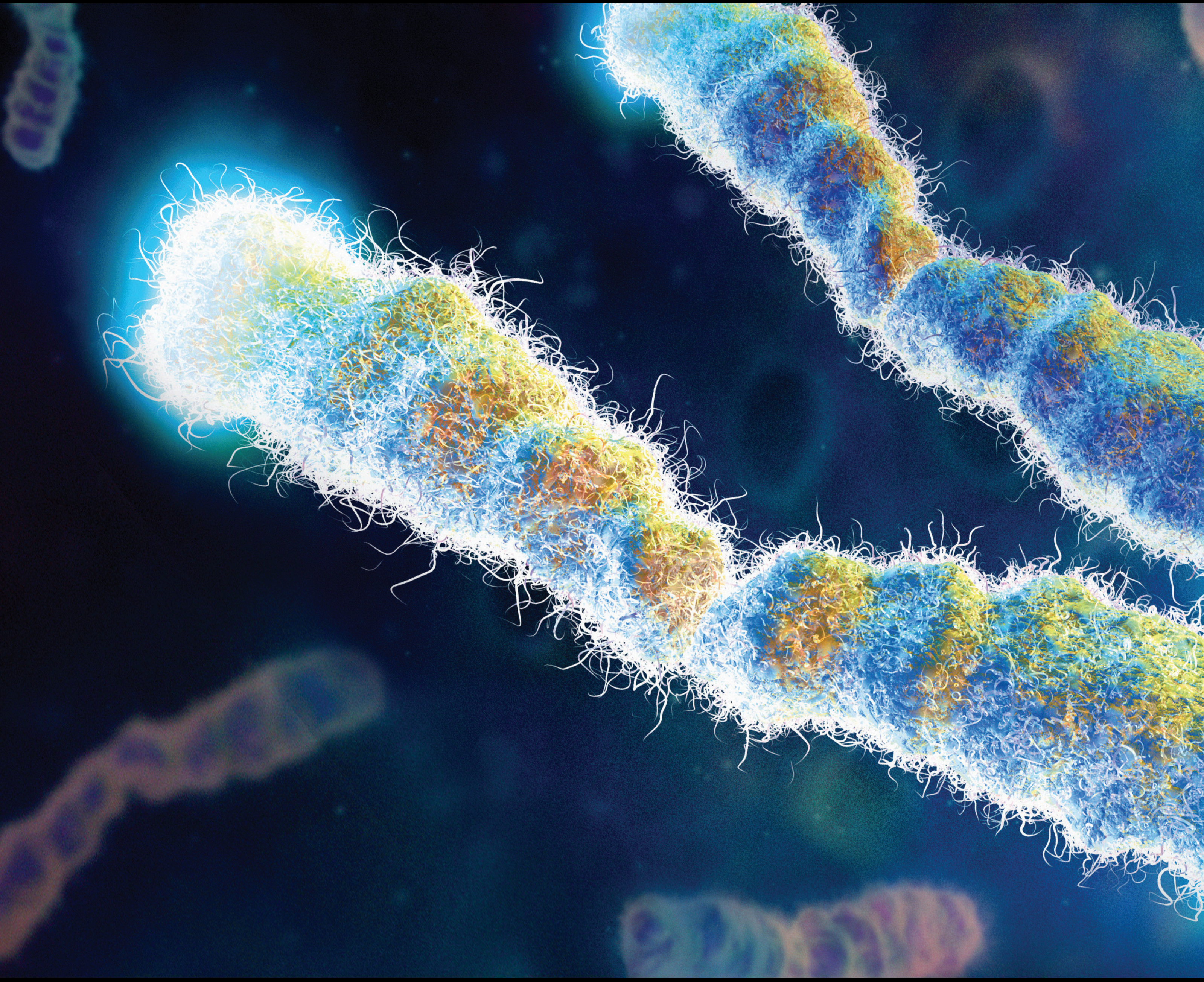
Journal of Aging Research

Management of Dynapenia, Sarcopenia, and Frailty: The Role of Physical Exercise

Lead Guest Editor: Ricardo Sampaio
Guest Editors: Priscila Sampaio, Marco C. Uchida, and Hidenori Arai



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Editorial Board

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Hindawi
Journal of Aging Research
Volume 2020, Article ID 8186769, 2 pages
https://doi.org/10.1155/2020/8186769

Editorial

Management of Dynapenia, Sarcopenia, and Frailty: The Role of Physical Exercise

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Received 11 December 2019; Accepted 11 December 2019; Published 31 January 2020

Aging is a result of physiological changes and their interactions with personal lifestyles, genetics, and chronic diseases. The musculoskeletal system and physical capabilities might decline with aging, and the transition from plateau to decline is determined by biological timing and individual life trajectories.

Dynapenia is defined as the loss of muscle strength that is not caused by neurologic or muscular diseases; it is a state in which reduced muscle strength is not necessarily accompanied by decreased skeletal muscle mass [1]. Indeed, muscle strength is presently the most reliable measure of muscle function, and when low muscle strength is verified, sarcopenia is imminent [2].

The recent European Working Group on Sarcopenia in Older People 2 (EWGSOP2) update recognized sarcopenia as a progressive and generalized skeletal muscle disorder diagnosed mainly by the presence of low muscle strength, and this low muscle strength overtook the role of low muscle mass as a primary parameter of sarcopenia [2]. Both dynapenia and sarcopenia reflect directly on older adults' activities of daily living, poor quality of life, falls and fear of falling, and the frailty syndrome and can lead to disability and mortality in older adults.

Given that physical exercise is an important nonpharmacological approach to promote healthy aging, the purpose of this special issue is to present applied studies that discussed the interaction among dynapenia, sarcopenia, frailty, and physical exercise in the context of aging. In addition, considering that many aspects of these conditions are better understood with all accumulated information during last years, it is expected that the articles published in this special issue will contribute adding high-quality information to this field of knowledge. A brief summary of all accepted papers is provided as follows.

In the paper by R. G. B. de Mello et al., a systematic review was conducted to identify randomized clinical trials (RCTs) which tested the effects of physical exercise programs to manage sarcopenia components in older individuals. The authors found 301 studies for inclusion, and after screening, five RCTs were included. All trials tested the efficacy of isolated exercise programs to improve sarcopenia components in older adults compared with no physical intervention. Resistance training was the main intervention component in all included trials compared with inactive control groups (mainly health education). They concluded that resistance training protocols can improve muscle strength and physical performance in older people previously diagnosed with sarcopenia compared with inactive control groups.

The paper by A. G. de Resende-Neto et al. presented a randomized crossover trial that analyzed the efficacy of functional training and traditional training (i.e., machine-based) in body composition and determinants of physical fitness in Brazilian older women. Forty-eight participants performed two 12-week periods of training. The authors verified that both functional and traditional training promoted improvements in physical fitness for daily activities in older women and may be prescribed in combination with optimizing general fitness levels in older adults.

Regarding the work by J. A. Vaccaro et al., a focused review was carried out to identify and integrate the evidence and lack of strategies to prevent frailty in older adults with diabetes. The authors found some evidence that motivational approaches have worked for older adults with various chronic disease conditions. However, studies applying motivational strategies are lacking for frail older adults with type 2 diabetes. Then, interventional studies specifically for this population are needed for the success in promoting health behavior changes to reduce frailty.

The paper by O. J. Perkin et al. presented a pilot study that examined the effect of a 28-day unsupervised home-based exercise intervention on indices of leg strength and muscle size in healthy older adults. Twenty participants were randomly assigned to either maintain their habitual physical activity levels (i.e., control) or undertake "exercise snacks" (ES) that included five leg exercises twice daily. Improvements of ES in leg muscle function and size in older adults were found when comparing with the control group.

In addition, the paper by M. Tomioka et al. presented a 12-month participation in and impact of Enhance®Fitness (i.e., a low-cost group exercise program designed specifically for older adults) on physical performance among older adults in Hawaii. This study analyzed several physical function tests at baseline and at 4, 8, and 12 months. Moreover, the authors compared the characteristics of participants who were engaged in all research activities with those who dropped out in order to gain insights on participant's adherence to exercise. Of all 1,202 older adults with baseline data, 427 (35.5%) were continuously enrolled in the program for 12 months. Participants' physical performance measures improved after 4 months, continued to improve until 8 months, and were maintained thereafter. Common reasons for dropping out ($n = 775$) were illness, relocation, time conflicts, lost interest, and transportation issues.

Finally, the paper by M. M. A. Mesquita et al. aimed to analyze the reproducibility of a protocol using the maximal isometric strength test of the trunk in older women. The rationale of this study was that changes related to trunk muscles, due to their important role in performing activities of daily living and in terms of better functional performance, is an important parameter to evaluate the state of health of an individual. In addition, the authors supported the development of alternative reliable and low-cost tests and protocols for evaluating muscle strength in older people.

Conflicts of Interest

The editors declare that they have no conflicts of interest.

Acknowledgments

The editors would like to thank all the authors who submitted their works to this special issue. The authors hope these articles will be useful in adding important information to the field of aging studies, especially dynapenia, sarcopenia, frailty, and physical exercise to older adults.

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Hindawi
Journal of Aging Research
Volume 2019, Article ID 3582679, 8 pages
https://doi.org/10.1155/2019/3582679

Review Article

Motivational Strategies to Prevent Frailty in Older Adults with Diabetes: A Focused Review

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Received 26 June 2019; Accepted 25 October 2019; Published 22 November 2019

Guest Editor: Ricardo Sampaio

The prevalence of diabetes among Americans aged 65 years and older is greater than 25%. Medical expenditures for persons with diabetes are more than twice as high as those for patients without diabetes. Diabetes in older adults often times coexists with frailty, resulting in reduced quality of life and increased health-care use. Many older adults with type 2 diabetes have mobility impairments and experience falls, which contributes to increased frailty. Exercise has a protective effect for frailty and falls, yet less than half of persons with diabetes exercise and approximately one-quarter meet exercise recommendations. In addition to exercise, nutrition may help reduce the risk for falls; however, nutritional interventions have not been tested as a fall-prevention intervention. According to a review, there is insufficient evidence to create nutritional guidelines specific for frail older adults with type 2 diabetes. There is a need to motivate and empower older adults with type 2 diabetes to make lifestyle changes to prevent frailty. The purpose of this review was to identify and integrate what is known and what still needs to be done for this population to be successful in making health behavior changes to reduce frailty. There is some evidence that motivational approaches have worked for older adults with various chronic disease conditions. However, studies applying motivational strategies are lacking for frail older adults with type 2 diabetes. A novel motivational approach was described; it combines aspects of the Health Belief Model and Motivational Interviewing. Intervention studies incorporating this model are needed to determine whether this client-driven strategy can help various racial/ethnic populations make the sustainable health behavior changes of increasing exercise and healthy eating while taking into consideration physiological, psychological, and economic barriers.

1. Introduction

Diabetes is a complex, chronic disease that requires medical management with a focus on lifestyle changes to prevent complications [1]. Type 2 diabetes is the most common form of diabetes and accounts for 90–95% of cases. For persons with type 2 diabetes, their insulin is produced but is relatively insufficient and leads to hyperglycemia. Chronic hyperglycemia in uncontrolled diabetes can cause long-term damage and dysfunction, particularly of the peripheral nervous system, eyes, kidneys, heart, and blood vessels [1]. According to the American Diabetes Association (ADA), the prevalence of diabetes among Americans aged 65 years and older was 25.2% in 2018 [2]. Medical expenditures for persons with diabetes are more than twice as high as those for patients without diabetes [3]. The estimated cost of diabetes in the U.S. was $237 billion in 2017 [3]. Diabetes in older adults often times coexists with frailty, resulting in reduced quality of life and increased health-care use.

Frailty affects 32 to 48% of older adults with diabetes, compared with only 5 to 10% of those without diabetes [4]. Frailty is a physiological decline that compromises the ability to deal with life's stressors, making people vulnerable to adverse health outcomes. People presenting three out of the following five phenotypic criteria are classified as frail: low grip strength, low energy, slow walking, low physical activity, and unintentional weight loss [5]. Despite Fried and colleague's frailty phenotype classification, there is considerable disagreement as to the operational definition of frailty, its role in the physical and cognitive domains, and its relationship with aging, disability, and chronic diseases [6].

There is a need to motivate and empower older adults with type 2 diabetes to make lifestyle changes to prevent frailty. The purpose of this review was to identify and integrate what is known and what still needs to be done for this population to be successful in making health behavior changes to reduce frailty. Specifically, the aims were to investigate and describe (1) the mechanisms why persons with type 2 diabetes are susceptible to frailty and falls, (2) the relationship between glycemic control and frailty, (3) exercise and frailty, (4) nutrition and frailty, (5) multimodal interventions for frailty in persons with diabetes, and (6) a novel motivational strategy to prevent frailty in older adults with type 2 diabetes.

2. Mechanisms for Frailty and Falls in Persons with Type 2 Diabetes

Many older adults with type 2 diabetes have mobility impairments and experience falls [7, 8], which contributes to increased frailty because it creates a vicious cycle of accelerated functional decline and deconditioning (Figure 1). Preventing and reducing diabetes' complications such as peripheral neuropathy, reduced vision, and renal function may help reduce falls [9].

The medical cost for fatal and nonfatal falls for adults aged 65 years and older in the U.S. was $50 billion in 2015, an increase from $38 billion in 2013 [11]. The Center for Disease Control and Prevention (CDC) estimated that fall-related medical costs in 2020 will be $67.7 billion [12, 13] and that a 20% reduction would represent $13.5 billion in savings. The mechanisms predisposing persons with type 2 diabetes and falls are multifacited and have not been clearly determined. Several factors contributed to increased fall risk in a longitudinal study older adults with type 2 diabetes, including reduced renal function, peripheral nerve function, and vision [9]. Stringent glycemic control (A1C <6.0%) leads to hypoglycemial and increased falls [9].

Diabetes was reported as an independent risk factor for falling even after controlling for balance in a prospective study of older European adults [14]. A meta-analysis of community-dwelling older adults aged ≥65 years showed that those who were frail or prefrail had higher rates of falls than those who were robust, and those who were frail were likely to have recurrent falls [15]. Fallers have a 66% chance of suffering subsequent falls within a year [16, 17]. Close to 95% of hip fractures are falls related; 95% of the hip fracture patients are discharged to nursing homes; and 20% die within a year [16, 18]. Falls for persons with diabetes can result in more serious injuries and a longer recovery process as compared with older adults without diabetes [19].

3. Glycemic Control and Frailty

Poor diabetes self-management increases functional impairments and diabetes' complications, leading to sarcopenia and frailty [20]. Lack of glycemic control and increase in insulin resistance and/or depletion are associated with loss of muscle mass and strength because insulin is an anabolic hormone [20]. Diabetes causes debilitation across muscle, nerve, and cardiopulmonary and executive reserve systems, leading to frailty and making it increasingly more difficult to maintain glycemic control [20]. Fewest complications were found at A1C levels between 7 and 8 percent [20]. High A1C was associated with heart disease, whereas oral hypoglycemic agents together with malnutrition result in lower than normal A1C levels producing hypoglycemia and leading to dementia and frailty [20]. Diabetes is associated with frailty and cognitive impairment, both of which make it difficult to maintain glycemic control [21]. Identifying cognitive impairment and frailty is essential in developing appropriate interventions.

The recommended method to reduce diabetes-related complications and costs is to provide education to people on how to manage their condition and maintain glycemic control [1]. Yet, the standard of care is only one diabetes self-management session per year including education on proper nutrition, physical activity, and glucose monitoring [1]. Additional sessions are recommended only when medical complications or major lifestyle transitions occur [22].

When forming a plan of care for older adults with diabetes, evaluation of health status and quality of life need to be undertaken because of the wide variations in physical functioning and medical conditions [23]. This may be why there are so few clinical trials of diet and exercise interventions that specifically target adults aged 65 years and older with type 2 diabetes. Evidence-based recommendations for glycemic control specific for older adults with type 2 diabetes have not been developed, since clinical trials for this population are scarce [23]. For a cohort of $n = 10{,}251$ adults aged 40–79 with type 2 diabetes, hemoglobin A1c >8.0, and at high risk of cardiovascular disease, intensive therapy (multiple meetings and phone calls) to lower hemoglobin A1c to 6% resulted in higher mortality after 3.7 years compared with the 7-8% standard target, resulting in discontinuation of the treatment in all groups [24].

Concurrent strength and endurance training improved glycemic and hemoglobin A1c control in middle-aged adults with type 2 diabetes [25, 26]. Better glycemic control was achieved by older adults receiving a group behavioral intervention focused in diabetes self-management, including exercise and nutrition compared with individual diabetes education alone [27]. Further evaluation of diabetes education interventions for older adult population is needed, but the existing findings indicate limited effect [27].

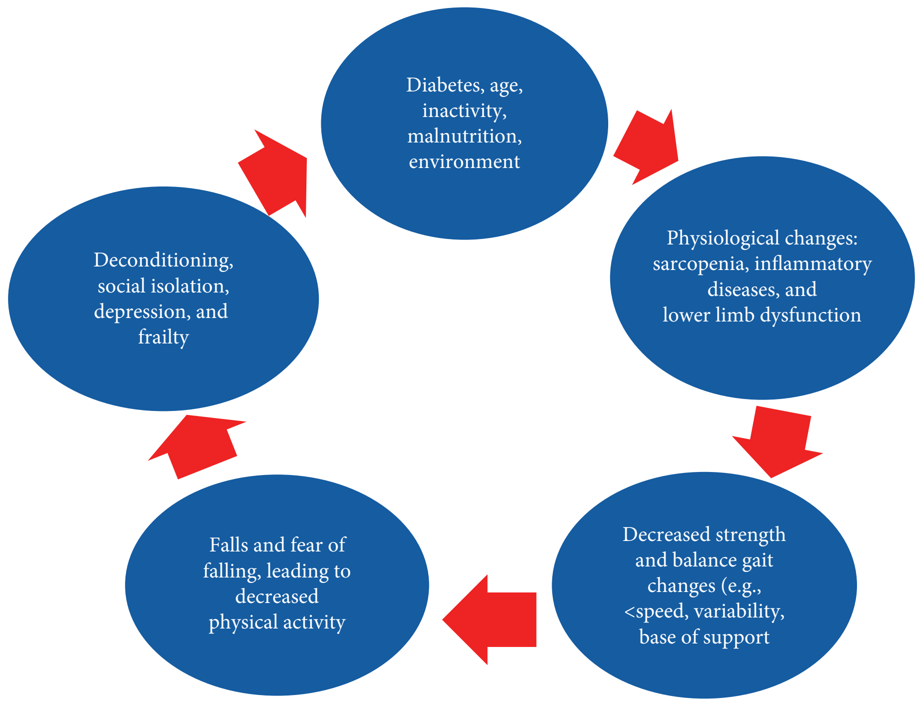

Figure 1: Cycle of changes and factors associated with frailty and falls among older adults with diabetes. Adapted from Vieira et al. [10].

