeat.



Start

End

FREE WEIGHTS & MACHINES EXERCISES EXAMPLES

Leg Extension

Steps:

1. Adjust and sit with your back flat against the seat and knees at 90 degrees. The lower leg pad should be in front at the top of your ankle and the top pad should be on your thigh.
2. Grip the handles on the side and extend your legs until its straight.
3. Pause, return to the starting position and repeat.



Start

End

Leg Curl

Steps:

1. Similar to leg extension, adjust and sit with your back flat against the seat and knees at 90 degrees. But this time, the lower leg pad should be at the back of your ankle while the top pad should still be on your thigh.
2. Grip the handles on the side and curl your legs towards your hips.
3. Pause, return to the starting position and repeat.



Start

End



MY TIME PLANNER

Write down your typical daily routine (**weekdays**) and list potential time(s) you can slot in resistance training. Even a short 10-minute session counts!

TIME	ACTIVITY	TIME	ACTIVITY
5:00 - 6:00 am		3:00 - 4:00 pm	
6:00 - 7:00 am		4:00 - 5:00 pm	
7:00 - 8:00 am		5:00 - 6:00 pm	
8:00 - 9:00 am		6:00 - 7:00 pm	
9:00 - 10:00 am		7:00 - 8:00 pm	
10:00 - 11:00 am		8:00 - 9:00 pm	
11:00 - 12:00 pm		9:00 - 10:00 pm	
12:00 - 1:00 pm		10:00 - 11:00 pm	
1:00 - 2:00 pm		11:00 - 12:00 am	
2:00 - 3:00 pm			

NOTES

POTENTIAL TIME TO EXERCISE:

- 1)
- 2)
- 3)
- 4)



MY TIME PLANNER

Write down your typical daily routine (**weekend**) and list potential time(s) you can slot in resistance training. Even a short 10-minute session counts!

TIME	ACTIVITY	TIME	ACTIVITY
5:00 - 6:00 am		3:00 - 4:00 pm	
6:00 - 7:00 am		4:00 - 5:00 pm	
7:00 - 8:00 am		5:00 - 6:00 pm	
8:00 - 9:00 am		6:00 - 7:00 pm	
9:00 - 10:00 am		7:00 - 8:00 pm	
10:00 - 11:00 am		8:00 - 9:00 pm	
11:00 - 12:00 pm		9:00 - 10:00 pm	
12:00 - 1:00 pm		10:00 - 11:00 pm	
1:00 - 2:00 pm		11:00 - 12:00 am	
2:00 - 3:00 pm			

NOTES

POTENTIAL TIME TO EXERCISE:

- 1)
- 2)
- 3)
- 4)



MY ACTION PLAN

Write down your implementation intention and if-then planning. This will help you to work towards your goal and adjust it accordingly if there's a change in routine.

IMPLEMENTATION INTENTION	I will do _____ at/in _____ during _____.
IF-THEN PLANNING	If _____, then I will _____.
IMPLEMENTATION INTENTION	I will do _____ at/in _____ during _____.
IF-THEN PLANNING	If _____, then I will _____.
IMPLEMENTATION INTENTION	I will do _____ at/in _____ during _____.
IF-THEN PLANNING	If _____, then I will _____.
IMPLEMENTATION INTENTION	I will do _____ at/in _____ during _____.
IF-THEN PLANNING	If _____, then I will _____.
IMPLEMENTATION INTENTION	I will do _____ at/in _____ during _____.
IF-THEN PLANNING	If _____, then I will _____.

By listing down the potential barriers and several ways you can overcome it, this can help making resistance training easier.

MY POTENTIAL BARRIERS	HOW CAN I OVERCOME THIS?

MY TRAINING PLAN

Use this section to plan out what activities you would like to do and for how many weeks. For the activity, you can write down what activity you want to do, such as body weight, resistance band, gym, or classes.

Week Overview (Do ____ days per week for ____ weeks)

DAY	MON	TUE	WED	THURS	FRI	SAT	SUN
ACTIVITY							

HOW MANY:			
SETS		LOAD	
REPS		REST	



Week Overview (Do ____ days per week for ____ weeks)

DAY	MON	TUE	WED	THURS	FRI	SAT	SUN
ACTIVITY							

HOW MANY:			
SETS		LOAD	
REPS		REST	

**Determining the set, reps, load, and rest would be related to the goal of the training, such as to build strength or muscle size. For exercise classes, it's not necessary to include the set, reps, load, and rest in this plan.*



MY TRAINING PLAN

Week Overview (Do ____ days per week for ____ weeks)

DAY	MON	TUE	WED	THURS	FRI	SAT	SUN
ACTIVITY							

HOW MANY:			
SETS		LOAD	
REPS		REST	



Week Overview (Do ____ days per week for ____ weeks)

DAY	MON	TUE	WED	THURS	FRI	SAT	SUN
ACTIVITY							

HOW MANY:			
SETS		LOAD	
REPS		REST	



NOTES

NOTES

NOTES

NOTES

NOTES

Appendix 5-H: WISH Training Log

University of Glasgow | College of Medical, Veterinary & Life Sciences

the strengthUK project

WOMEN IN STRENGTH

GIRL POWER

A randomised pilot feasibility trial of a muscle strengthening exercise intervention for women

24 WEEKS TRAINING LOG

PARTICIPANT ID: _____

ABOUT THIS TRAINING LOG

This training log contains tables for you to fill out your 24 weeks participation in any kind of muscle strengthening exercises that you do.

A member of the research team will guide you through this training log during your baseline visit, and if there is anything you do not understand or are unsure of, please let the researcher know.

CONTACT DETAILS

If you have any questions, then please contact the research team using the details below:

Researcher: Nur Dania Rosaini

Phone Number:

Email: n.rosaini.1@research.gla.ac.uk

BEFORE YOU BEGIN...

What activities are considered muscle strengthening exercises?

We consider these activities as muscle strengthening exercises:

- Weight machines: at home, in a gym or fitness centre.
- Bodyweight exercises: such as push ups, sit-ups or planking.
- Resistance exercises: using free weights such as dumbbells or resistance bands.
- Holistic exercises: including Pilates, Yoga and Tai-Chi.
- Strength exercises classes: body pump, legs bums and tums, kettlebell classes.

If you are unsure if the activity you want to do is considered a muscle strengthening exercise, get in touch with the researcher (Nur Dania Rosaini)

How frequently should I do these activities?

We want you to do these activities for at least 2 days a week as per the physical activity guidelines for muscle strengthening. You can always do more than 2 days a week.

Where should I do these activities?

It is up to you if you want to do these activities in the gym, at home, or even outdoors at the park. Activities and location choices are according to your own preferences at your own time.

BEFORE YOU BEGIN...

How do I fill this log?

On the weekly sheet, you will have to fill in your activities as detailed as possible.

- Fill up the week and participant ID on the top of the page.
- Date/day: write down the date/day that you do the activities.
- Time/duration: write down the starting and ending time or the duration you took to complete the activities.
- Activities: fill up the activities that you did. Example: press up, squat, lunges.
- Set: this is the number of times you will repeat a particular number of repetitions of the exercise.
- Repetitions: this is the number of times you perform a single exercise in one set.
- Load: this is the amount of weight or resistance you use.
- Rate of perceived exertion (RPE): this is how you perceive the level of effort, strain, discomfort, or fatigue that you feel during exercise. More information in the next section..

At the end of each week, you will be asked to send your weekly training report to the researcher (Nur Dania Rosaini).

BEFORE YOU BEGIN...

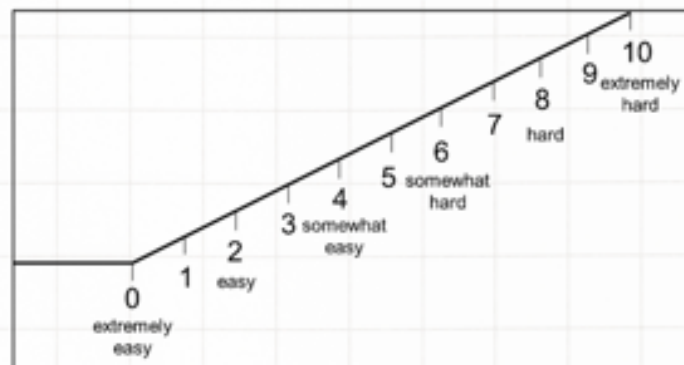
How do I fill up the Rate of Perceived Exertion (RPE)?