4. Exercise and Frailty

There is evidence of reduced falls for persons with diabetes who underwent strength, balance, and gait training programs; however, sustainability has not been established [19]. A systematic review of randomized controlled trials of exercise interventions in community-dwelling adults aged 60 years and older demonstrated a 15% greater reduction of falls for the exercise group as compared with the control group [28]. The authors concluded that exercise programs were effective in reducing both the rate of falls and the number of people experience falls [28]. Exercise programs with balance and functional exercises reduced falls, but their effect on other measures of frailty is uncertain. The authors were uncertain of the effects of exercise programs without balance and functional exercises such as walking, dance, and resistance weights, alone on the rate of falls [28]. Less than half of persons with diabetes exercise, and approximately one-quarter meet exercise recommendations [29–31]. Middle-aged outpatients with diabetes had lower physical activity (lower active energy expenditure/day, fewer number steps, and lower physical activity duration) than their matched controls without diabetes [32]. It is likely that this trend would remain the same since physical activity decreases with age. Diabetes combined with physical inactivity accelerates muscle loss in older adults, and the most effective exercise intervention for older adults with diabetes is a combination of resistance and endurance training [33, 34]. For frail, older adults with diabetes and severe functional decline, a multicomponent exercise program is recommended which addresses gait and balance, as well as endurance and power training to counteract functional decline and reduce incidence of falls [33, 35]. For persons with frailty and diabetes, improving functional capacity is equally if not more critical than metabolic control [36].

For older adults with frailty and diabetes, specific guidelines on frequency of exercise performance, repetitions, and progression of intensity for both resistance and endurance training have been proposed [34, 37]. However, attrition can be high and the proportion of older adults that stay engaged in recommended exercise programs has not been determined. In our experience with interventions, attrition rates for older adults ≥40% are common. Frailty was associated with lower hourly measured activity levels in older adults across sex and age-groups [38]. A systematic review of randomized controlled trials (RCTs) of exercise interventions in frail older adults showed that exercise improved physical function [39]. Improvements in lower body strength were found for older adults with type 2 diabetes in a meta-analysis of three RCTs [40]. Lower incidence of frailty was reported for the nutrition and exercise intervention groups versus the control group in a 12-month follow-up of prefrail, community-dwelling older adults [41]. There is a scarcity of RCTs of exercise interventions for frail older adults with type 2 diabetes. Thus, further research is needed in this area.

5. Nutrition and Frailty for Older Adults with Type 2 Diabetes

In addition to exercise, nutrition may help reduce the risk for falls; however, nutritional interventions have not been tested as a fall-prevention intervention. Behaviorally focused nutrition education and exercise intervention improved physical function in the MID-FRAIL study, a multinational study of older adults (aged 70 and older) [42]. According to a review, there is insufficient evidence to create nutritional guidelines specific for frail older adults with type 2 diabetes [43]. The limited available research suggests that diets rich in protein and calories may be used to prevent weight loss and malnutrition, but the evidence does not specifically address frailty [43]. Dietary recommendations for persons with frailty include sufficient energy (calories per day determined by age, sex, body weight, height, and physical activity level) and diet quality incorporating foods that are nutritionally dense as opposed to calorie dense [44]. Medical professionals together with dietitians could develop dietary plans specific for the individuals within the wide dietary targets.

Nutritional status, particularly in older adults with type 2 diabetes, may be a confounder in exercise motivation, performance, and results. Unintentional weight loss is one of the five clinical criteria for frailty. Recall that the frailty syndrome requires at least three of the five characteristics: unintentional weight loss, as evidenced by as loss as 5% of body weight from the previous year or 10 lbs; low physical activity, self-reported fatigue, physical slowness, and based on the time to walk 15 feet; in the lowest 20% of grip strength for age, sex, and BMI [5].

Diet has been shown to influence blood glucose regulation and is a key factor in diabetes self-management. Both higher and lower hemoglobin A1c levels were found to be associated with frailty in older adults with type 2 diabetes [20]. There are safety issues for exercising with diabetes; proper nutrition and hydration before, during, and after exercise are essential factors for assuring a safe and pleasant experience. Hypoglycemia can be prevented in older adults with type 2 diabetes by education on exercise timing with medication schedules, meals, and snacks [44, 45]. According to medical nutrition therapy, exercise should be performed postmeal when blood glucose levels are high [46].

According to a position statement by the American Diabetes Association (ADA), low and moderate intensity physical activity should be undertaken by adults with type 2 diabetes, and the risk of exercise-induced adverse events is low [47]. Physical activity and nutritional status have a reciprocal relationship in older adults with diabetes [48]. Physical activity can improve insulin sensitivity, aid in weight maintenance, and increase lean body mass [48]. In turn, physical activity can further the effects of nutrition care with improvements in appetite and glucose control, whereas proper nutrition can be a strategy to increase "energy" and physical activity levels in frail older adults with type 2 diabetes [48]. A review of nine studies of fall interventions for persons with type 2 diabetes and diabetic peripheral neuropathy showed that a targeted, multicomponent program resulted in improved gait and balance without any serious adverse events [49].

6. Multimodel Behavioral Interventions for Frailty and Diabetes

How can we motivate and empower older adults with type 2 diabetes to perform the recommended strength and endurance exercises [50] to reduce the rates of frailty and other diabetes complications? There are several behavioral models: cognitive-behavioral therapy, the Health Belief Model, and motivational interviewing have been used to motivate behavioral changes in other populations. *Cognitive-behavioral therapy* is a client-focused technique to increase motivation by removing negative thoughts that interfere in functioning [51]. Feelings of incompetency can interfere with performing exercises, particularly for older adults with comorbidities and/or low physical/functional levels. Cognitive and cognitive-behavioral interventions were more effective in increasing physical activity in older adults than behavioral interventions in a meta-analysis of 20 studies [52]. In cognitive-behavioral therapy, the clinician uses an encouragement approach when the client is ambivalent, whereas in motivational interviewing, a more collaborative strategy, the client would be prompted to discuss their ambivalence.

Another behavioral model used to motivate people to participate in exercise as a treatment for diabetes and frailty is the *Health Belief Model (HBM)* [53]. The HBM was first developed in the 1950s by social psychologists Hochbaum, Rosenstock, and Kegels to explain the reluctance for a free tuberculosis vaccine and this model has been widely applied to other areas of health behaviors. The six constructs of the HBM are (1) perceived susceptibility: person's perception of their likelihood of getting the disease/health condition, (2) perceived severity: the individual's perception of the seriousness of the disease/health condition, (3) perceived benefits, (4) perceived barriers, (5) cues to action (internal, such as a symptom, or external, such as environmental influences), and (6) self-efficacy [54, 55]. The individual's perception of their susceptibility and seriousness of the disease form their perception of threat [54, 55]. According to the HBM, people need to realize that they are vulnerable, understand the severity of their condition and the changes that are required, they need to believe that they can make these changes, and the benefits must outweigh the barriers [54, 55]. Cues to action can serve as motivators to action [56]. Self-efficacy, added as a construct in the 1980s, is an individual's level of confidence in their ability to successfully perform a behavior and is necessary to overcome barriers to take the health action [55, 56].

There are no studies, to date, applying the HBM to prevent frailty and improve diabetes self-management skills in older adults with type 2 diabetes. The majority of studies were in middle-aged to older adults and focused on diabetes self-management skills, only. Significant improvements in self-care behaviors (including diet and exercise) were found applying the HBM to Iranian [57–59], African American women [60], and Pacific Islander populations [57]. Thus, HBM could serve as another possible motivational tool to prevent frailty in older adults with type 2 diabetes.

Another widely used health behavioral model is motivational interviewing (MI); it is suited to those persons who lack motivation to change and can be applied to help individuals increase their physical activity [61, 62]. Motivational interviewing was developed in the clinic to treat addictions and has since been applied to persons with chronic diseases to help them work through their ambivalence about behavior change [63]. There are four core principles of MI: (1) *cultivating change talk*, which engages

Table 1: Application of motivational strategies and likelihood of following recommendations to manage diabetes and prevent frailty.

HBM construct	MI construct	Modifying factors	Application	Likelihood of action*
Perceived susceptibility	Partnership	*Age*, *sex*, *ethnicity*, *personality*, *socioeconomics*, and *knowledge*	Clinician works with client to explain vulnerability consequences: risk of falls for persons with diabetes	Perceived benefits outweigh the perceived barriers
Perceived severity	Partnership/ empathy	Perceived threat of falls and uncontrolled diabetes	Clinician educates client about frailty and diabetes in relationship to their individual/ social background	Likelihood of performing the recommended exercise and nutrition for diabetes self-management and frailty prevention
Perceived benefits	Cultivating change talk/partnership	*Cues to action* (i) Education (ii) Symptoms (iii) Media		Clinician indicates specifically how exercise and nutrition can improve the client's quality of life by preventing/reducing frailty and managing blood glucose
Perceived barriers	Softening sustained talk			Clinician ignores negative talk and presents solutions
Cues to action	Cultivating change talk/partnership	*Physiological and psychological state (depression*, *stress*, and *anxiety)Hypoglycemia*,*cognitive function*, *fear of falling*, *and safety*	Likelihood of performing the recommended exercise and nutrition for diabetes self-management and frailty prevention (i) Examples of actions: Participating in strength training for older adults at the senior center (ii) Increasing lean protein and vegetables while decreasing bread, rice, and pasta	Clinician provided exercise/ nutrition education in conjunction with cognitive, physical and economic limitations (i) Involves physician in medication timing/dose changes (ii) Involves social worker and psychiatrist for economic and psychological issues (iii) Engages client and family/ caretakers to discuss what he/ she will change and why (iv) Consider structured programs such as SilverSneakers
Self-efficacy	Empathy			Clinician affirms the client's abilities

Adapted from Hamrin et al. [64] and Janz et al. [71] *Likelihood of action is the outcome of constructs, modifying factors and applications.

the client by questions such as "why do you want to change this behavior now?" and "what are you willing to do to change?"; (2) *softening sustain talk* by not paying attention to negative talk; (3) *partnership* where the clinician and client engage in mutual problem solving; and (4) empathy, which the clinician affirms the client's strengths and efforts [64]. The process of MI applied to a specific task can be considered as follows: (a) *engagement*, both the counselor and client establish a helpful connection and working relationship; (b) *focusing*, the counselor maintains the conversation in a specific direction; (c) *evoking*, helps to elicit the client's own motivation for change; and (d) *planning*: this requires a commitment for change along with a specific plan of action [62].

There are no publications applying motivational interviewing to frailty prevention in older adults with type 2 diabetes. Improvements in physical activity have been the consequence of MI; however, these gains are mostly walking at unspecified effort [65]. Studies demonstrating gains in cardio and functional capacity for older adults are limited. What is missing are long-term studies and studies of motivation with strengthening exercises [65]. Motivational interviewing increased physical activity in persons with chronic conditions, according to a meta-analysis of 10 trials. However, there was no evidence that cardiovascular or functional exercise capacity increased [66]. As in the case of cognitive and cognitive-behavioral interventions, motivational interviewing demonstrated increased physical activity, but investigators did not measure functional improvements. Motivational interviewing, alone, may not work with certain racial/ethnic groups who want their physician to prescribe a treatment plan [63]. Based on a systematic review, improvements in diet for persons with diabetes (ages 18 and older) using MI were found in four out of seven trials, whereas the other three showed no improvements [76]. Compared with usual care, group MI was effective in weight loss and improved glycemic index in an 18-month program for women aged approximately 40–60 years with type 2 diabetes [76]. However, African American women compared with White women experienced less weight loss and improvements in glycemic control [67]. There is some evidence to support that motivational approaches work for older adults with various chronic disease conditions [68]. A review of motivational interviewing interventions for lifestyle changes in older adults demonstrated significant improvements in chronic disease management [68]. Motivational interviewing builds on the empowerment model already used in diabetes education. The usefulness of MI on persons with poorly controlled diabetes is currently being investigated in a four-year clinical trial [69].

6.1. Novel Motivational Strategy: Combination of HBM and MI to Manage Diabetes and Prevent Frailty. Implementing health behavior change using HBM and MI for clients has not been tested and requires considerable investigation, particularly across race/ethnicity for older populations with type 2 diabetes. We propose a new model combining the HBM and MI aimed at health behavioral change in this population; aspects of this model are already used in diabetes education. Table 1 shows a nesting of MI within HBM. Increasing self-efficacy may prove to be an effective strategy for long-term behavioral changes in physical activity. Exercise programs for older adults should nurture self-efficacy, the individual's belief that they can achieve the desired results [70].

6.2. Considerations of Psychological, Economic and Physiological Barriers for Exercise. Barriers need to be addressed in the application of motivational strategies for persons with type 2 diabetes. Exercise plans need to consider the older adult's access and/or ability to safely exercise in their home, at a community center, or at a park. Older adults of lower socioeconomic status were more likely to perceive their neighborhood as disadvantaged and have lower participation in exercise [72]. Programs recommended by the National Council on Aging provide free classes to members on Medicare and include chair classes. Chair exercises can combine cardio and strength and may be beneficial for adults with orthopedic issues. Motivational techniques for persons with psychological issues such as depression, stress, or anxiety should be done in conjunction with a therapist.

Another barrier to exercise is change in glycemic control. Sedentary older adults with type 2 diabetes who begin an exercise program (either aerobic or strength) will experience noninsulin-dependent uptake of blood glucose because of muscular contractions [47]. Meal timing and medication dose/frequency/timing may need to be adjusted by the physician and dietitian in conjunction with the patient's exercise routine to prevent hypoglycemia. The American Diabetes Association recommends a small carbohydrate snack be carried. Cognitive function may be another barrier to safe exercise. Caretakers and/or family members should be involved in the exercise plan to ensure safety and effectiveness.

7. Conclusion

The risk of frailty is doubled in persons with type 2 diabetes, but frailty is not an inevitable consequence of aging and/or diabetes. Older adults with diabetes require preventative interventions to minimize the compounding effects of aging and diabetes on physical function. Health behavioral interventions that motivate and instill confidence have been recommended to make sustainable behavior changes. There is some evidence to support that motivational approaches work for older adults with various chronic disease conditions. However, studies applying motivational strategies to increase physical activity, exercise, improve nutrition and glycemic control, and prevent frailty are lacking for frail older adults with type 2 diabetes. A novel motivational approach was described; it combines aspects of the Health Belief Model and motivational interviewing. Intervention studies incorporating this approach are needed to determine if this client-driven strategy can help various racial/ethnic populations make sustainable health behavior changes by increasing exercise and healthy eating while taking into consideration physiological, psychological, and economic barriers, and finding ways to overcome them.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
Journal of Aging Research
Volume 2019, Article ID 5315376, 9 pages
https://doi.org/10.1155/2019/5315376

Research Article

The Efficacy of Functional and Traditional Exercise on the Body Composition and Determinants of Physical Fitness of Older Women: A Randomized Crossover Trial

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Received 24 July 2019; Revised 27 August 2019; Accepted 5 September 2019; Published 21 November 2019

Guest Editor: Ricardo Sampaio

Aim. To analyze the efficacy of functional training (FT) and traditional training (TT) in body composition and determinants of physical fitness in older women. *Methods*. This is a randomized clinical trial in which participants performed two 12-week periods of different training methods, separated by eight weeks of washout. Forty-eight physically active older women (≥60 years of age) completed the intervention in three groups: (i) program that started with FT and ended with TT (FT ⟶ TT: $n = 19$), (ii) program that started with TT and ended with FT (TT ⟶ FT: $n = 13$), and (iii) stretching group (SG: $n = 16$). Before and after the interventions, the body composition was evaluated by bioimpedance, the physical fitness by battery of the Senior Fitness Test, and the quality of movement by Functional Movement Screen®. *Results*. Compared with SG, TT ⟶ FT and FT ⟶ TT promoted significant improvements in balance/agility (13.60 and 13.06%, respectively) and upper limb strength (24.91 and 16.18%). Only FT showed a statistically significant improvement in the strength of the lower limbs, cardiorespiratory capacity, and movement patterns when compared with SG considering the adaptations of methods separately. *Conclusion*. The programs used are equally effective in increasing physical fitness for daily activities in physically active older women, and therefore, they may be complementary to combat some of the deleterious effects of senescence.

1. Introduction

Ageing comprises a set of physiological, biochemical, and morphological changes resulting in a gradual inability for the individual to adapt to the environment [1]. This process leads to a decrease in neuromuscular function and a change in muscle contractile properties, resulting in decreased functional capacity with consequent physical dependence, frailty, and sarcopenia, often associated with increased falls, infectious processes, and other associated complications [2].

Currently, surgical and pharmacological interventions have been fundamental in several situations in the treatment and prevention of these natural declines, which could be avoided by involving older adults in regular programs of physical exercises, whose benefits are well known and have been the focus of recent research [3, 4]. When analyzing the efficacy of different exercise protocols in a systematic review, 70% of the included studies showed a reduction in the incidence of falls, 54% had improved gait ability, 80% reported increased balance, and 70% reported increased muscle strength in the frail elderly [5].

Although machine-based traditional training (TT) protocols promote several structural adaptations such as increased muscle mass [6], bone mineral density [7], and reduction of adipose tissue [8], there are questions about their ability to transfer to activities of daily living [9]. Serra-Rexach et al. [10], reported increase of strength in nonagenarian older adults after eight weeks of TT but no change was observed in the functional standing up and walking test. Moreover, recent studies show that the benefits of exercise are dependent on tasks performed during training, requiring specific movements for daily tasks to achieve greater gains in functional capacity, preventing the onset of physical disabilities [11].

In this context, functional training (FT) arises to stimulate the psychobiological system in an integral way. This method proposes the application of a systematized program of multiarticular and multiplanar exercises aimed at improving movement ability, central body strength, and neuromuscular efficiency for each individual's specific needs [12].

However, the benefits of this method are not well known in the elderly population. It is also observed the absence of a systematic training model in the studies available in the literature, as well as the lack of investigations comparing and integrating FT with TT methods, hindering a bigger analysis between the protocols used and the answers found. Thus, this experiment sought to compare the efficacy of functional and traditional training on body composition and determinants of physical fitness in physically active older women. Our initial hypothesis was that specific training protocols for daily activities carried out at an early stage are more effective in adaptive responses related to the functionality.

2. Methods

2.1. Study Design and Participants. The intervention was disseminated through leaflets, social networks, and websites of the local university, recruiting participants that met the following criteria: age between 60 and 80 years, female, practicing some type of regular physical exercise in the period of six months preceding the study, who could present the medical release term and be physically independent. Among the older women eligible for the research, the following exclusion criteria were adopted: hypertension ≥ stage 2 (systolic ≥ 160 mmHg and diastolic ≥ 100 mmHg) and musculoskeletal disorders that could restrict the practice of high-intensity exercises, these criteria, evaluated by a specialized medical team.

Forty-eight older women physically active were allocated by set randomization, in which the participants were equally distributed according to their strength of lower limbs in two training programs and group that served as control: (i) program that started with FT and ended with TT (FT ⟶ TT: $n = 19$; 64 ± 4.3 years); (ii) program that started with TT and ended with FT (TT ⟶ FT: $n = 13$, 65.9 ± 5.8); and (iii) stretching group (SG: $n = 16$; 64.1 ± 3.6). Thus, participants completed two 12-week intervention periods with alternation of methods (functional/traditional) after eight weeks of no training (Figure 1).

2.2. Data Collection Procedures. The initial evaluation included an anamnesis with questions regarding sociodemographic aspects, health characterization, type and quantity of medication used, presence of diseases, and level of physical activity. Then, a medical evaluation was carried out to further detail the physiological parameters of each participant. They were informed about the objectives of the study, possible discomforts of the procedures, voluntary nature, right of secrecy, and possibility of withdrawal at any stage of the research, and after the acceptance of the study, they signed a free and informed consent form. Finally, the participants were advised to maintain normal dietary intake throughout the study. This study was carried out in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of the Federal University of Sergipe (No. 2.897.793/CAAE: 97652918.7.0000.5546) and also by the Brazilian Registry of Clinical Trials (RBR-9Y8KJQ).

The evaluators were blinded to the program (FT ⟶ TT or TT ⟶ FT) performed by the participants. The battery of tests was performed in five different moments and organized in the following order: body composition measurements, Functional Movement Screen, and Senior Fitness Test battery. For all performance tests, the participants were verbally encouraged to give their best.

2.2.1. Anthropometry and Body Composition. Body weight was determined by a scale (Lider®, P150C, São Paulo, Brazil), with a maximum capacity of 150 kg. Height (cm) was determined using a stadiometer (Sanny®, ES2030, São Paulo, Brazil). The estimated percentage of fat, muscle mass, and basal metabolic rate were determined by electrical bioimpedance (model BC-418MA, Tanita Corporation, Tokyo, Japan). To ensure the accuracy of this evaluation, the instructions provided by the manufacturer were followed.

2.2.2. Movement Patterns. The Functional Movement Screen® (FMS) was applied for analysis of movement patterns. This is a battery test involving seven functional movements that assess body mobility and stability. Each pattern was executed three times and assigned a score of 0 to 3 (1: did not perform the movement; 2: performed the movement with compensations; and 3: perfect execution). For the analyses, the total score reached by the participant was used [13, 14].

2.2.3. Determinants of Physical Fitness. The Senior Fitness Test battery proposed by Rikli and Jones [15] was used to verify functional fitness, with tests that evaluate physical

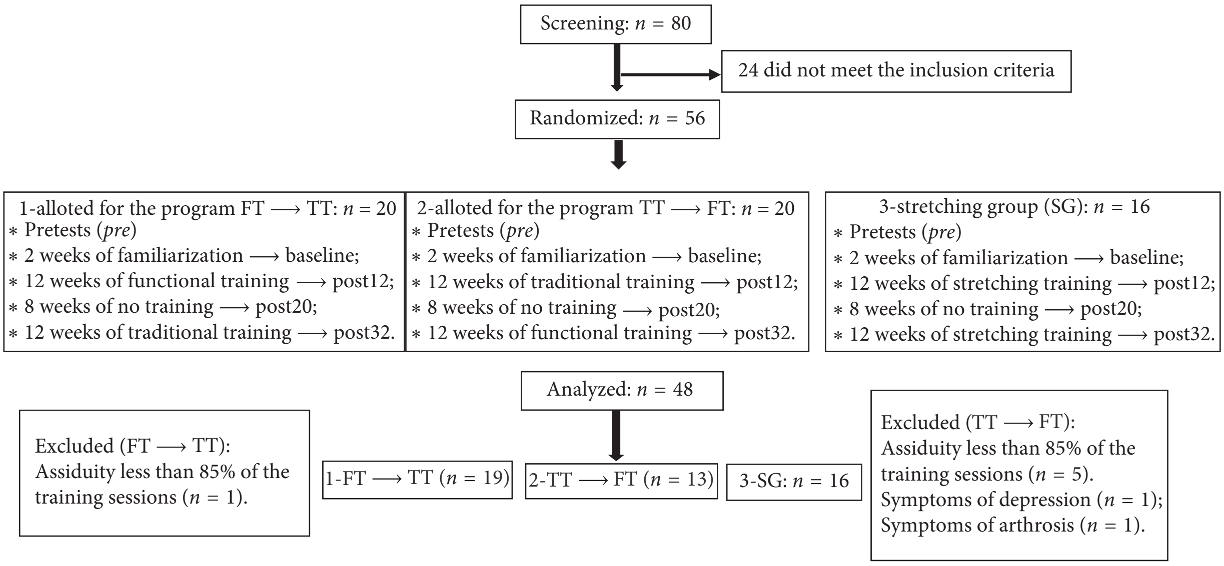

Figure 1: Schematic representation for screening, recruitment, allocation, and intervention.

fitness components (flexibility, agility/dynamic balance, muscular strength of lower and upper limbs, and cardiorespiratory capacity) to perform normal daily activities in a safe and independent way, without undue fatigue.

2.3. Intervention

2.3.1. Brief Intervention Programs. After the initial evaluations, program participants (FT ⟶ TT and TT ⟶ FT) went through two weeks of familiarization with the methods and completed 36 sessions per intervention period, lasting 50 minutes and respecting the 48-hour recovery time between training sessions. The OMNI-GSE scale was used to control and normalize training intensity between groups [16].

Stretching group: performed two sets of 20 seconds per stretch exercise for the main body parts (neck, shoulders, back, thorax, arms, wrists, hands, lower torso, hips, knees, thighs, feet, and calves) with amplitude levels articulate submaximes and relaxation practices without physical effort, with the same frequency and duration of the experimental programs.

Separately, participants of the FT performed specific exercises for their daily needs, with each session divided into four sets: (1) five minutes of mobility for the main joints (ankle, hip, and glenohumeral) and exercises for general warm up that included ten repetitions of squats and jumps; (2) 15 min of intermittent activities, organized in circuit that mainly required agility and coordination (OMNI-GSE: 6-7); (3) 25 min of multiarticular exercises for lower and upper limbs, and intense recruitment of spinal stabilizing muscles, also organized in a circuit (OMNI-GSE: 7-8); and (4) five minutes of intermittent activities (OMNI-GSE: 8-9).

In TT, the participants performed traditional exercises predominantly analytical in machines (Physicus, PLP®, Auriflama, São Paulo, Brazil), each session also divided into four sets: (1) five minutes of mobility and exercises for general warm up; (2) 15 min of continuous walking that mainly required muscular and cardiorespiratory endurance (OMNI-GSE: 6-7); (3) 25 min of resisted exercises for upper and lower limbs (squatting on the smith machine, rowing machine, leg press 45°, vertical bench press, leg curl, lat pull down, leg press, and stiff—OMNI-GSE: 7-8); and (4) five minutes of intermittent activities (OMNI-GSE: 8-9).

2.3.2. Detailed Intervention Programs. The mobility exercises (1^{st} set) and the intermittent activities (4^{th} set) were performed in the same space, with only the participants of the programs (TT ⟶ FT and FT ⟶ TT). The five activities applied in the 2^{nd} set of the FT followed a density of 30 seconds of work for 30 seconds of transition between the stations. The intensity was progressive through modifications in the activities according to the level of ability and comfort:

(i) Medicine ball launches (2 kg): from the 1^{st} to the 18^{th} session, launches were made towards the ground, and from the 19^{th} to the 36^{th} session, vertical launches were performed on the wall at maximum concentric speed.

(ii) Displacements with cones: from the 1^{st} to the 18^{th} session, lateral movements were performed, and from the 19^{th} to the 36^{th} sessions, short sprints were performed with a change of direction.

(iii) Jump on a 10 cm step: from the 1^{st} to the 19^{th} session, the step up and down activity was performed, and from the 19^{th} to the 36^{th} sessions, vertical jumps were performed on the step.

(iv) Coordinated exercises in agility ladder: from the 1^{st} to the 18^{th} session, *lateral* movements were performed, and from the 19^{th} to the 36^{th} sessions, jumps were performed.

(v) Alternating waves (battle rope): alternating linear movements were performed with stabilization of the shoulder girdle; every 12 sessions, the length of the rope was extended.

For logistic reasons, in the 3rd set strength exercises, the individuals trained in pairs, supervised by experienced instructors, whose responsibility was to maintain the established protocols and ensure an optimal execution pattern, as well as safety and motivation. For TT, the intensity in this set was progressive by adding external loads, increased from level 6 (easy) on the OMINI-GSE scale, and with the number of repetitions performed for maintenance of 8 to 10 repetitions, that is, if the participant performed more than the maximum number of pre-established repetitions (>10), an increase of 5 to 15% in the external load was performed.

For the FT protocol, the aforementioned criterion was followed for addition of external load in the possible exercises, and modifications were made in the exercises in those performed with the own body weight, according to level of ability and comfort. The training density was 30 seconds of work per 30 seconds of transition between the stations. The modifications in the eight exercises applied in the 3rd set of the FT are described below:

(i) Kettlebell deadlift: from the 1st to the 18th session, the exercise was performed with an average external load of 16 kg, and from the 18th to the 36th session, an external load of 20 kg was used.

(ii) TRX suspension rowing: two *lines* parallel to the displacement of the TRX suspension with a distance of 20 cm between them were demarcated. The overload was given with the greatest inclination of the body during the sessions.

(iii) Sit-to-stand from a 40 cm bench*:* from the 1st to the 18th session, the exercise was performed with the body weight, and from the 19th to the 36th, holding a mean external load of eight kg at the chest level.

(iv) Push-ups: from the 1st to the 18th session, this pushing action was performed with elastic bands (Strong Tension, ProAction®, G144, São Paulo, Brazil), and from the 19th to the 36th, the exercise was performed in a 60 cm height.

(v) Farmers walk: from the 1st to the 18th session, the exercise was performed with an average external load of 12 kg, and from the 19th to the 36th, it was performed with 16 kg.

(vi) Elastic band rowing: three lines parallel to the point of attachment of the elastics were demarcated, with the first line at a distance of 40 cm and a distance of 20 cm between the others. The overload occurred with the participant positioning in the lines farthest from the point of fixation, causing greater tension in the elastic.

(vii) Hip elevation: from the 1st to the 18th session, the exercise was performed with the body weight, and from the 19th to the 36th, the movements were performed unilaterally with the knees extended and suspended alternately.

(viii) Front plank: from the 1st to the 18th session, the exercise was performed in a 40 cm bench, and from the 19th to the 36th, it was performed in a 10 cm step.

In the high-intensity intermittent exercises (4th set), collective activities of executable motor complexity were used, following a 10-second work density for 20 seconds of recovery between stations and intensity equivalent to 8-9 at OMNI-GSE [17]. Here, there is a description of the two activities used to achieve this stimulation:

(i) Interval sprint: in a space of 30 meters, the participants were divided into five groups; three of the groups formed a column behind a cone and the other two groups formed another column, at a distance of 20 meters. Working time consisted of walking this distance with maximum speed, and recovery was achieved while the other participants in the group performed the sprints. The total volume was 8 to 12 sprints per participant.

(ii) Tug of war: the rope was divided equally in the middle, and at each end, there was a group of participants. The activity began when groups began to perform the pull action, whose maximum strength corresponded to their work. To achieve the maximum effort in the estimated time, two coaches positioned in the middle of the rope were needed to equalize the strength between the groups. The total volume was 8 efforts per participant.

The present intervention proposal was elaborated according to the concepts presented by Da Silva-Grigoletto et al. [9] and was previously tested by Aragão-Santos et al. [18].

2.4. Statistical Analysis. The sample size was calculated using the G ∗ Power program (Erdfelder, Faul, and Buchner, 1996; Kiel, Germany—version 3.1.9.2) on all variables of the Senior Fitness Test battery from the results obtained by Resende-Neto et al. [19], expecting an average increase of 15% in the performance of the participants. Thus, we considered a power of 0.80 for the performed analyses for the sample size of this study.

Data were tabulated and analyzed using the Statistical Package for Social Sciences (SPSS—version 22) software. Descriptive analysis was used to summarize the general characteristics of the study participants. Data homogeneity was proven from the Levene test. The reproducibility of the functional measures was evaluated from the analysis of the interclass correlation coefficient (ICC) between initial collection and retest, adopting ≥0.85 as an acceptance criterion. For the analyzed variables, ICCs were found between 0.87 and 0.96.

The bidirectional analysis of variance for repeated measures was used to verify the differences between the interventions. When an F-ratio was significant, the Bonferroni post hoc test was used to identify where the significance occurred. The comparison between experimental groups for body composition was assessed by Student's dependent *t* test. All tests were two-tailed, and the effect size (ES) was calculated according to the equation proposed by Cohen [20], as well as the classification of each result.

The minimal clinically important difference (MCID) of each measure, determined after the intervention, was compared to assess whether intragroup changes were

Table 1: Efficacy of functional training (FT) and traditional training (TT) on the body composition of physically active elderly women.

	Moments	TT ⟶ FT ($n = 13$) 65.92 ± 5.88 years		FT ⟶ TT ($n = 19$) 64.84 ± 4.34 years		SG ($n = 16$) 64.19 ± 3.68 years
Body mass index (kg/m^2)	*Baseline*	TT	29.22 ± 6.06	FT	29.57 ± 5.32	25.95 ± 4.68
	Post_12_w		28.89 ± 4.96		28.85 ± 5.74	26.08 ± 4.70
	Post_20_w	FT	28.96 ± 5.27	TT	28.82 ± 5.70	26.45 ± 4.61
	Post_32_w		28.74 ± 5.47		28.87 ± 5.66	26.03 ± 4.69
Fat (%)	*Baseline*	TT	38.61 ± 4.35	FT	38.43 ± 4.45	35.06 ± 5.40
	Post_12_w		37.92 ± 5.58		36.62 ± 4.60	35.63 ± 5.70
	Post_20_w	FT	37.92 ± 5.13	TT	38.15 ± 4.72	37.06 ± 5.50^A
	Post_32_w		37.26 ± 5.05		37.02 ± 5.25	36.00 ± 6.11
Lean mass (kg)	*Baseline*	TT	39.88 ± 7.04	FT	40.17 ± 5.98	39.55 ± 6.40
	Post_12_w		41.27 ± 5.97		41.38 ± 5.99	39.48 ± 6.17
	Post_20_w	FT	41.12 ± 7.40	TT	40.71 ± 6.37	38.30 ± 6.52
	Post_32_w		41.28 ± 7.55		41.74 ± 6.30^A	39.15 ± 6.31
Basal metabolic rate	*Baseline*	TT	1214.00 ± 224.03	FT	1254.01 ± 194.74	1203.31 ± 193.99
	Post_12_w		1252.07 ± 185.92		1260.36 ± 179.30	1200.37 ± 188.02
	Post_20_w	FT	1254.76 ± 226.83	TT	1249.21 ± 201.79	1185.75 ± 201.33
	Post_32_w		1255.76 ± 229.64		1282.05 ± 202.28	1181.06 ± 196.09

Values presented in mean and standard deviation (M ± SD). $^A p \leq 0.05$ vs. baseline. w: weeks. SG: stretching group.

clinically significant. The following MCID values of measures in older adults were retrieved from the literature: 2.53 repetitions for elbow flexion, 3.3 repetitions for sit-to-stand, 1 s for time up go, 27 m for six-minute walk [21].

3. Results

The participant's attendance was 85% (approximately 62 sessions) for TT ⟶ FT, 95% (approximately 68 sessions) for the FT ⟶ TT and SG. Before the exercise intervention, there were no statistically significant differences between the programs in any of the analyzed variables. At the end of the two periods of 12-week training (eight weeks of no training in the middle), no statistically significant differences were observed between the TT ⟶ FT, FT ⟶ TT, and SG programs in the body composition variables (Table 1).

The programs were equally efficient in increasing physical fitness and the quality of movement patterns ($p \leq 0.05$). When compared to SG, both TT ⟶ FT and FT ⟶ TT promoted significant improvements in balance/agility and upper limb strength. When considering TT and FT separately, only FT showed a statistically significant improvement in the strength of the lower limbs, cardiorespiratory capacity, and quality of movement patterns comparing to SG, besides a higher ES in these outcomes compared with TT. However, in the posterior chain flexibility and shoulder mobility, no differences were observed between TT ⟶ FT and FT ⟶ TT compared with SG. Also, there were no statistically significant differences between the programs in any of the evaluation moments in all outcomes analyzed (Table 2).

4. Discussion

This research highlights the efficacy of FT and TT in improving physical fitness for activities daily, regardless of the manipulation of the order of application of interventions. However, when analyzing the methods separately, it seems that the FT can provide greater effects than TT in lower-body strength, cardiorespiratory capacity, and quality of movement patterns.