The Rate of Perceived Exertion (RPE) is referring to how you feel about the level of effort, strain, discomfort, and/or fatigue that you feel during exercise.

Use the scale below to describe how your body feels during each of the exercises that you do. If you feel that the exercise is:

- Extremely Easy: rate this as number 0.
- Extremely Hard: rate this as number 10.
- Somewhere between extremely easy (0) and extremely hard (10): rate this as any number between 0 and 10.

There are no right or wrong numbers. Use the words below to help select the numbers to describe how you feel when performing the exercise.



SUMMARY OF THIS TRAINING LOG

We will ask you to perform the exercise at least 2 times a week for the 24-week study period. During the first week of performing each exercise we would like you to stop when you reach 4-6 on the RPE scale above. In the following weeks, we would like you to stop each exercise when you reach 8-10 on the RPE scale. This may be any number of repetitions, but we suggest that adjust the level of each exercise to reach these points on the RPE scale within the range of 8-20 repetitions. Once you find yourself doing more than 20 repetitions of an exercise, it is time to move up a level.

You can do these exercises all in a single session on the same day, or you can break them up throughout the day or even do them on different days. As long as you do the activities at least twice a week, the choice is yours!

MY 24 WEEKS OVERVIEW

HOW MANY DAYS DID I DO MUSCLE STRENGTHENING EXERCISES?

Week	Days							Notes
	1	2	3	4	5	6	7	
Week 1								
Week 2								
Week 3								
Week 4								
Week 5								
Week 6								
Week 7								
Week 8								
Week 9								
Week 10								
Week 11								
Week 12								
Week 13								
Week 14								
Week 15								
Week 16								
Week 17								
Week 18								
Week 19								
Week 20								
Week 21								
Week 22								
Week 23								
Week 24								

PARTICIPANT ID:

WEEK 1

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 1

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 2

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 2

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 3

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 3

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 4

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 4

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 5

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 5

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 6

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 6

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 7

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 7

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 8

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 8

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 9

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 9

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 10

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 10

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 11

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 11

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 12

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 12

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 13

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 13

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 14

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 14

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 15

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 15

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 16

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 16

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 17

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 17

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 18

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 18

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 19

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 19

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 20

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 20

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 21

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 21

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 22

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 22

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 23

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 23

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 24

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

PARTICIPANT ID:

WEEK 24

Date /Day	Time / Duration	Activities	Set	Repetitions	Load (kg/lb)	RPE

NOTES:**REFLECTION / GOALS FOR NEXT WEEK:**

REMEMBER TO SEND YOUR WEEKLY TRAINING LOG AT THE END OF EACH WEEK

Appendix 5-I: WISH Trial Interview Topic Guides

WISH TRIAL INTERVIEW (POST-INTERVENTION)

Introduction

- I would also like to remind you that this meeting is audio recorded.
- Before we begin, can you please state your participant ID for the recording?
- First of all, thank you for volunteering to participate in this study. In this interview, we are going to discuss your experiences participating in this study so far as well as your opinions on the interventions. The term exercises in this interview refers to muscle strengthening exercises.
- The whole interview will range from about 30 to 60 minutes. Are you okay to proceed?

Muscle Strengthening Exercises Participation (ExP)

Exp1. Previous experience – Have you done any muscle strengthening exercises before participating in this study? Are you restarting or is this completely new to you?

Exp1.1 If yes, how long ago was your participation? How many years did you do it before?

Exp1.2 If no, is muscle strengthening exercise completely new to you?

Exp2. How has your experience been with participating in this intervention so far?

Exp2.1 How easy or difficult has incorporating these exercises into your daily routine been?

Exp2.2 Do you think this intervention fits well with your lifestyle?

Exp2.3 Was there a specific time or place that made it easier for you to do the exercises?

Exp3. What barriers have you encountered when trying to complete muscle-strengthening exercises twice a week?

Exp4. Have you noticed any changes, either physically or mentally?

Exp4.1 If yes, can you share an example?

Exp4.2 Did these changes help you stay motivated to continue?

Exp5. What do the people around you (e.g., family or friends) think about your participation in this intervention?

Strength Education Session (Edu)

Edu1. How do you find the education sessions?

Edu2. Do you think that the sessions are useful/helpful?