The multisystemic adaptations evidenced by the FT ⟶ TT and TT ⟶ FT programs can be justified by the combination of different physical exercises in the same training session [22]. The organization of the session in different sets followed recommendations directed to the functionality previously published by our group [23] that besides contemplating different modalities of training in a short period of time (~1 hour) aimed at applying these modalities in a sequence that allows gradual increase of intensity and complexity, respecting the peculiarities of the senile. Thus, there was no stagnation of effects of these training methods during the intervention period.

Although consistent investigations demonstrate the efficiency of the combination of metabolic and neuromuscular stimulation for promoting structural changes such as increased muscle mass and reduced adipose tissue [24, 25], few significant changes in body composition in active older women were observed in this study, and these adaptations may have been limited due to the absence of food control or not observed due to the low sensitivity of the instrumentation. Nevertheless, regarding muscle quality, it is worth noting that the intensity applied may not have been enough to cause clinically relevant improvement, but it was satisfactory to avoid fat gain and loss of muscle mass. Cress et al. [26] confirmed positive adaptations in muscle quality from exercises with systematization similar to the TT and FT interventions, coupled with more accurate evaluation methods.

The instability and the change of direction in the exercises of the FT can stimulate proprioceptive receptors present in the body, which provide better development of synesthetic awareness and postural control and activate stabilizing muscles with more intensity, efficiently

Table 2: Efficacy of functional training (FT) and traditional training (TT) on the physical fitness related to daily activities and the quality of movement patterns of physically active elderly women.

	Moments		TT ⟶ FT ($n = 13$)		FT ⟶ TT ($n = 19$)	SG ($n = 16$)
Sit and reach (cm)	*Baseline*		2.80 ± 6.92		1.76 ± 6.29	2.62 ± 9.83
	Post_12_w	TT	5.84 ± 7.04^{A}	FT	4.71 ± 7.12^{A}	5.21 ± 11.42^{A}
	Δ%—ES		108.57–0.44*		167.61–0.47*	98.85–0.26*
	Post_20_w		6.25 ± 5.78		3.73 ± 7.84	3.50 ± 8.87
	Post_32_w	FT	9.59 ± 5.21^{AC}	TT	6.36 ± 7.70^{AC}	5.96 ± 9.42^{C}
	Δ%—ES		53.44–0.58**		70.51–0.34*	70.29–0.28*
Back scratch (cm)	*Baseline*		-4.36 ± 6.68		-4.60 ± 6.26	-1.04 ± 6.59
	Post_12_w	TT	-2.82 ± 6.29^{A}	FT	-3.48 ± 6.31^{A}	0.08 ± 6.91^{A}
	Δ%—ES		54.61–0.23*		32.18–0.18	107.69–0.17
	Post_20_w		-3.68 ± 6.63		-6.24 ± 6.82^{B}	-0.73 ± 6.96
	Post_32_w	FT	-1.95 ± 6.63^{C}	TT	-4.30 ± 6.70^{C}	1.06 ± 7.09^{C}
	Δ%—ES		47.01–0.26*		31.09–0.28*	245.21–0.26*
Time up go (sec)	*Baseline*		5.11 ± 0.69		5.04 ± 0.54	4.82 ± 0.53
	Post_12_w	TT	$4.57 \pm 0.48^{A+}$	FT	$4.32 \pm 0.36^{A+}$	5.10 ± 0.61
	Δ%—ES		10.57–0.78**		14.29–1.33****	5.81 to −0.53
	Post_20_w		4.59 ± 0.54^{A}		4.65 ± 0.39^{B}	4.71 ± 0.56^{B}
	Post_32_w	FT	$4.19 \pm 0.63^{ABC+}$	TT	$4.21 \pm 0.35^{AC+}$	4.76 ± 0.53^{B}
	Δ%—ES		8.71–0.74**		9.46–1.13***	1.06 to −0.09
Sit-to-stand (rep)	*Baseline*		16.38 ± 3.37		15.68 ± 2.45	15.95 ± 3.19
	Post_12_w	TT	19.00 ± 4.22^{A}	FT	$20.89 \pm 3.19^{A+}$	16.50 ± 2.19
	Δ%—ES		16.00–0.78**		33.23–2.13****	3.45–0.17
	Post_20_w		18.23 ± 2.61		18.26 ± 3.55^{AB}	17.25 ± 2.64
	Post_32_w	FT	$21.61 \pm 3.54^{ABC+}$	TT	$21.00 \pm 4.59^{AC+}$	16.50 ± 2.09
	Δ%—ES		18.41–0.95****		15.01–0.77**	−4.35 to −0.28
Elbow flexion (rep)	*Baseline*		19.92 ± 4.28		19.52 ± 3.68	18.90 ± 3.44
	Post_12_w	TT	$22.73 \pm 4.47^{A+}$	FT	$23.39 \pm 3.57^{A+}$	18.68 ± 3.73
	Δ%—ES		14.11–0.66**		19.83–1.05***	−1.16 to −0.06
	Post_20_w		22.46 ± 2.96^{A}		22.13 ± 3.36^{A}	22.71 ± 3.96^{AB}
	Post_32_w	FT	$27.07 \pm 3.08^{ABC+}$	TT	$25.18 \pm 3.46^{AC+}$	21.67 ± 3.52^{AB}
	Δ%—ES		20.53–1.56****		13.78–0.91***	−4.58 to −0.26
Six-minute walk (m)	*Baseline*		536.93 ± 59.21		551.33 ± 51.30	549.59 ± 51.11
	Post_12_w	TT	563.11 ± 51.47	FT	$590.49 \pm 40.27^{A+}$	548.46 ± 54.79
	Δ%—ES		4.88–0.44*		7.10–0.76**	−0.21 to −0.02
	Post_20_w		553.74 ± 53.17		572.41 ± 44.87	566.73 ± 40.44
	Post_32_w	FT	$587.34 \pm 48.62^{AC+}$	TT	$593.47 \pm 44.08^{AC+}$	541.44 ± 50.66^{C}
	Δ%—ES		6.07–0.63**		3.68–0.47*	−4.46 to −0.63
Functional Movement Screen (points)	*Baseline*		9.38 ± 2.29		9.00 ± 2.64	8.75 ± 2.32
	Post_12_w	TT	10.15 ± 2.30	FT	$12.00 \pm 2.02^{A+}$	9.93 ± 2.54
	Δ%—ES		8.21–0.34*		33.33–1.14***	13.49–0.51**
	Post_20_w		10.23 ± 1.87		9.36 ± 3.13^{B}	9.75 ± 2.95
	Post_32_w	FT	11.53 ± 2.50^{A}	TT	10.78 ± 2.78^{AC}	9.93 ± 3.02
	Δ%—ES		12.71–0.70**		15.17–0.45*	1.85–0.06

Values presented in mean and standard deviation (M ± SD). Post_12: 12 weeks of functional training, post_20: 8 weeks of no training, and post_32: 12 weeks of traditional training. $^{A}p \leq 0.05$ vs. baseline, $^{B}p \leq 0.05$ vs. post_12, $^{C}p \leq 0.05$ vs. post_20, $^{+}p \leq 0.05$ vs. SG, $^{\neq}p \leq 0.05$ vs. TT, and $^{\#}p \leq 0.05$ vs. FT. SG: stretching group. w: weeks. Δ%: percent change. ES: effect size: *small: 0.2; **median: 0.5; ***large: 0.8; ****very large: >1.3.

developing the agility and balance [27, 28]. However, also with exercise, we performed the maximum concentric speed in set two, TT causes important adaptations in muscle power [29], which is a component strongly associated with dynamic balance and postural oscillation [30]. Thus, the integration of these methods may be the most effective strategy in reducing the incidence of falls and greater independence in the activities of daily living in the older women.

The integrative results of this article show similar answers of the methods regarding strength, corroborated by Cadore et al. [31] who found significant increases in muscle power, maximum dynamic and isometric strength, from the combination of strength, balance and gait exercises. The benefits of strength training, especially TT in muscle strength, are clearly evidenced in the scientific community [32]. In contrast, TF seems to act by promoting an integrated action of body structures in order to promote important neuromuscular adjustments, which result in increased strength for the performance of daily activities. In this study, these adaptations even in greater effect size than TT could be explained by the neuromuscular and metabolic specificity to the *sit-to-stand* test but also due to the greater muscular activation [33] and better functional performance [34] of exercises performed with free weights when compared with exercises performed in machines.

Concerning the cardiorespiratory capacity, it seems that the metabolic characteristic of the high-intensity interval exercises (4th set), together with the circuitry and intermittent nature present in sets main of the FT (2nd and 3rd), can promote changes in the mechanisms responsible for oxygen transport and utilization, such as increased cardiac output, mitochondrial density, and activity of oxidative enzymes [35–38], which could explain the adaptations superior to TT and SG. Corroborating this finding, Whitehurst et al. [38] also observed an increase of 7.4% in cardiorespiratory endurance after 12 weeks of functional training in circuit. It is also worth mentioning that the walking performed (2nd set) by the TT was low speed, not corresponding to the speed with change of direction, required by the six-minute walking test.

Considering our results, we can affirm that the improvement of the quality of movement patterns in physically active older women seems to benefit from dynamic exercises, with greater motor complexity, specific to everyday tasks. However, Pacheco et al. [13], comparing these intervention proposals in adults and elderly physically active, did not find significant differences between methods FT and TT, also evaluated by the Functional Movement Screen, maybe due to the low intensity and complexity of the exercises applied in their intervention proposals.

In this study, the programs used were equally efficient in improving flexibility, and this adaptation could be related with the mobility exercises performed in the first set of the interventions and the accomplishment of multiarticular exercises in large amplitudes [39]. In this perspective, Correia et al. [40] state that strength training promotes important increases in range of motion through mechanisms such as reduction of joint stiffness and increased muscle elasticity in the elderly women.

Another important aspect supporting the need for integration between these two training proposals is that the older women who practiced traditional machine exercises also showed a significant increase compared with the initial values in most of the tests, suggesting that multicomponent training, with similar actions to daily activities performed at maximum concentric speed, is capable of promoting the improvement in the functionality of elderly women. In other words, the greater control in the training along with the possibility of adding external load provided by the traditional devices is also translated in improving the physical function of the older adult, as evidenced in the scientific community [25].

This investigation is focused on comparing the adaptive responses to training protocols aimed at improving functional performance in older women and presented two safe, effective, easily reproducible, and practical application methods. Despite providing important information, we recommend future studies to apply longer interventions, with a 6-month transition period between the different methods for effective washout of adaptations. We also suggest analyzing the levels of habitual physical activity and the standard food ingestion for better isolation of these intervening factors. In addition, some limitations should be taken into account when interpreting the present results: First, the small sample size and the losses to follow-up. However, losses were minimal and not expected to change the overall results. Second, the participants in our study were physically able to participate in a physical training program of high volume and intensity and thus may not be fully representative of the general older adult population.

5. Conclusion

Strength training programs were equally effective in improving the determinants of physical fitness and movement patterns in physically active older women, and therefore, they may be complementary to combat some of the deleterious effects of senescence. However, it appears that FT is a better option for starting health promotion programs because it provides faster adaptations and in some cases greater magnitude than TT. It is important to point out that the resistance training intervention used in the present study was designed to stimulate the different systems that promote health benefits in older people. We focused on improving the components of physical fitness and specific exercises for the daily activities, as well as providing the adequate dose of exercise against the possibilities of response to the stimulus and guarantee of optimal adaptations, respecting criteria of safety, efficacy, and functionality.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

AGRN, JCAS, BCOA, ABSV, and CAS participated in data collection, performed statistical analysis, and processed and drafted original manuscript. FJA, ELC, JMS, and MESG assisted in data interpretation and in revising the manuscript. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

Acknowledgments

The authors would like to thank the Functional Training Group (FTG by UFS) from Department of Physical Education of Federal University of Sergipe for technical and methodological support; the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES); and Conselho Nacional de Pesquisa e Desenvolvimento Científico (CNPq). AGRN was a recipient of scholarship from CAPES.

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Hindawi
Journal of Aging Research
Volume 2019, Article ID 1959486, 7 pages
https://doi.org/10.1155/2019/1959486

Review Article

Effects of Physical Exercise Programs on Sarcopenia Management, Dynapenia, and Physical Performance in the Elderly: A Systematic Review of Randomized Clinical Trials

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Received 26 July 2019; Accepted 10 October 2019; Published 20 November 2019

Guest Editor: Priscila Sampaio

Introduction. Sarcopenia is a prevalent condition in the elderly population, imposing a significant impact over their functional ability as well as their quality of life. Furthermore, it is associated with greater incidence of major geriatric outcomes, as reduced mobility, falls, loss of independence, cognitive impairment, and all-cause mortality. Physical Exercise Programs directed to improve muscle mass and its function may be key to reduce sarcopenia consequences. However, a significant heterogeneity is found in clinical trials, especially as a consequence of different exercise protocols applied to research subjects. *Objectives*. To access the effects of physical exercise programs compared to no exercise interventions to improve sarcopenia components and its determinants in sarcopenic elder individuals. *Methods*. A systematic review was conducted in the Pubmed database to identify randomized clinical trials (RCTs) which tested the effects of physical exercise programs to manage sarcopenia components in sarcopenic elder individuals. Two independent reviewers assessed the studies' eligibility according to specified inclusion criteria in a four-step strategy. Data regarding population characteristics, muscle mass, muscle quality, muscle strength, and muscle function were extracted from each one of the included studies. Assessment of quality and individual studies risk of bias were assessed through Cochrane Risk of Bias Tool®. Assuming theoretical expected heterogeneity among studies, especially regarding different physical exercise programs and different outcome measurements, authors decided to be conservative and present study results in descriptive tables. *Results*. Search strategy retrieved 298 papers on PubMed database. Three more were identified through manual search, being 301 studies revised for inclusion. 278 were excluded during title/abstract review. After further evaluation of 23 full-texts, 5 RCTs were included. All 5 trials tested the efficacy of isolated exercise programs to improve sarcopenia components in the elderly compared to no physical intervention. Resistance training was the main intervention component in all included trials compared to inactive control groups (health education mainly). Physical training improved muscle strength, muscle quality, and muscle function compared to inactive control groups. Considering muscle mass, no differences were demonstrated. Data meta-analysis was not possible to be performed due to high heterogeneity among trials and small number of studies for each outcome comparison. *Conclusion*. Heterogeneity among trials and small number of RCTs limited robust conclusions and data meta-analysis. However, resistance training protocols can improve muscle strength and physical performance in elders previously diagnosed with sarcopenia, although its effect size and clinical impact are barely relevant.

1. Introduction

According to the European Working Group on Sarcopenia in older people revised consensus, sarcopenia is a skeletal muscle disorder in which muscle strength is the key feature of a clinical condition with increased risk for major geriatric outcomes [1]. It is a prevalent condition in the elderly, varying according to age-related variables especially when different clinical settings where compared. In community-dwelling samples, a wide prevalence range was found from 1% to 29%; and in long-term care facilities, the range is 14–33% [2]. However, it is presumed that this heterogeneity would be also explained by different applied diagnostic criteria.

It is postulated that physical exercise programs can shift sarcopenia clinical course. A systematic review was conducted in 2014, and the authors concluded that physical exercise has an impact on improving muscle strength and physical performance; however, interventions did not significantly improved muscle mass. Several limitations were pointed out to explain the low impact of exercise interventions: lack of standardization of exercise protocols, low duration of interventions, heterogeneity in outcome measurements, and selection bias due to heterogeneous eligibility criteria.

Most recently, in 2017, the last published systematic review regarding exercise and sarcopenia showed better physical performance after resistance training exercise intervention, but no improvement in muscle strength [3]. Beyond physical exercise impact on physical performance and muscle strength and mass, it is important to access its effects on reducing major geriatric outcomes. Guerreiro et al. demonstrated that both muscle mass estimated by bedside ultrasound and muscle performance and strength in hospitalized elderly patients are important predictors for functional decline, rehospitalization, and death [4]. However, most clinical trials testing physical exercise in sarcopenic elder patients yet do not access its effects over major clinical geriatric outcomes.

Considering the aforementioned reasons, the main objective of this systematic review is to analyze the effectiveness of physical exercise on improving sarcopenia in older populations. Muscle mass, muscle function, muscle strength, and physical resistance improvement in the elderly will be investigated. Furthermore, we will show these effects on the incidence of major geriatric outcomes.

1.1. Methods. This systematic review protocol followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations [5].

1.2. Design: Systematic Review of Randomized Clinical Trials (RCTs)

1.2.1. Eligibility Criteria. RCT testing effects of physical exercise programs were compared to those of a physically inactive control group on sarcopenia clinical variables in elderly populations previously diagnosed with sarcopenia. The eligible criteria are predefined by the characteristics of the primary studies. At this point, it is only necessary to define the following criteria: the target population, the intervention, and the outcomes. Characteristics of the included study populations, such as intervention types and outcome measure, are presented in Table 1.

Population: elderly (>65 years) with diagnosed sarcopenia; intervention and control: physical exercise programs compared to a control group (no exercise); outcomes: sarcopenia, muscle mass, muscle strength, physical performance, and muscle quality; length of follow-up: not specified; study design: randomized clinical trial. There was no limitation of gender. The types of exercises were predominantly resistance training (Table 1).

1.2.2. Search Strategy. A systematic search was conducted in the PubMed electronic articles database using the following strategy: (((Sarcopenia) AND (Elderly)) AND ((Physical activity) OR (Exercise)) AND (Clinical trial)). No specific date limit was defined; no language limitation was imposed; all available studies were included. Last search was conducted on June 30th, 2019. For those articles with limited access or incomplete data, the authors were contacted directly by email. Additional manual search was performed to increase search sensitivity.

(1) Study Selection and Data Collection Process. Step 1: two independent reviewers assessed all titles and abstracts to verify eligibility criteria on Revision. Step 2 included a full-text revision for further eligibility assessment. Step 3: duplicates were excluded. Final inclusion results are presented in the systematic review inclusion flowchart (Figure 1). A standardized Microsoft Office ExcelTM spreadsheet was used to organize independent data collection. Investigators followed a step by step extraction process according to the PICOTS prespecified strategy, extracting study´s population data, followed by intervention description, outcomes variables collection, and its main results.

Quality and individual studies risk of bias were assessed through Cochrane Risk of Bias Tool® [11] and are presented in Table 1.

2. Data Analysis

Assuming theoretical expected heterogeneity among studies, especially regarding different physical exercise programs and different outcome measurements, authors decided to be conservative and present study results in descriptive tables. We assumed that lack of studies' exercise protocols standardization as well as lack of outcomes measurement standardization limits data meta-analysis as theoretical homogeneity assumption is not reached.

Publication bias was also assessed by trim and fill strategy. Analyses were performed using the software Comprehensive Meta-AnalysisTM version 3—free trial [12].

Table 1: Basic characteristics of included randomized controlled clinical trials.

Reference	Population	Design	Intervention	Control	Outcome measurement and definition	Main results
Strasser et al. [6] Moderate RoB*	33 women and men (82.4 ± 6.0 years) with impaired health status (mostly sarcopenic)	RCT	Resistance training (RT): 12 weeks elastic band resistance training ($n = 16$)	Control group (CG) ($n = 17$)	Measured by DEXA Skeletal muscle mass: apendicuar lean mass (ALM in kg) Muscle quality: isokinetic force measurement of knee flexion and extension (Nm/kg)	Muscle mass: apendicular lean mass: no significant differences between groups Muscle quality (Nm/kg) Baseline 6 months Extension force RT: 10.1 ± 2.9 12.1 ± 2.6 CG: 11.5 ± 2.5 9.9 ± 3.0 $P = 0.006$ Flexion force (MQ) RT: 5.2 ± 1.4 6.8 ± 1.0 CG: 5.7 ± 1.5 5.5 ± 1.5 $P = 0.009$
Liao et al. [7] High RoB*	56 sarcopenic or obese women (mean ± SD age 67.3 ± 5.1 years)	RCT	Resistance training (RT): 12 weeks of elastic band resistance training (ERT) ($n = 33$)	Control group (CG) matched by age ($n = 23$)	Measured by DEXA Muscle mass—apendicular lean Mass (ALM in kg) Muscle quality (MQ) after lower limb muscle flexion (kg/kg) Physical capacity and function outcomes Timed Up and Go (TUG in s); gait speed (GS in m/s) Quality of life (qol measured by SF-36)	Results presented as mean differences between groups (RT-CG) Muscle mass (kg) ALM: 0.99 (0.33, 1.66) $P < 0.01$ Muscle quality (N/kg) MQ-LE: 1.82 (1.25, 2.39) $P < 0.01$ Function TUG: −1.64 (−2.34, −0.95) $P < 0.01$ GS: 0.14 (0.33, 0.25) $P < 0.05$ QoL SF-36: 13.62 (6.47, 20.76) $P < 0.001$
Kim et al.[8] Moderate RoB*	139 sarcopenic elderly women; 69 randomized to resistance training or control group	RCT	Resistance training (RT): 12 weeks elastic band for upper limbs and ankle weight for lower limb training ($n = 35$)	Control group (CG) Health education ($n = 34$)	Measured by bioeletrical impedance analysis (BIA) Apendicular skeletal muscle mass (kg) Performance TUG; GS; grip strength	No differences in muscle mass, strength, and function were observed after intervention
Kim et al.[9] Moderate RoB*	138 sarcopenic elderly women; 64 randomized to resistance training or control group	RCT	Resistance training (RT): 12 weeks elastic band for upper limbs and ankle weight for lower limb training. ($n = 32$)	Control group (CG): health education ($n = 32$)	Measured by bioeletrical impedance analysis (BIA) Apendicular skeletal muscle mass (kg) Performance TUG; GS; grip strength	Apendicular muscle mass: no difference Performance Grip strength: no difference GS and TUG: no relevant differences found

Table 1: Continued.

Reference	Population	Design	Intervention	Control	Outcome measurement and definition	Main results
Kim et al.[10] Moderate RoB*	155 sarcopenic elderly women; 78 randomized to exercise group or control group	RCT	Exercise group (EG): 12 weeks combined training—warm up; strengthening exercise, balance and gait training, and cool down. ($n = 39$)	Control group (CG): health education ($n = 39$)	Measured by bioeletrical impedance analysis (BIA) Apendicular skeletal muscle mass (kg) Performance Walking speed, knee extension strength (Nm/kg)	Apendicular muscle mass: no difference Walking speed (m/s) Baseline 6 months EG: 1.31 ± 0.24 1.50 ± 0.23 $P = 0.007$ CG: 1.19 ± 0.21 1.22 ± 0.23 Strength: no difference

RCT = randomized clinical trial; RoB: risk of bias; *in accordance with Cochrane's risk of bias tool.

2.1. Results. A total number of 298 studies were retrieved by search strategy application on PubMed database. Three more studies were found in a previous meta-analysis and included in the next step [3]. 278 studies were excluded in the Step 1 reviewing process. In Step 2, 23 full-text articles were reviewed for further eligibility evaluation and 18 were excluded. The reasons for the exclusion of these studies are described in the flowchart of Figure 1. Finally, 5 randomized clinical trials were included in this present systematic review as described in the inclusion flowchart (Figure 1).

Table 1 presents study details regarding population, study design, interventions, control groups, outcome measurements, and main results [6–10].

All five studies have high to moderate risk of bias according to Cochrane's risk of bias tool. In three studies conducted by Kim et al., direct comparison of physical training against inactive control is only possible in a study subsample composed by two different intervention groups (exercise versus health education groups).

Different measurement protocols were applied to assess outcomes among studies. In two studies—Strasser et al. [6] and Liao et al. [7]—dual-energy X-ray absorptiometry was used to measure muscle mass as well as muscle quality. All studies conducted by Kim et al. [8–10] measured these variables using bioelectrical impedance analysis.

2.2. Main Results

2.2.1. Muscle Mass, Muscle Quality, Strength, and Function. Results regarding muscle mass, muscle strength, and muscle quality are summarized in Table 2. Muscle mass was only significantly improved in the RCT conducted by Liao et al. [7] Sarcopenic elder patients submitted to 12 weeks intervention of resistance training (RT) gained almost 1 kg of appendicular muscle mass (AMM) compared to the control group. All other 4 studies did not show muscle mass differences compared to control. However, when muscle quality was analyzed, significant results were found by both Strasser et al. [6] and Liao et al. [7]. Kim et al. did not access the muscle quality in neither 3 studies. Muscle strength was not improved after RT intervention.

RT exercise protocols significantly improved the muscle function measured by gait speed (GS) as well as by the Timed Up and Go test (TUG) in 3 of 5 studies as described in Table 3. Kim et al. [8, 9] did not evidence the muscle function improvement after RT.

In [7], quality of life was accessed before and after exercise interventions and it was possible to show significant improvement in QoL in the RT group when compared to control (mean difference 13.62 (6.47, 20.76); $P < 0.001$), especially a relevant difference in the physical component of the SF-36 questionnaire.

3. Discussion

In this systematic review to assess the effectiveness of exercise training to improve sarcopenia-related outcomes in sarcopenic elder populations, a sensitive search strategy retrieved 301 studies on PubMed database. During the first step review process, 278 papers were excluded and 23 more were excluded after full-paper review, leading to 5 RCTs to be included in this study.

RCTs results according to sarcopenia component varied significantly. Only one study evidenced muscle mass gain; muscle quality, on the other hand, was improved in both studies that this factor was measured. Although effects over muscle strength and muscle mass were not clear, muscle function—walking speed and Timed Up and Go test—was homogeneously improved among studies, but the size effect seems to be limited.

However, it is presumed that resistance training prevents muscle mass wasting because it stimulates muscle hypertrophy and increases muscle strength, as postulated by Johnston et al. [13], and also it is postulated that resistance training is a key strategy to treat sarcopenia; only one clinical trial [7] evidenced improvement of muscle mass after a physical exercise protocol was applied in elder individuals previously diagnosed with sarcopenia. One possible explanation resides in lack of power to detect significant differences in the other 4 trials, as sample sizes are quite small. Another reason is the duration of resistance training protocols, especially exercise *volume of training*—defined as the total work sets per exercise session. Peterson et al. demonstrated that the greater the volume training the greater the

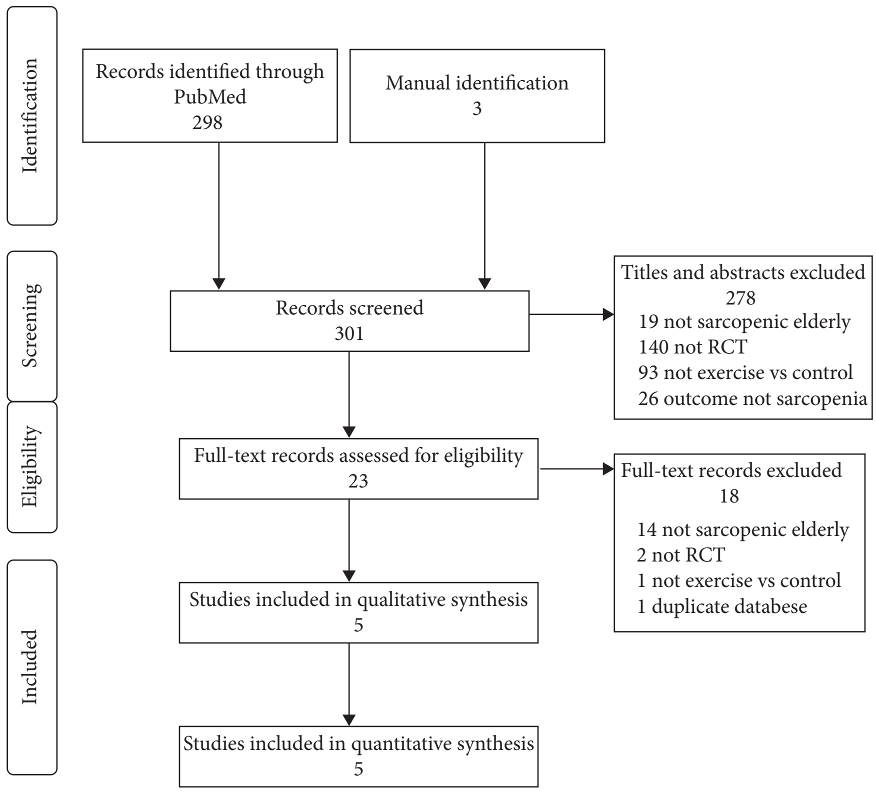

Figure 1: Flowchart of records retrieved, screened, and included.

muscle mass gain [14]. Furthermore, they showed a significant effect attenuation of physical interventions according to aging, one possible strong explanation for lack of exercise training effect.

In comparison with previous systematic reviews that evaluated the effect of physical exercises over sarcopenia components, published in 2014 [2] and 2017 [3], this present review included only RCTs in which physical training protocols alone were compared to control groups to improve muscle associated outcomes in previously diagnosed sarcopenic elderly. Cruz-Jentoft et al. included trials testing the aforementioned interventions in different clinical scenarios, as in frail participants, community-dwelling elderly, and in postoperative hip-replacement therapy patients. Regardless of methodological differences between Cruz-Jentoft and this review, results are similar, i.e., no robust effects were demonstrated in most included RCTs. The present search strategy has resemblance to those used in Yoshimura et al.'s systematic review [3]. Although they tried to meta-analyze data to show summary effects for several dependent variables, most forest plots are provided in less than 3 studies, in discordance with meta-analysis guides recommendations. Theoretically, only 2 studies are needed to perform a meta-analysis, but it may carry several important biases as well as statistical inferences especially when random effect models are chosen; the number of studies matters, according to Guolo and Varin [15]. Besides that, it is possible to point a significant difference in the Yoshimura et al. study: two more studies were added to the state of the art regarding physical activity to manage sarcopenia in the elderly—Strasser et al. [6] and Liao et al. [7] Both studies have more robust methodology than those already included in the Yoshimura review. Its results were also more consistent, showing significant improvement in both muscle mass and muscle quality. Furthermore, these both recent RCTs evidenced improvements in muscle function in sarcopenic elderly submitted to a resistance training protocol, allowing to hypothesize that exercises may have relevant impact over major geriatric outcomes as falls, immobility, and dependence. Moreover, Liao et al. showed better results in quality of life scores in those randomized to physical exercise.

The authors decided not to run data meta-analysis to identify a single summary effect for each dependent variable as a significant heterogeneity among studies was assumed, especially regarding intervention protocols and measurement of sarcopenia components. Also noteworthy is the small sample sizes included in the clinical trials, imputing worrisome power limitations to detect significant outcome differences. All 5 studies have moderate to high risk of bias in accordance with the Cochrane risk of bias tool. Assuming these aforementioned limitations in conjunction with small number of available RCTs, it is not recommended to run data meta-analysis due to high risk of bias as meta-analysis will directly reflect the study biases. Additionally, as described by Borenstein et al. [16], it is very important to avoid "*mixing apples and oranges,*" referring to misplaced comparisons by data meta-analysis from theoretically heterogeneous studies, the specific case found in this systematic review.

Table 2: Muscle mass, strength, and muscle quality mean differences between groups.

	Muscle mass (kg)					Muscle strength					Muscle quality				
	Baseline		After exercise		Mean difference	Baseline		After exercise		Mean difference	Baseline		After exercise		Mean difference
Study	I	C	I	C		I	C	I	C		I	C	I	C	
Strasser et al. [6]	$^{*}17.8$	$^{*}17.7$	$^{*}18.3$	$^{*}18.2$	I: 0.5 C: 0.5	NA	NA	NA	NA	NA	$^{\&}10.1$	$^{\&}11.5$	$^{\&}12.1$	$^{\&}9.9$	I: 2.0
Liao et al. [7]	$^{**}36.5$	$^{**}37.0$	$^{**}36.8$	$^{**}36.5$	I: 0.28 C: −0.44	$^{\#}13.6$	$^{\#}15.26$	$^{\#}21.17$	$^{\#}13.59$	I: 7.57 C: −1.67	$^{£}2.47$	$^{£}2.95$	$^{£}4.07$	$^{£}2.49$	I: 1.6
Kim et al.[8]	$^{*}15.79$	$^{*}16.86$	$^{*}13.0$	$^{*}12.9$	I: −2.79 C: −3.9 6	181.3	197.5	202.7	204.1	I: 21.4 C: 6.6	NA	NA	NA	NA	NA
Kim et al. [9]	$^{*}14.79$	$^{*}13.96$	$^{*}14.45$	$^{*}14.11$	I: 1.23 C: −0.34	$^{\$}51.39$	$^{\$}47.54$	$^{\$}49.73$	$^{\$}43.13$	I: −1.66 C: −4.41	NA	NA	NA	NA	NA
Kim et al. [10]	$^{*}13.9$	$^{*}13.57$	$^{*}14.19$	$^{*}13.67$	I: 0.29 C: 0.1	$^{\&}1.12$	$^{\&}1.14$	$^{\&}1.14$	$^{\&}1.0$	I: 0.02 C: −0.14	NA	NA	NA	NA	NA

I: intervention; C: control; NA not available; $^{\#}$N: Newton; $^{\$}$Nm: Newton meter; $^{\&}$Nm/kg: Newton meter/kilogram; $^{£}$N/kg" Newton/kilogram; *ASM: appendicular skeletal muscle mass; **FFM: fat free mass.

Table 3: Muscle function mean differences between groups.

	Walking speed					TUG*				
	Baseline		After exercise		Mean difference	Baseline		After exercise		Mean difference
Study	I	C	I	C		I	C	I	C	
Liao et al. [7]	1.51	1.16	1.53	1.14	I: 0.02 C: −0.02	8.4	9.51	7.08	9.45	I: 7.57 C: −1.67
Kim et al. [8]	1.1	1.1	1.3	1.2	I: 0.2 C: 0.1	NA	NA	NA	NA	NA
Kim et al. [9]	1.26	1.27	1.36	1.26	I: 0.1 C: −0.01	8.81	8.43	7.03	8.88	I: −1.66 C: −4.41
Kim et al. [10]	1.31	1.19	1.5	1.22	I: 0.19 C: 0.03	NA	NA	NA	NA	NA

I: intervention; C: control; NA: not available; TUG: Timed Up and Go test; *walking speed in m/s (meters/second); TUG in s (seconds).

4. Conclusions

Heterogeneity among trials and small number of RCTs limited robust conclusions and data meta-analysis. However, resistance training protocols can improve muscle strength and physical performance in elders previously diagnosed with sarcopenia, although its effect size and clinical impact are barely relevant. Two trials were published since last available systematic review, both of it showing positive results of resistance training protocols over muscle quality and muscle function as well as better results in quality of life scores.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
Journal of Aging Research
Volume 2019, Article ID 7516939, 9 pages
https://doi.org/10.1155/2019/7516939

Clinical Study

Exercise Snacking to Improve Muscle Function in Healthy Older Adults: A Pilot Study

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Received 20 June 2019; Revised 30 August 2019; Accepted 10 September 2019; Published 3 October 2019

Guest Editor: Marco C. Uchida

Loss of muscle mass and strength are seemingly accepted as part of the ageing process, despite ultimately leading to the loss of independence. Resistance exercise is considered to be primary defence against loss of muscle function in older age, but it typically requires access to exercise equipment often in a gym environment. This pilot study aimed at examining the effect of a 28-day, unsupervised home-based exercise intervention on indices of leg strength and muscle size in healthy older adults. Twenty participants were randomly assigned to either maintain their habitual physical activity levels (Control; $n = 10$; age, 74 (5) years; body mass, 26.3 (3.5) kg/m^2) or undertake "exercise snacks" twice daily (ES; $n = 10$; age, 70 (4) years; body mass, 25.0 (3.4) kg/m^2). Both groups consumed 150 g of yogurt at their breakfast meal for the duration of the intervention. Sixty-second sit-to-stand score improved by 31% in ES, with no change in Control ($p < 0.01$). Large effect sizes were observed for the difference in change scores between the groups for interpolated maximum leg pressing power (6% increase in ES) and thigh muscle cross-sectional area (2% increase in ES). The present pilot data suggest that exercise snacking might be a promising strategy to improve leg muscle function and size in older adults and that further investigation into zero-cost exercise strategies that allow high frequency of training is warranted.