Edu2.1 What do you like about the sessions?

Edu2.2 What do you dislike about the sessions?

Edu3. What do you think can be done to improve the session

Edu3.1 What other topics should we include or cover in the education sessions?

Edu4. What do you think about the 1-2-1 consultation (week 4)? Is it helpful/useful? Why or why not?

Exercise Session (ExS)

ExSYes1. You participated in the exercise session that we offered, how did you find the session?

ExSYes2. Do you think that the sessions are useful/helpful?*ExSYes2.1* What do you like about the sessions?*ExSYes2.2* What do you dislike about the sessions?**ExSYes3. What do you think can be done to improve the session****ExSNo1. As you know, we offered an optional exercise session from week 4 to week 11, Could you please share why you didn't participate in the exercise session we offered?***ExSNo1.1* If timing, if we were to add in more time slot options, would you find that to be more helpful for you to attend?*ExSNo1.2* If location, if this session were done in more locations, including those closer to the area you live, would you find that to be more helpful for you to attend?**ExSBoth1. Do you attend any exercise classes on your own?***ExSBoth1.1* If yes, what kind of exercise classes do you attend?*ExSBoth1.2* If no, were there any particular reasons for not joining exercise classes?**Social Component – WhatsApp group and Accountability (SC)****SC1. Is the social aspect (e.g., talking with others, having companionship) important to you when participating in this exercise?***SC1.1* If yes, do you have an exercise partner?*SC1.2* Does having an exercise partner make you feel more accountable for showing up?**SC2. When participating in this exercise, do you feel accountable to me and the study, or to yourself?***SC2.1* If you feel accountable to me, how important is it for you to maintain that sense of responsibility in order to make progress?*SC2.2* If you feel accountable to yourself, what drives you to keep going?**SC3. Do you find the WhatsApp group helpful?***SC3.1* In what ways does it help?**Training Log (TL)***Opening: Your training log is up to date/I have your training log up to week...***TL1. What are your thoughts on the training log?****TL2. Do you find the log useful or helpful?***TL2.1* What aspects of the training log do you like?*TL2.2* Are there any aspects of the training log that you dislike?**TL3. What improvements would you suggest for the training log?****TL4. Did filling out the training log help keep you accountable for completing your training? Why or why not?****TL5. Which of the following is better to help you do the exercise: choosing your own workouts or following a set plan? Why?****Modalities (M)****M1. What are your thoughts on the gym or class memberships and resistance bands?****M2. Do you find having access to these options useful or helpful? In what ways?**

M3. Would you consider continuing your gym membership after this experience?*M3.1* Is cost a factor that would influence your decision?*M3.2* Does the distance or accessibility of the gym pose any challenges for you?*M3.3* Do you feel confident enough to continue, or do you feel self-conscious about going?*M3.4* Were you able to create a routine to attend these sessions, and if so, can you share what that looks like?**M4. Do you prefer the gym or the resistance bands more?***M4.1* Which of these do you think would help you stay committed to exercising in the long term? Why?*M4.2* Which do you believe would be more beneficial for improving your physical or mental well-being? Why?**M5. What kind of information or advice would help you feel more confident continuing to use the resistance bands or go to the gym?****Testing Protocol (TP)****TP1. What are your thoughts on the testing protocol?***TP1.1* Did you understand the instructions and the purpose of the test we conducted?*TP1.2* How did you find the test? Which one did you enjoy the most, and which one did you like the least? What was it about them that influenced your preferences?**TP2. Were you comfortable with the testing procedures?***TP2.1* If not, can you share why?**TP3. How do you feel about the length of the testing protocol?***TP3.1* Do you think it's too long or too short?*TP3.2* Is it manageable with your schedule?**TP4. Do you think the tests are beneficial to you?****Opinion and Suggestion (OS)****OS1. Do you believe this intervention could help you maintain lifelong participation in muscle-strengthening exercises?***OS1.1* If yes, what makes you think so? In what ways do you think it could help?*OS1.2* If no, what are the reasons you feel that way?**OS2. To encourage long-term participation, what do you think you would need in order to continue?***OS2.1* If we were to adapt this intervention (e.g., fully online or through an app), do you think that would make a difference? Why?**OS3. If you were in my position, what would you change or improve in this intervention?****OS4. Do you have any other advice or suggestions for improving this intervention?****Conclusion**

- Do you have any questions that you would like to ask us?
- Thank you so much for your input. Keep on participating in muscle strengthening exercises and I will see you again during the week 24 follow-up visit in June.
- I will email you the voucher code to your email address.
- Once again thank you for coming in today.