1. Introduction

Frailty is underpinned by a progressive loss of muscle mass and strength, particularly from the lower limbs, and is associated with increased risk of falls and reduced quality of life [1, 2]. There is a minimum threshold of strength required to complete tasks of daily living independently, and finding means to delay individuals reaching this "frailty threshold" has been identified as an urgent health care priority [3]. With muscle mass lost at 0.5–1% per year after 50 years of age [4] and strength lost even more rapidly [5], modest improvements of a few percent in muscle size and strength from a training programme may, in essence, represent postponement of frailty measurable in years. Crucially, intervention is needed before older adults' functional capacity declines past the point that exercise is no longer a safe means to maintain muscle strength.

Progressive resistance exercise training improves muscle strength in older adults, and it is accompanied by multifaceted improvements in health and function [6, 7]. Traditionally, heavy load resistance training has been regarded as the most effective strategy to increase muscle strength, due to associated neural and hypertrophic adaptations [8, 9]. Recent evidence suggests that low-load resistance training can also be efficacious in increasing muscle strength, particularly in an untrained population, albeit to a lesser degree in comparison to high-load resistance training [10, 11]. Training with low loads and low overall session volume may allow for increased training frequency, as recovery times may be shorter between sessions [12]. Dankel et al. [13] suggests that manipulation of training frequency to maintain overall training volume with more sessions of lower load across a week may even increase hypertrophic training responses. Although this has not yet been borne out empirically [8], it is intuitively appealing to reason that a reduced training session load with short recovery times may suit an older population previously doing no formal exercise because it may overcome some of the barriers to starting an exercise programme [14].

Short bouts of exercise spread across the day, termed "exercise snacks," have received attention as a time-efficient exercise strategy. Francois et al. [15] identified that exercise snacking before each meal, consisting of six discrete minutes of exercise separated by one minute of rest, improved glycaemic control the following day in middle-aged adults with impaired glucose handling. Jenkins et al. [16] reported improvements in cardiorespiratory fitness in healthy inactive adults performing three sets of maximum effort 60-step stair climbs a day, three times a week, for six weeks. The improvement in exercise tolerance included an increase in maximum power output during a VO_2 peak test on a cycle ergometer [16]. This suggests that an exercise snacking model may have the potential to improve function beyond just cardiovascular fitness. As such, exercise snacking was examined in the present pilot study with the aim of providing a stimulus to improve leg strength in older adults that could be undertaken in the home on a daily basis without the need for supervision.

The primary aim of the present pilot study was to investigate the effects of four weeks of twice daily "exercise snacking" on maximum number of sit-to-stands from a chair performed in one minute, compared with a control group maintaining their habitual physical activity patterns. The secondary aims were to assess adherence to the exercise snacking intervention, along with the effects on force, velocity, and power, during leg press dynamometry and on whole-body and lower limb anthropometry. The proposed intervention was specifically designed to be suitable to perform in the home environment, without the need for supervision or specific exercise equipment. The overall objective of this pilot study was to inform future work on exercise strategies extending to populations with lifestyle-compromising age-related loss of muscle strength or mass.

2. Materials and Methods

A two-group experimental research design was used in this pilot study to examine the effects of twice daily "exercise snacking" on muscle function and size in healthy, community-dwelling older adults. For 28 days, one group undertook a home-based exercise snacking intervention (ES) and the other group acted as a nonexercising control by maintaining habitual physical activity levels. As a control variable, both groups were provided with 150 g of yogurt to consume as part of their breakfast meal for the 28 days, to both act as a "positive control" to reduce participant dropout from the Control group and to achieve optimal dietary protein intake [17]. All participants completed two familiarisation sessions to functional measures used in the pre- and postintervention assessment, separated by at least seven days, with the second session completed at least five days before the preintervention assessments. Function testing and imaging measures were completed on the day before and the day after the 28-day intervention. Between familiarisation sessions and during the last week of the intervention, physical activity and diet were assessed. See Figure 1 for a schematic overview of the pilot study timeline.

2.1. Participants. Twenty healthy, community-dwelling, older men and women (65–80 years), not undertaking regular structured exercise, were recruited for the pilot study through local newspaper advertisement and social media. Individuals who were nonsmokers, had BMI of $\geq 20 < 30\,\text{kg/m}^2$, had no contraindications to exercise or recent history of musculoskeletal injury, and had scored 8 or above with no score of zero on any test of the SPPB [18] at the initial screening were invited to take part in the pilot study. Participants were assigned to groups by way of minimisation to limit differences in mean age, BMI, and 60-second sit-to-stand (STS) score at the screening visit, on account of the small sample size [19, 20]. An individual outside of the study team performed participant group allocation. Participant characteristics recorded during screening are presented in Table 1. All participants provided written informed consent. The protocol was approved by the National Health Service (NHS) South West—Frenchay Research Ethics Committee (Ref: 16/SW/0300) and registered on ClinicalTrials.gov (Identifier: NCT02991989).

3. Measures

3.1. Imaging. Participants arrived at the laboratory for trial days following a 10-hour overnight fast, having drunk 1 pint of water, and having not undertaken exhaustive exercise in the previous 24 hours. Participants were asked to void before weight was measured with electronic scales (BC543, Tanita, Amsterdam, Netherlands). Whole-body composition, whole-body lean mass, and leg lean mass were estimated using a DXA system (QDR software version 12.4.2, Hologic Discovery W, Bedford, MA) by differentiating the fat, bone, and lean (nonbone nonfat) masses. A spine phantom was used for the quality control scan performed at the start of every trial day before participant testing, as per the manufacturer's guidelines. Participants wore the same light clothes for pre- and postintervention trials and removed all metal items. The investigator positioned the participant to be laying supine on the scanning bed such that body regions could be partitioned upon analysis. Manual placement of boundaries between discrete anatomical regions was conducted for all scans by the same investigator (OJP), before analysis using manufacturer's software.

Lower limb (calf and thigh) muscle cross-sectional area (mCSA) was assessed by peripheral quantitative computed tomography (pQCT; XCT3000, StraTec Medizintechnik GmbH, Pforzheim, Germany). During the preintervention trial, tibia (medial knee joint line to medial malleolus) and femur length (greater trochanter to lateral knee joint line) of the dominant leg were measured using a fabric tape measure whilst participants were standing. Scans were performed with the participant laying supine on a bed with leg placed through the scanning gantry and foot strapped into a footplate. Scout scans were performed at the distal ends of

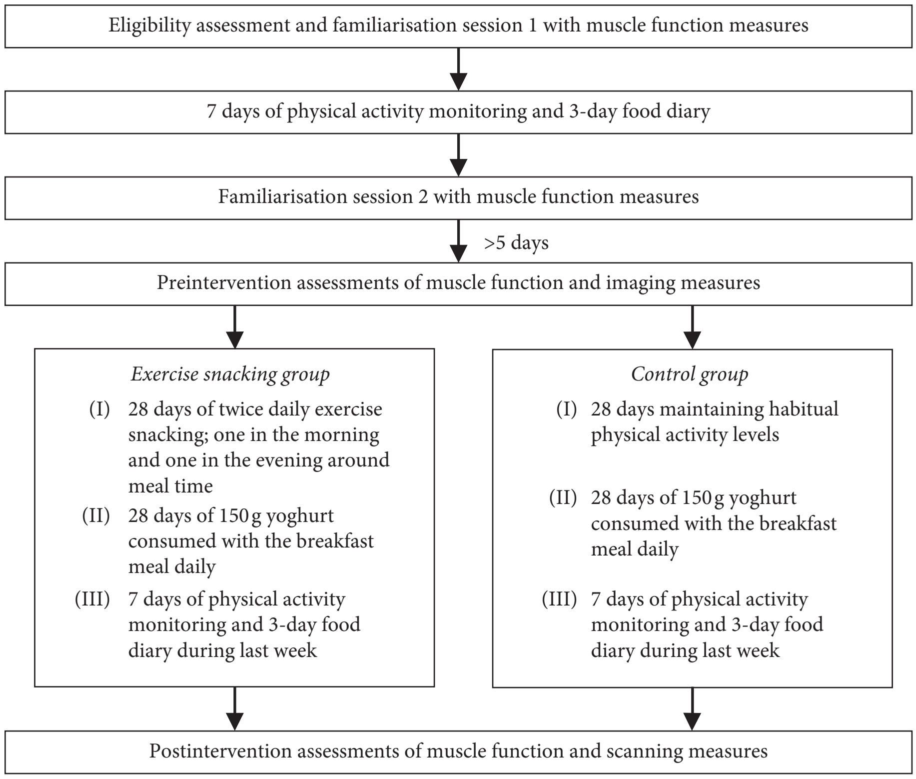

Figure 1: A schematic overview of the pilot study timeline.

Table 1: Participant characteristics at screening.

	Control ($n = 10$; ♀ = 7)	ES ($n = 10$; ♀ = 7)
Age (years)	74 (5)	70 (4)
Body mass (kg)	70.9 (11.9)	69.7 (9.9)
BMI (kg/m^2)	26.3 (3.5)	25.0 (3.4)
SPPB score	11 (1)	12 (1)
STS score at screening	29 (12)	29 (10)
PAL at screening	1.63 (0.19)	1.70 (0.14)

Data are presented as mean (standard deviation). ES: exercise-snacking group; BMI: body mass index; SPPB: short physical performance battery; STS: 60-second sit-to-stand test; PAL: physical activity level (ratio of total energy expenditure to basal metabolic rate).

the tibia and femur to locate the end of bones, respectively. Single 2D slice scans were performed at 66% of the tibia length proximally from the medial malleolus, and 25% of the femur length proximally to the lateral femoral epicondyle, based on the bone lengths previously recorded. Scan images were analysed using the BoneJ plugin (Version 1.4.2) for ImageJ (1.44p, Wayne Rasband, National Institutes of Health, USA) [21, 22]. Following scanning measures, participants were provided with a breakfast of their choice, which was matched on the postintervention trial day.

3.2. Functional Measures. A maximum number of repeated STS in 60 seconds were performed from a chair with a seat height of 44 cm, with arms folded across the chest and reaching full hip and knee extension on standing. During familiarisation, a researcher counted the number of repetitions aloud, with a timing clock in view of the participant. On trial days, participants were not in view of a clock and repetitions were not counted aloud, with participants instructed to complete repetitions at the fastest rate they could manage until told to stop. Immediately on completion of the STS, a rating of perceived exertion (RPE) was assessed using Borg's RPE 15-grade scale [23].

Maximum leg pressing velocity, force, and power characteristics were measured on a seated pneumatic leg press dynamometer (A420, Keiser®, Fresno, CA). Data collection, processing, and analysis were performed as described previously [24]. Briefly, during familiarisation sessions, participants completed tests of one-repetition maximum (1-RM) leg pressing force against self-selected increments in resistance. No emphasis was placed on contraction velocity for the 1-RM test, and participants were instructed to reach 1-RM within 15 repetitions with self-selected interrepetition rest. Participants then performed a series of approximately 10 discrete repetitions, each performed at maximum concentric contraction velocity against an incrementally increasing pedal resistance, up to a resistance equalling the previously achieved 1-RM. On trial days, a set warm-up was performed based on the 1-RM achieved in the second familiarisation, consisting of 5 × 30%-1RM, 5 × 50%-1RM, 2 × 70%-1RM, and 1 × 80%-1RM, followed by five minutes of seated rest. The aforementioned incremental test was then performed, with the tenth repetition at a resistance equal to the 1-RM achieved in the second familiarisation. To extrapolate theoretical maximum contraction velocity (V_{max}) and force (F_{max}), linear regression of force and velocity at which peak power of each repetition occurred was calculated. Interpolated peak power (P_{max}) was determined by numerical differentiation of the second-order polynomial calculated from the force-power profile, i.e., from peak power and the force at the instant of peak power for each repetition [25].

3.3. Physical Activity. Free-living physical activity was assessed on seven consecutive days by continuous wear of an armband mounted physical activity monitor (SenseWear, BodyMedia, Inc., Pittsburg, PA, USA). This was undertaken between the familiarisation sessions before the intervention period as a baseline measure and during the last week of the intervention period. Physical activity level (PAL) was calculated as estimated mean daily energy expenditure/resting metabolic rate (estimated using the World Health Organisation equation). Only days with >95% wear time achieved were included in the analysis. Participants were instructed to remove the armband for water-based activity, such as bathing or showering, and any water-based activities were recorded in the logbook.

3.4. Diet Records. Three-day weighed diet records (two weekdays and one weekend) were completed by participants. Again, this was undertaken between familiarisation sessions and during the last week of the intervention period. Commercially available online software (v4.312 Nutritics Education, Dublin, Ireland) was used for diet record analysis, all of which was performed by the same researcher (OJP). Mean daily intake of total kcal, carbohydrate (CHO), protein (PRO), and fat were obtained and calculated relative to body mass using screening body mass and postintervention body mass for baseline and intervention dietary records, respectively. Between pre- and postintervention trials, participants consumed 150 g of yogurt (Natural flavour, Skyr, Arla®; 98 kcal, 0.3 g fat, 6 g carbohydrate, 16.5 g protein) as part of their breakfast meal. Participants were provided with food weighing scales and a logbook to record whether the full 150 g of yogurt had been consumed each day and deliberately not given any further instruction concerning dietary intake.

3.5. Intervention. The Control group was asked to continue with their habitual physical activities for 28 days. The exercise snacking group was asked to perform two bouts of "exercise snacking" per day, once in the morning and once in the evening. Exercise snacking bouts consisted of five exercises, each undertaken for one minute with the aim to complete as many repetitions as possible in that minute. Between each exercise, participants rested for one minute. The exercises were STS from a chair, seated knee extensions of alternating legs, standing knee bends of alternating legs, marching on the spot, and standing calf raises (see Supplemental Figures S1–S5, respectively). Participants were advised to hold onto a chair for stability during standing exercise if they felt the need to. The STS exercise was performed first, with the number of repetitions completed recorded in a provided logbook as a means to assess adherence. Any adverse events during the intervention period for either group were to be recorded in a logbook, regardless of whether they were related to the intervention.

3.6. Statistical Analysis. Shapiro–Wilks tests of normality were performed on participant characteristic data recorded at screening (age, body mass, BMI, and STS score) due to the small sample size. Participant characteristic variables were normally distributed, thus compared with independent-samples *t*-test. Outcome variables were analysed with a two-way repeated measures ANOVA, and where there was a significant interaction or time effect was observed, a Holm–Bonferroni *post hoc* test performed. Statistical significance was accepted at $p < 0.05$. To infer the magnitude of differences between the groups, Hedges g effect size for difference in change scores between the groups was calculated, to account for low sample size [26]. Effect sizes were classed as small (0.2), moderate (0.5), and large (0.8) according to Cohen [27]. Data are presented as mean (standard deviation); ANOVA and *post hoc* analysis were performed using SPSS v22.0 (SPSS Inc., Chicago, IL), and effect size analysis was performed using Microsoft® Excel® 2016.

4. Results

4.1. Functional Measures. Adherence to the ES intervention was 98% (2 (1) sessions out of 56 sessions missed), and no adverse events occurred during the intervention period in either group. Pre- to postintervention STS scores were significantly increased ($p < 0.01$) in the ES group (29 (8) to 38 (13)), compared with the Control group (29 (14) to 29 (13)). There was a large between-group effect size of $g = 1.40$ for the difference in STS change scores (Figure 2). There was no significant change in RPE for the STS pre- and postintervention in either group (Control: 13 (3) to 14 (2); ES: 13 (2) to 14 (2)). There were no significant time or interaction effects for V_{max}, F_{max}, or P_{max} (Table 2). Effect sizes for change scores between the groups were moderate for V_{max} and F_{max} ($g = 0.62$ and $g = 0.49$, respectively) and large for P_{max} ($g = 0.81$).

4.2. Anthropometry. One participant from the Control group was removed from DXA analysis due to movement artefact on one scan. As shown in Table 3, there were no significant changes in body mass, or DXA measured % body fat, total lean mass, or lean leg mass in either group, but a moderate effect size for the difference in leg lean mass change scores ($g = 0.68$).

One participant from the ES group was removed from the calf pQCT scan analysis, and one participant from the Control group was removed from the thigh pQCT scan analysis, both due to movement artefact. Calf mCSA did not change significantly for either group, with an effect size for difference in the change scores between the groups being $g = 0.10$. There were no statistically significant changes in thigh mCSA in either group, although there was a large effect size for the difference in change scores

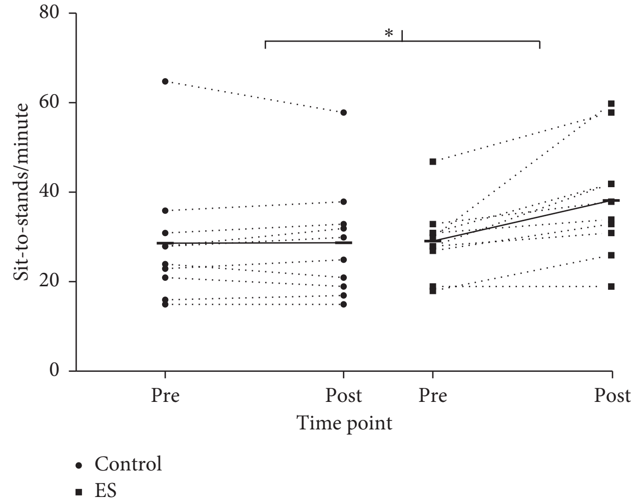

Figure 2: Individual changes in sit-to-stand score from pre- to postintervention of either 28 days of yogurt at breakfast only (Control) or yogurt at breakfast and exercise snacking twice daily (ES). Horizontal bars connected with solid lines display group mean. *denotes significant difference in change score between the groups ($p < 0.01$).

Table 2: Summary data of leg pressing outcome measures.

	Group	Pre	Post	%Δ	p	g
V_{max} (m/s)	Control	1.61 (0.29)	1.56 (0.24)	−3	0.19	0.62
	ES	1.75 (0.34)	1.81 (0.23)	3		
F_{max} (N)	Control	950 (290)	929 (170)	−2	0.29	0.49
	ES	984 (249)	1032 (289)	5		
P_{max} (W)	Control	370 (98)	363 (86)	−2	0.09	0.81
	ES	446 (170)	472 (166)	6		

ES: exercise snacking group; V_{max}: extrapolated maximum leg pressing velocity; F_{max}: extrapolated maximum leg pressing force; P_{max}: interpolated maximum leg pressing power. Data are presented as mean (SD); %Δ, pre- to postchange within groups, p values for interaction effect from two-way repeated measures ANOVA, and Hedges g effect size of difference in changed scores between the groups.