WISH TRIAL INTERVIEW (FOLLOW-UP)

Introduction

- I would also like to remind you that this meeting is audio recorded.
- Before we begin, can you please state your participant ID for the recording?
- First of all, thank you for volunteering to participate in this study. In this interview, we are going to discuss your experiences participating in muscle-strengthening exercises for the past 12 weeks. The term exercises in this interview refers to muscle strengthening exercises.
- The whole interview will range from about 30 to 60 minutes. Are you okay to proceed?

1. How did you find participating in muscle-strengthening exercises on your own for the past 12 weeks?

- a. Was it easier/harder?
- b. Did you continue doing the muscle exercises? If not, why?

If you continue: What barriers do you face when trying to aim for 2 days a week of muscle strengthening exercises? What did you do to overcome those barriers? What helped you to complete the 2 days a week of muscle-strengthening exercises?

If you did not continue: What barriers do you face in your muscle strengthening participation? What do you think would help you to complete the 2 days a week of muscle-strengthening exercises?

2. Which part of the intervention component (education session, group exercise session, support group, gym memberships, 1-2-1 consultations, training log, reminders, lab visits) do you find very important for your participation in muscle-strengthening exercises?

- a. Why? In what ways?
- b. In the previous interview, some participants found that having the reminders and training log was helpful for them. Is it still relevant?

3. How would you rate your overall experience in participating in this study? (1 = extremely dissatisfied, 5 = extremely satisfied)

- a. What do you like the most about your whole experience?
- b. What do you like the least about your whole experience?

4. How would you rate your understanding of muscle strengthening exercises before and after the intervention? (1 = terrible, 5 = excellent)

- a. In what way does the intervention help you?

5. If you were to participate again in the study, what changes or suggestions would you like us to include or remove in the intervention?

- a. Why? In what ways?
- b. If not, why?

Closing

- Do you have any questions that you would like to ask us?
- Thank you very much for your input. Continue participating in muscle-strengthening exercises, even if it's just for one day a week – remember, something is better than nothing.
- I will email you the voucher code to your email address.
- Once again, thank you for coming in today.

Appendix 5-J: CONSORT Checklist

CONSORT 2025 checklist of information to include when reporting a randomised trial*			
Section / Topic	No	CONSORT 2025 checklist item description	Reported on page no.
Title and abstract			
Title and structured abstract	1a	Identification as a randomised trial	102
	1b	Structured summary of the trial design, methods, results, and conclusions	Not in chapter
Open science			
Trial registration	2	Name of trial registry, identifying number (with URL) and date of registration	102
Protocol and statistical analysis plan	3	Where the trial protocol and statistical analysis plan can be accessed	102
Data sharing	4	Where and how the individual de-identified participant data (including data dictionary), statistical code and any other materials can be accessed	Not in chapter
Funding and conflicts of interest	5a	Sources of funding and other support (e.g., supply of drugs), and role of funders in the design, conduct, analysis and reporting of the trial	Not in chapter
	5b	Financial and other conflicts of interest of the manuscript authors	Not in chapter
Introduction			
Background and rationale	6	Scientific background and rationale	99-101
Objectives	7	Specific objectives related to benefits and harms	99-101

Methods				
Patient and public involvement	8	Details of patient or public involvement in the design, conduct and reporting of the trial		100
Trial design	9	Description of trial design including type of trial (e.g., parallel group, crossover), allocation ratio, and framework (e.g., superiority, equivalence, non-inferiority, exploratory)		101-102
Changes to trial protocol	10	Important changes to the trial after it commenced including any outcomes or analyses that were not prespecified, with reason		N/A
Trial setting	11	Settings (e.g., community, hospital) and locations (e.g., countries, sites) where the trial was conducted		102
Eligibility criteria	12a	Eligibility criteria for participants		101
	12b	If applicable, eligibility criteria for sites and for individuals delivering the interventions (e.g., surgeons, physiotherapists)		N/A
Intervention and comparator	13	Intervention and comparator with sufficient details to allow replication. If relevant, where additional materials describing the intervention and comparator (e.g., intervention manual) can be accessed		101-111
Outcomes	14	Pre-specified primary and secondary outcomes, including the specific measurement variable (e.g., systolic blood pressure), analysis metric (e.g., change from baseline, final value, time to event), method of aggregation (e.g., median, proportion), and time point for each outcome		107-110
Harms	15	How harms were defined and assessed (e.g., systematically, non-systematically)		Not in Chapter
Sample size	16a	How sample size was determined, including all assumptions supporting the sample size calculation		110
	16b	Explanation of any interim analyses and stopping guidelines		110
Randomisation:				
Sequence generation	17a	Who generated the random allocation sequence and the method used		102