Table 3: Summary of body mass and dual energy X-ray absorptiometry measures.

	Group	Pre	Post	%Δ	p	g
Body mass (kg)	Control	70.5 (11.2)	70.3 (11.4)	0	0.64	0.27
	ES	69.0 (10.0)	69.0 (10.0)	0		
% body fat	Control (n = 9)	35.1 (7.4)	35.2 (6.8)	0	0.34	0.48
	ES	34.0 (7.0)	33.7 (7.0)	−1		
Lean mass (kg)	Control (n = 9)	44.8 (8.6)	44.6 (8.4)	0	0.37	0.44
	ES	44.9 (6.5)	45.0 (6.4)	0		
Leg lean mass (kg)	Control (n = 9)	15.3 (2.4)	15.3 (2.3)	0	0.17	0.68
	ES	15.3 (2.0)	15.5 (2.2)	1		

ES: exercise snacking group. Data are presented as mean (SD); %Δ, pre- to postchange within groups; p values for interaction effect from two-way repeated measures ANOVA, and Hedges g effect size of difference in changed scores between the groups. Group size was n = 10 unless stated otherwise.

between the groups ($g = 0.96$) with an increase of 2% in the ES group (see Figure 3).

4.3. Physical Activity and Diet. There were no changes in PAL in either group from baseline assessment to the last week of the intervention, nor were there changes in total energy (kcal/kg/day) or carbohydrate intake (g/kg/day). There were significant time effects for an increase in daily protein intake ($p < 0.01$) and decrease in daily fat intake ($p < 0.05$). Because there were no differences between the groups, the effect size for the pooled change score (pre- to postintervention for all participants) were moderate for dietary protein and fat intake ($g = 0.71$ and $g = 0.60$, respectively) (see Table 4).

5. Discussion and Implications

The impact of undertaking 28 days of twice daily home-based exercise snacking, supplemented with 150 g of yogurt at breakfast, on lower limb muscle function and anthropometry was explored in healthy older adults. Adherence to the exercise regime was very high (98%), and participants in the ES group showed marked improvements in the number of sit-to-stands performed in 60 seconds, with no improvement in the Control group.

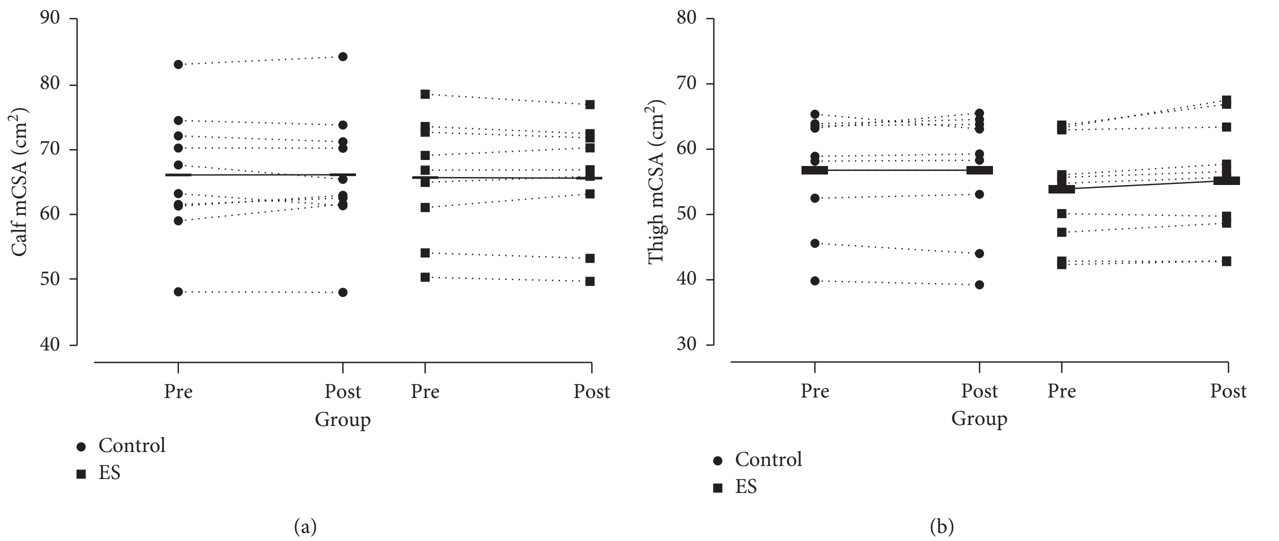

Figure 3: Individual changes in pQCT measured (a) calf muscle at 66% tibia and (b) thigh muscle group at 25% femur, pre- and postintervention of either 28 days of yogurt at breakfast only (Control) or yogurt at breakfast and exercise snacking twice daily (ES). Horizontal bars connected with solid lines display group mean.

Table 4: Summary data of dietary intake preintervention and during the intervention.

	Group	Pre	During	%Δ	*p*	*g*
Energy intake (kcal/kg/day)	Control	28 (7)	26 (6)	−9	0.73	0.18
	ES	28 (6)	27 (9)	−4		
CHO intake (g/kg/day)	Control	3.02 (0.88)	2.82 (0.84)	−7	0.84	0.09
	ES	2.95 (1.21)	2.66 (0.85)	−10		
PRO intake (g/kg/day)	Control	1.01 (0.19)	1.17 (0.30)	17	0.73	0.16
	ES	1.10 (0.21)	1.30 (0.34)	19		
Fat intake (g/kg/day)	Control	1.11 (0.47)	0.83 (0.28)	−25	0.67	0.19
	ES	1.32 (0.40)	1.11 (0.40)	−15		

ES: exercise snacking group; CHO: carbohydrates; PRO: protein. Data are presented as mean (SD); %Δ, pre- to postchange within groups; *p* values for interaction effect from two-way repeated measures ANOVA, and Hedges *g* effect size of difference in changed scores between the groups.

Large effect sizes were also observed in the change scores for interpolated maximum leg pressing power and thigh muscle cross-sectional area, albeit the absolute increases in these variable appear modest.

The exercise snacking regime consisted of five leg exercises; each completed twice a day across two bouts, with the aim to complete as many repetitions of each exercise as possible in a minute with no external load above body weight. This mode of exercise deviates from successful home-based exercise programmes explored previously; primarily, in that, all exercise was nonloaded, participants undertook exercise twice a day, there were no supervised exercise sessions in the home, and the programme lasted only four weeks [28]. The ES group showed significantly improved STS score, with the 31% improvement in the STS in 60 seconds in the present pilot study being remarkably similar to the 30% improvement in 30-second STS score observed after six weeks of resistance training in older adults by Cavani et al. [29]. With 60-second STS being one of the exercises completed twice daily for the ES group, this was not unexpected, even though the conditions between exercise bouts and testing sessions were deliberately different (self-timed vs. no information of time remaining in the test). Although the improvement in STS is likely largely due to task-specific training, the movement pattern is nonetheless relevant for tasks of daily living [30]. Given that the mode of training applied no external load beyond body weight and did not require participants to exercise to momentary failure, improvements in leg press V_{max} and F_{max} of 3% and 5%, respectively, along with a trend toward significant increases in P_{max} (6% increase; $p = 0.09$) were perhaps not expected and provide an indication of the potential efficacy of this type of "little and often" intervention.

As a point of comparison, in the study by Bean et al. [31], older adults trained three times a week for 12 weeks, completing three sets of 10 repetitions of maximum concentric contraction speed exercises similar to those of the present pilot study, whilst wearing a weighted vest. The weighted vest group increased maximum leg press power by 12%, also assessed with pneumatic leg press dynamometry. Although the present pilot study employed an intervention only one-third of the programme duration as the aforementioned study, and without external loading, a 6% increase in P_{max} was observed. Whether functional improvements of the exercise snacking regime over longer training durations would continue to increase with the only element of progression being completion of more repetitions in a minute cannot be known. It should be noted that although the participants in the present pilot study were previously undertaking no regular structured exercise, they were healthy and not functionally impaired, so were perhaps more physiologically receptive to the training stimulus provided than a frail or clinical population might be [32]. Nonetheless, increases in F_{max} and P_{max} of 5% and 6%, respectively, represent changes with real-world relevance given the estimated annual loss of muscle strength of 1–5% described by Seene and Kaasik [33], particularly as the strength and power gains were achieved in four weeks with a zero-cost exercise intervention. However, whether these task-specific increases in strength and power lead to clinically relevant improvements in outcomes, such as delaying dynapenia/sarcopenia or frailty, would require further investigation and long-term follow-up.

There were some small but noteworthy changes in anthropometric measures of the legs following the ES intervention. In particular, leg lean mass measured by DXA increased by 1% ($g = 0.68$) and thigh mCSA increased by 2% with a large effect size ($g = 0.98$). In comparison to an effect size of 0.39 (0.17) (95% CI: 0.05, 0.73) for hypertrophy induced by low-load resistance exercise training calculated in a recent meta-analysis by Schoenfeld et al. [11], the potential increase in muscle size observed in present pilot is notable. No mechanisms for an increase in muscle size were examined in this work, but it could be in part due to the comparatively high frequency of training, although this of course can only be speculated due to the scarcity of studies using twice daily exercise programmes [8, 13]. It is also possible that any hypertrophy observed in the present pilot study was in part due to the additional protein ingested at breakfast via the yogurt supplement. This notion would be supported by the evidence of Mamerow et al. [34], albeit in a younger population, that 24-hour muscle protein synthesis rate was greater with an even distribution of protein throughout the day compared with a more traditional, evening heavy, protein distribution. Although it is encouraging that two independent measurement techniques concomitantly suggest that a short-term exercise snacking intervention may have potential to increase leg muscle size, the absolute changes were small, and exercise-induced oedema from the previous day's exercise cannot be ruled out as a potential confounder in this instance [35]. However, this seems unlikely given the nature of the exercise snacking bouts, the fact that participants would have been accustomed to the exercise after 28 days, and that the increase in mCSA was not observed in the calf muscle group that was also measured by pQCT [36].

Both groups modestly increased daily protein intake per kilogram of body mass by 17% and 19% during the intervention (Control and ES, respectively), going from 1.05 (0.20) g/kg/day to 1.24 (0.32) g/kg/day (pooled mean). Although the older adults in the present pilot study were previously consuming over-the-recommended daily allowance (RDA) of protein, Phillips et al. [17] present convincing rationale that the RDA may not represent an optimal daily protein intake for older adults in particular. The suggested range of 1.2 to 1.6 g/kg/day as a more appropriate daily protein intake was achieved in the present pilot study with the addition of 16.5 g of dairy protein at breakfast. However, further inspection of the absolute change in dietary protein consumption highlighted that total protein intake increased by ≈10 g/day. There was not an increase in daily protein intake equal to the amount contained in the yogurt possibly because protein that would have been included in the breakfast meal may have been replaced with the yogurt. This is potentially important on a per meal basis, as larger protein doses are required to maximally stimulate muscle protein synthesis in older adults. Moreover, this potentially serves to highlight the challenges with supplementing older adult diets with additional protein. In any case, whether an extra 10 g/d protein intake would lead to clinically relevant outcomes in an older population is questionable. The lack of increase in strength or hypertrophy in the Control group support the work of Kim et al. [37], finding that even adjusting protein distribution for 8 weeks without the addition of exercise does not increase muscle mass or strength in older adults. Importantly, this was despite achieving over 1.2 g/kg/day of protein, highlighting the importance of a combination of exercise and nutrition to address muscle loss with ageing However, the duration of the intervention in the present pilot study was very short, and the use of only three-day diet records are often criticised for a bias toward under reporting [38]. Consequently, these data should not be seen to undermine the potential health and body composition benefits of a longer-term increase in dietary protein intake for older adults not meeting recommended quantities of dietary protein intake [39].

There are a number of crucial considerations when contextualising the present findings. Most obviously, the pilot study design employed cannot support the efficacy of exercise snacking without dietary protein supplementation. The addition of two further groups (a true nonexercising control group and an exercise snacking without yogurt group) would shed light on the importance of the additional protein at breakfast, but it would require a large increase in sample size. Moreover, based on the effect size of the present pilot study data, power calculations (G∗power, Version 3.1.9.4) indicated that for statistically significant differences in P_{max} ($\alpha = 0.05$ and power = 0.8), 27 participants per group would have been required using the current research design. Equally, group sizes of 19 would have been required for statistically significant differences in thigh mCSA. By increasing sample size, a traditional randomisation strategy to allocate participants to study groups could have been appropriate, whereas due to a small sample size, minimisation was implemented as means to reduce chance difference in baseline characteristics of groups in this present pilot study [20]. Although the adherence to the exercise programme was very high, it cannot be assumed that this would persist longer than four weeks or in other older populations [40]. Investigation of physiological mechanisms to support the strength and hypertrophic gains observed in the present findings may also allow for further optimisation of the exercise regime itself, creating a potentially more efficacious training stimulus. In the same vein, a longer-term follow-up would also be required to establish whether the physiological adaptions might continue to occur if the exercise stimulus were to be maintained. It should of course not be overlooked that high-load resistance training has superior effects on increasing muscle mass and strength [11, 41], potentially through more pronounced neural adaptations [42], and more easily accommodates progressive overload to facilitate continuous improvements in muscle mass and strength. However, accepting that access and cost of exercise participation and lack of knowledge of exercise modalities are often key barriers to exercise in older adults [43], very simple home-based exercise snacking-style regimes are a promising strategy to engage older adults in exercise.

6. Conclusions

In conclusion, although underpowered to show statistically significant changes, the present study highlights the potential efficacy of a 28-day, home-based "little and often" exercise snacking programme, for improving leg power and muscle size in healthy older adults. Along with marked task-specific improvements in sit-to-stand score, indications that maximum leg press force and power may also improve modestly with exercise snacking demonstrate transferability of the training. Whether these changes represent potentially clinically relevant improvements in function requires further investigation. Although more research is certainly needed to explain the mechanisms by which such a short-term exercise snacking regime may improve muscle strength and size, understanding the real-world acceptability of this exercise strategy could help provide easy-to-act-upon recommendations for older adults to maintain function into later life.

Data Availability

All data supporting this study are openly available from the University of Bath data archive at https://doi.org/10.15125/BATH-00701

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

The authors received funding from their own institution (University of Bath) in the form of a PhD studentship (OJP). The authors thank the participants for the generosity of their time in participating in this work and the Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, UK, for their endorsement of this work.

Supplementary Materials

Supplementary Figure S1: sit-to-stand (STS) performed from a chair with arms folded across the chest, reaching full hip extension at the top of the stand. Supplementary Figure S2: seated knee extensions, with repetitions performed unilaterally alternating the moving leg, aiming to fully extend the knee at the end of the movement. Supplementary Figure S3: standing knee bends, with repetitions performed unilaterally alternating the moving leg, aiming the shank to reach parallel with the floor whilst the thigh stays vertical. Supplementary Figure S4: marching on the spot, with hands held at waist height (or one holding a chair for balance if required) and aiming to bring thighs up to parallel with the floor. Supplementary Figure S5: standing calf raises, performed bilaterally holding onto a chair for balance, aiming to rise as high onto tiptoes as possible and returning heels to the floor between repetitions. (*Supplementary Materials*)

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Hindawi
Journal of Aging Research
Volume 2019, Article ID 9836181, 7 pages
https://doi.org/10.1155/2019/9836181

Research Article

Twelve-Month Retention in and Impact of Enhance®Fitness on Older Adults in Hawai'i

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Received 7 June 2019; Accepted 12 August 2019; Published 2 September 2019

Guest Editor: Priscila Sampaio

Introduction. Enhance®Fitness is a low-cost group exercise program designed specifically for older adults (60+ years) to improve physical performance. The Hawai'i Healthy Aging Partnership, a statewide health promotion initiative, has continuously offered Enhance®Fitness to Hawai'i's multicultural population since 2007. This study examined 12-month participation in and impact of Enhance®Fitness on physical performance among older adults in Hawai'i. *Method*. Linear mixed-effects models were applied to analyze the physical performance measures (chair-stands, arm curls, and the up-and-go test) collected at baseline (month 0) and at 4, 8, and 12 months. We also compared the characteristics of participants who participated in the program for 12 months with those who dropped out in order to gain insights on participant retention. *Results*. Of 1,202 older adults with baseline data, 427 (35.5%) were continuously enrolled in Enhance®Fitness for 12 months and participated in follow-up data collection. On average, participants attended 63.7% of thrice-weekly classes each month. Participants' physical performance measures improved after 4 months, continued to improve until 8 months, and were maintained thereafter. Besides continuous attendance, performance-measure improvements were associated with younger age, male gender, living with others (vs. alone), and fewer chronic conditions. Compared to those who completed 12 months of the program, the 775 who left the program over the course of the year were more likely to be younger, to be Caucasian (vs. Asian or Pacific Islander), to self-report depression as a chronic condition, and to have lower levels of fitness at baseline. Common reasons for dropping out were illness, relocation, time conflicts, lost interest, and transportation issues. *Conclusions*. Long-term participants in Enhance®Fitness initially improved and then maintained physical performance. Future research is needed to identify strategies to maintain enrollment of older adults in the exercise programs over time.

1. Introduction

The majority of older adults live with at least one chronic condition that may reduce physical performance or well-being [1, 2]. Poor health and disability are associated with loss of independence and falls. In 2015, the direct medical cost of fall injuries was $50 billion, and it is projected to increase to $67.7 billion by 2020 and to $100 billion by 2030 [2, 3]. Engaging in physical activity is beneficial because it helps not only to prevent falls but also to lower mortality and promote physical and psychological well-being among older adults with and without disabilities [4–10].

Research suggests that participation in physical activity is influenced by a range of personal, social, and environmental factors. Personal factors include age, socioeconomic status, and gender. Social factors include social support, physician influences, and exercise programs such as class size and group cohesion. Environmental factors include availability of free or affordable exercise opportunities and transportation to them [11, 12].