	17b	Type of randomisation and details of any restriction (e.g., stratification, blocking and block size)	102
Allocation concealment mechanism	18	Mechanism used to implement the random allocation sequence (e.g., central computer/telephone; sequentially numbered, opaque, sealed containers), describing any steps to conceal the sequence until interventions were assigned	102
Implementation	19	Whether the personnel who enrolled and those who assigned participants to the interventions had access to the random allocation sequence	102
Blinding	20a	Who was blinded after assignment to interventions (e.g., participants, care providers, outcome assessors, data analysts)	102
	20b	If blinded, how blinding was achieved and description of the similarity of interventions	N/A
Statistical methods	21a	Statistical methods used to compare groups for primary and secondary outcomes, including harms	110-111
	21b	Definition of who is included in each analysis (e.g., all randomised participants), and in which group	110-111
	21c	How missing data were handled in the analysis	110-111
	21d	Methods for any additional analyses (e.g., subgroup and sensitivity analyses), distinguishing prespecified from post-hoc	110-111
Results			
Participant flow, including flow diagram	22a	For each group, the numbers of participants who were randomly assigned, received intended intervention, and were analysed for the primary outcome	112-113
	22b	For each group, losses and exclusions after randomisation, together with reasons	112-113
Recruitment	23a	Dates defining the periods of recruitment and follow-up for outcomes of benefits and harms	112
	23b	If relevant, why the trial ended or was stopped	N/A
Intervention and comparator delivery	24a	Intervention and comparator as they were actually administered (e.g., where appropriate, who delivered the intervention/comparator, how participants adhered, whether they were delivered as intended [fidelity])	112-130

	24b	Concomitant care received during the trial for each group	N/A
Baseline data	25	A table showing baseline demographic and clinical characteristics for each group	114
Numbers analysed, outcomes and estimation	26	For each primary and secondary outcome, by group: - the number of participants included in the analysis - the number of participants with available data at the outcome time point - result for each group, and the estimated effect size and its precision (such as 95% confidence interval) - for binary outcomes, presentation of both absolute and relative effect size	112-136
Harms	27	All harms or unintended events in each group	112
Ancillary analyses	28	Any other analyses performed, including subgroup and sensitivity analyses, distinguishing pre-specified from post-hoc	N/A
Discussion			
Interpretation	29	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	136-143
Limitations	30	Trial limitations, addressing sources of potential bias, imprecision, generalisability, and, if relevant, multiplicity of analyses	142-143

*We strongly recommend reading this statement in conjunction with the CONSORT 2025 Explanation and Elaboration and/or the CONSORT 2025 Expanded Checklist for important clarifications on all the items. We also recommend reading relevant CONSORT extensions. See www.consort-spirit.org.

Citation: Hopewell S, Chan AW, Collins GS, Hróbjartsson A, Moher D, Schulz KF, et al. CONSORT 2025 Statement: updated guideline for reporting randomised trials. BMJ. 2025; 388:e081123. <https://dx.doi.org/10.1136/bmj-2024-081123>.

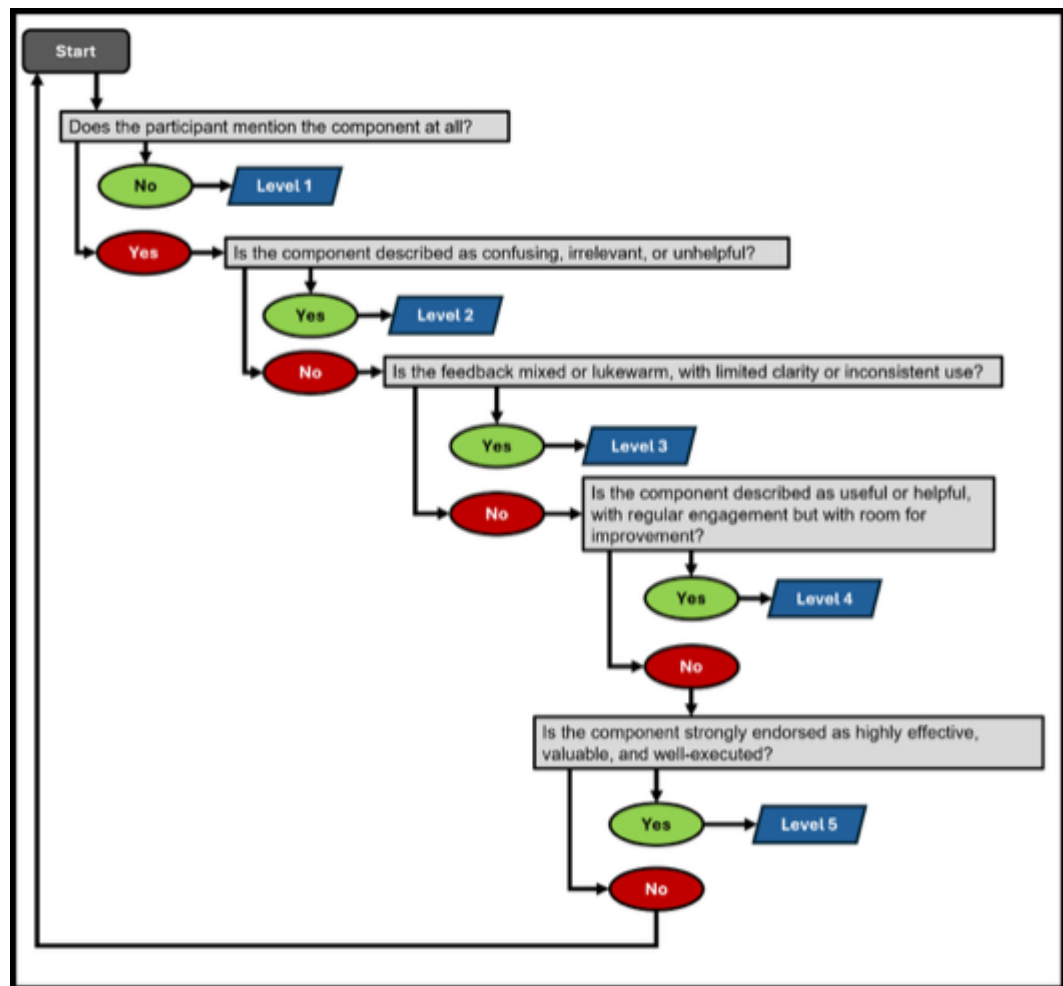
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Appendix 5-K: Participant's Perception Matrix and Decision Tree

Participant Perception Scoring Matrix for the WISH Intervention Component			
Score	Label	Description	Keywords Suggestion
1	No reference	- No quotes. - The participant does not mention or acknowledge anything about the intervention component.	No mention/quotes
2	Needs a lot of work	- Minimal engagement. - The component is viewed negatively or irrelevant, unhelpful, doesn't see the point or confusing and needs a lot of changes.	- Not helpful - Don't see the point - Confusing - Irrelevant
3	Needs some work	- Partial or inconsistent. - The component is seen as somewhat useful but with mixed feelings because of a lack of clarity and consistency. May include some critiques or confusion about purpose or execution.	- Somewhat useful - Mixed feelings - Could be better - Inconsistent
4	Doing okay	- Moderate - The component is seen as useful or relevant, with room for improvement. May include minor, more tailored suggestions, but overall satisfaction.	- Useful - Helpful - Clear - Worked well - Positive Experience
5	Doing great	- High and consistent. - The component is regarded as highly effective, engaging, and valuable and no changes are needed.	- Very useful - Excellent - Really helped - Highly effective - Loved it

Decision Tree for the Participant Perception Scoring Matrix



Appendix 7-A: Insights from the Women in Strength (WISH) Study