To promote the health of older adults, much attention has been given to implementing health promotion interventions that have proved to be effective in reducing the risk of disability, falls, and chronic conditions [13]. The Hawai‘i Healthy Aging Partnership (HHAP), a statewide health promotion initiative, was formed in 2003 to improve the health of older adults through evidence-based programs [14]. Hawai‘i has a unique population demographic, as two-thirds of the population is of Asian, Native Hawaiian, or other Pacific Islander ancestry. One of the programs implemented has been Enhance®Fitness, a low-cost group exercise program designed specifically for older adults by Sound Generations in Seattle in partnership with the University of Washington [15].

Earlier studies have investigated the impact of Enhance®Fitness on physical performance [15–20]. For example, Belza and colleagues examined 2,889 Enhance®Fitness participants who participated in outcomes testing and found improvements at 4 and 8 months on performance tests [15]. However, no studies outside of Hawai‘i have presented findings on Asian and Native Hawaiian/Pacific Islander (NHPI) elders, and most of the previous studies have examined short-term outcomes [20]. Only one other study was found that examined characteristics of elders who retained by Enhance®Fitness programs and those that drop out. Specifically, in a follow-up survey of elders joining a new Enhance®Fitness site, Gillette and colleagues found that former participants reported lower motivation to exercise and greater barriers than current participants [21]. Thus, this paper fills a gap by presenting findings from a longer-term (12-month) analysis of Enhance®Fitness physical performance data from a sample that includes large proportions of Asians and NHPI elders and adding to the research on program drop out.

2. Methods

2.1. Intervention. Enhance®Fitness is a low-cost group exercise program offered three times per week for one hour by nationally certified fitness instructors. Each class includes balance, flexibility, cardio, and strengthening exercises. These exercises help participants at any level of fitness by providing adaptations for people with special needs, such as offering seated versions of standing exercises. Each class enrolls up to 25 participants, depending on the space of the site. The classes are offered in a variety of community settings, such as residential and retirement communities, senior housing facilities, adult day care centers, YMCAs, private gyms, churches, and multipurpose centers [15–21].

Among the diverse older adult population of Caucasians, Asians, Native Hawaiian, other Pacific Islanders, and others, some elders adhere strongly to the traditional beliefs and practices of their cultures, while others follow a mix of cultural beliefs and practices. To ensure the attractiveness of and practicality of Enhance®Fitness for Hawai‘i older adults, HHAP worked with the program developers to make minor modifications, such as renaming certain exercises to relate them to daily activity and utilizing culturally appropriate music [22]. The program started with two sites on Kaua‘i County in 2007 (with additional sites added incrementally) and launched in Maui County in 2012.

2.2. Study Design. A longitudinal study was conducted. Each participant's physical performance and prevalence of falls were assessed at baseline, which is the first week of the class, and reassessed after 4, 8, and 12 months with the program. Attendance and reasons for drop out were tracked.

2.3. Study Sample. Participants aged 50 or older were recruited over time through Area Agencies on Aging and their Aging and Disability Resource Centers (28%), eldercare, faith-based, and healthcare organizations (31%), word-of-mouth (15%), health professionals (2%), and other avenues including community events and mass media (24%). Because participants had to find a way to get to the sites, HHAP partnered with organizations where individuals already congregated or to which they had easy access. For most, family members drop them at the sites, but some utilized public transportation (i.e., bus) or drove themselves. Data were collected from all 19 Enhance®Fitness sites in the state (8 multipurpose centers, 4 senior housing facilities, 5 faith-based organizations, 1 adult daycare, and 1 fitness gym) from 2007 to 2016. At enrollment, participants completed consent, registration, and health history forms and provided physician clearance for participation. No elder was excluded from joining the program, and informed consent was obtained from all participants. This study was approved by Institutional Review Board at the University of Hawai‘i.

2.4. Outcome Measures. Physical performance was tested using the Fitness Check created by Sound Generations [23], which adapted standardized measurements by Rikli and Jones [24]. The Fitness Check assesses the participant's lower- and upper-body strength, agility, and balance using three types of tests: chair stand, arm curl, and up-and-go tests. For the chair stand test, the tester records the number of times the participant can move from sitting to standing in 30 seconds. For the arm curl test, the tester records the number of times the participant can perform a bicep curl using a weight (5 pounds for women and 8 pounds for men) in 30 seconds. For the up-and-go test, the observer records the number of seconds it takes for a seated participant to stand, travel 8 feet, round a cone, return to the chair, and be reseated. Participants' attendance was collected each session.

2.5. Independent Variables. Independent variables were age group (<65, 65–69, 70–74, 75–79, 80–84, and 85+), gender (female or male), race/ethnicity (Caucasian, Filipino, Japanese, Native Hawaiian and Pacific Islander (NHPI), or other), marital status (married, divorced, widowed, or others), living arrangement (live alone or with others),

Table 1: Characteristics of the full sample ($N = 1{,}202$), those completing 12 months ($N = 427$), and those dropping out ($N = 775$).

	Baseline ($N = 1{,}202$), N (%)	12 months ($N = 427$), N (%)	Dropped-out ($N = 775$), N (%)	Significance probability
Baseline age				
<65	217 (18.1)	61 (14.3)	156 (20.1)	$p < 0.001$
65–69	269 (22.4)	91 (21.3)	178 (23.0)	
70–74	225 (18.7)	69 (16.2)	156 (20.1)	
75–79	193 (16.1)	83 (19.4)	110 (14.2)	
80–84	155 (12.9)	74 (17.3)	81 (10.5)	
85+	143 (11.9)	49 (11.5)	94 (12.1)	
Female gender	1053 (87.6)	385 (90.2)	668 (86.2)	ns
Race/ethnicity				
Caucasian	474 (39.4)	125 (29.3)	349 (45.0)	$p < 0.001$
Filipino	153 (12.7)	46 (10.8)	107 (13.8)	
Japanese	369 (30.7)	198 (46.4)	171 (22.1)	
NHPI	101 (8.4)	32 (7.5)	69 (8.9)	
Others	105 (8.7)	26 (6.1)	79 (10.2)	
Married	574 (47.8)	212 (49.6)	362 (46.7)	ns
Living alone	401 (33.4)	136 (31.9)	265 (34.2)	ns
Household income				
<15K	247 (20.5)	73 (17.1)	174 (22.5)	ns
15–25K	267 (22.2)	99 (23.2)	168 (21.7)	
25–50K	291 (24.2)	107 (25.1)	184 (23.7)	
50–75K	154 (12.8)	55 (12.9)	99 (12.8)	
75K+	97 (8.1)	44 (10.3)	53 (6.8)	
Unknown	146 (12.1)	49 (11.5)	97 (12.5)	
Chronic condition(s)	888 (73.9)	317 (74.2)	571 (73.7)	ns
Depression	117 (9.7)	28 (6.6)	89 (11.5)	$p = 0.008$
Performance measure (baseline)	Mean (SD)	Mean (SD)	Mean (SD)	
Chair stands	11.3 (3.9)	11.6 (4.0)	11.1 (3.9)	$p = 0.05$
Arm curls	12.0 (4.1)	11.7 (4.0)	12.2 (4.3)	$p = 0.01$
Up-and-go	7.8 (4.2)	7.7 (3.6)	8.0 (4.7)	$p = 0.05$
Participation (%)	55.8 (18.5)	63.7 (14.6)	51.4 (19.0)	$p < 0.001$

household income (<15K, 15–25K, 25–50K, 50–75K, or ≥ 75K+), any chronic conditions (e.g., hypertension, arthritis, and depression), and monthly attendance rate. Reasons for drop out were reported by site leaders.

2.6. Statistical Analysis. The analysis of baseline data excluded 63 participants because of missing data for age and gender ($n = 15$), chronic conditions ($n = 11$), and/or physical performance measures ($n = 37$). Descriptive statistics were used to summarize the sample characteristics at baseline and to compare the characteristics of those that remained in the program at least 12 months against those that dropped out.

The analysis of 12-month outcomes was limited to elders continuously enrolled for 12 months who participated in the 4-, 8-, and 12-month Fitness Checks. We performed linear mixed-effect model analysis of the trajectories of each physical performance measures (chair stand reps, arm curl reps, and up-and-go seconds) at months 0, 4, 8, and 12 [25]. Random intercepts were used to account for the correlations of repeated measures among each participant and the dependencies of participants nested under the implementation sites. Dispersions of repeated measures were tested but not statistically significant. Independent variables included age group (reference: <65), gender (reference: female), race/ethnicity (reference: Caucasian), marital status (reference: married), living arrangement (reference: alone), household income (reference: <15K), chronic conditions (reference: no conditions), and participation rate. Statistical software R version 3.5.1 was used to analyze the data. The data that support the findings of this study are available from the corresponding author, MT, upon reasonable request.

3. Results

Between 2007 and 2016, 1,202 older adult participants enrolled in Enhance®Fitness and completed baseline data collection. Not all enrollees choose to continue long-term with the program, with 546 lost by the 4-month follow-up, another 194 lost by the 8-month follow-up, and another 35 lost by the 12-month follow-up. The remaining 427 (35.5%) participants were continuously enrolled for 12 months and participated in the 4-, 8-, and 12-month Fitness Checks; analysis is limited to this group. Of these, 125 (29.3%) were Caucasian, 46 (10.8%) were Filipino, 198 (46.4%) were Japanese, 32 (7.5%) were NHPI, and 26 (6.1%) were from other ethnic groups (Table 1). The majority was 65 years or older (85.7%) and female (90.2%). More than half of them lived with others (68.1%) and had at least one chronic condition (74.2%). Nearly half of them were married (49.6%)

Table 2: Mean differences (Est) in physical performance tests (chair stand, arm curl, and up-and-go) and 95% confidence intervals (CIs) estimated from multivariate linear mixed-effects models.

	Chair stand (repetitions)			Arm curl (repetitions)			Up and go (seconds)		
	Est	95% CI	*p* value	Est	95% CI	*p* value	Est	95% CI	*p* value
Intercept	16.05	(14.27, 17.84)	<0.0001	14.34	(12.83, 15.85)	<0.0001	3.63	(2.50, 4.75)	<0.0001
Month (ref: month 0)									
Change 0–4	2.32	(1.99, 2.65)	<0.0001	2.20	(1.85, 2.54)	<0.0001	−0.85	(−1.03, −0.67)	<0.0001
Change 4–8	1.20	(0.84, 1.56)	<0.0001	0.95	(0.57, 1.32)	<0.0001	−0.24	(−0.44, −0.05)	0.0149
Change 8–12	0.16	(−0.19, 0.52)	0.3662	0.52	(0.16, 0.89)	0.0051	0.08	(−0.11, 0.27)	0.4260
Age group (ref: <65)									
65–69	−0.98	(−2.18, 0.22)	0.1100	−0.38	(−1.39, 0.63)	0.4558	0.31	(−0.45, 1.06)	0.4287
70–74	−2.14	(−3.44, −0.83)	0.0013	−1.71	(−2.81, −0.60)	0.0024	0.98	(0.16, 1.80)	0.0196
75–79	−3.69	(−4.96, −2.42)	<0.0001	−2.15	(−3.22, −1.08)	<0.0001	1.64	(0.84, 2.44)	<0.0001
80–84	−4.55	(−5.90, −3.19)	<0.0001	−3.80	(−4.94, −2.67)	<0.0001	3.04	(2.19, 3.89)	<0.0001
85+	−6.30	(−7.81, −4.79)	<0.0001	−4.34	(−5.61, −3.07)	<0.0001	4.08	(3.13, 5.03)	<0.0001
Gender (ref: female)									
Male	1.71	(0.48, 2.94)	0.0063	1.57	(0.53, 2.60)	0.0030	−0.31	(−1.08, 0.46)	0.4350
Race/ethnicity (ref: white)									
Filipino	0.77	(−0.56, 2.09)	0.2571	−0.67	(−1.79, 0.45)	0.2405	0.51	(−0.33, 1.35)	0.2313
Japanese	1.93	(1.04, 2.83)	<0.0001	−0.43	(−1.18, 0.33)	0.2692	−0.28	(−0.84, 0.29)	0.3385
NHPI	0.37	(−1.07, 1.81)	0.6141	0.27	(−0.94, 1.48)	0.6598	0.49	(−0.41, 1.40)	0.2849
Others	−0.20	(−1.79, 1.38)	0.8000	−0.30	(−1.64, 1.04)	0.6637	1.04	(0.05, 2.04)	0.0397
Marital status (ref: married)									
Divorced	−1.76	(−3.24, −0.29)	0.0188	−0.59	(−1.83, 0.65)	0.3500	1.24	(0.31, 2.17)	0.0086
Widowed	−1.15	(−2.19, −0.10)	0.0322	−1.15	(−2.04, −0.27)	0.0106	1.86	(1.20, 2.52)	<0.0001
Others	−2.89	(−4.19, −1.59)	<0.0001	−1.06	(−2.15, 0.04)	0.0587	1.21	(0.39, 2.02)	0.0038
Living arrangement (ref: live alone)									
With others	−1.57	(−2.56, −0.59)	0.0018	−0.79	(−1.63, 0.04)	0.0618	1.57	(0.95, 2.19)	<0.0001
Household income (ref: <15K)									
15–25K	0.46	(−0.68, 1.59)	0.4302	0.69	(−0.27, 1.64)	0.1576	−0.04	(−0.76, 0.68)	0.9106
25–50K	−0.67	(−1.80, 0.47)	0.2486	0.45	(−0.50, 1.40)	0.3543	0.31	(−0.41, 1.02)	0.4009
50–75K	0.59	(−0.75, 1.92)	0.3908	0.91	(−0.21, 2.04)	0.1102	−0.29	(−1.13, 0.55)	0.4947
75K+	−0.55	(−2.03, 0.94)	0.4729	0.55	(−0.70, 1.80)	0.3885	−0.51	(−1.45, 0.43)	0.2867
Unknown	−0.72	(−2.10, 0.66)	0.3038	−0.20	(−1.35, 0.96)	0.7391	0.54	(−0.33, 1.40)	0.2255
Chronic disease (ref: no)									
Yes	−0.88	(−1.70, −0.06)	0.0354	−0.04	(−0.73, 0.65)	0.9085	0.76	(0.24, 1.27)	0.0040
Percent of participation									
1% increase	−0.01	(−0.03, 0.02)	0.6377	0.00	(−0.02, 0.02)	0.7988	−0.01	(−0.03, 0.00)	0.1770

and had an annual household income of less than 25K (40.3%). While in the program, participants attended 63.7% (about 8) of the 12–13 classes offered each month. This equates to about 100 minutes of moderate exercise per week.

The 775 individuals who discontinued their participation dropped out over time. Based on reports by site leaders, the most common reasons for stopping, in order of frequency, were illness, time conflicts, relocation, lost interest, and transportation issues. An examination of baseline data suggests that those that dropped out differed from those that stayed in several variables. A significantly larger proportion of younger participants dropped out than older participants. Caucasians were more likely to drop out, and Japanese were more likely to stay in the program, while the proportions of the other ethnic groups remained constant. The groups did not differ in number of chronic conditions; however, a significantly greater proportion of drop outs reported depression (11.5% vs. 6.6%). The groups also differed in baseline fitness measures, with the drop outs having lower levels of fitness. Those that dropped out over the course of the year also attended a significantly lower percentage of available classes than those that continued. Although gender was not a significant predictor of drop out, we found that males had better performance measures than females at baseline (not shown in table). There were no differences between the groups based on being married, living alone, or household income.

Table 2 shows the multivariate results of physical performance tests. The mean number of chair stands increased by 2.32 repetitions (95% confidence interval (CI): 1.99 to 2.65; $p < 0.0001$) at 4 months and by an additional 1.2 repetitions (95% CI: 0.84 to 1.56; $p < 0.0001$) at 8 months, and changes were maintained at month 12. Among the control variables, age and gender were associated with average number of repetitions, with males showing more improvement than females and individuals <65 years showing more improvement than individuals aged 70 and older. Other associated variables included marital status (married participants improved more than nonmarried participants), living arrangement (those living with others improved more than those living alone), and presence of chronic conditions (those with no chronic conditions made greater improvement).

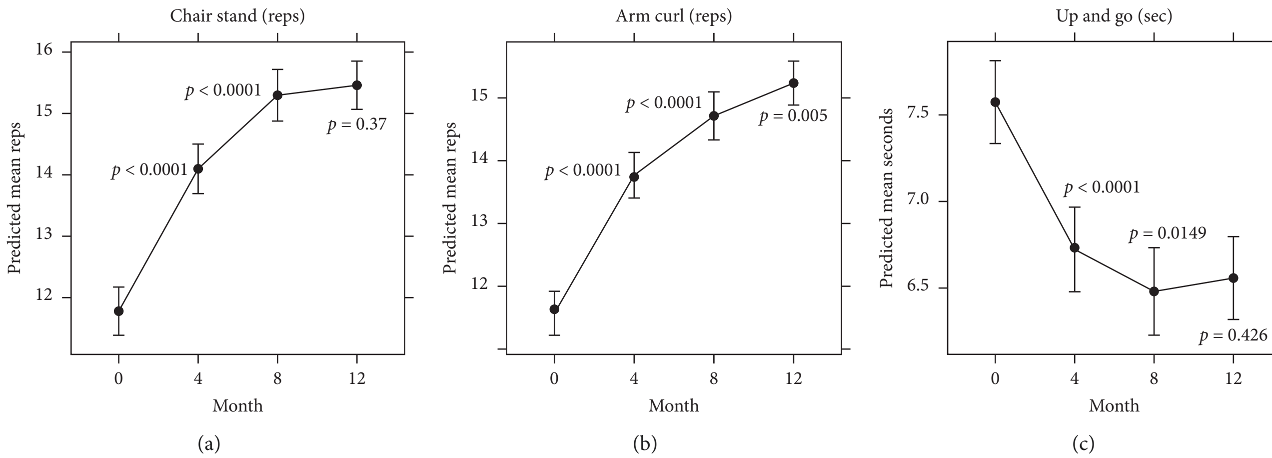

Figure 1: Trajectories of mean performance measures and 95% confidence intervals (CIs) at baseline, 4, 8, and 12 months. Statistical significance for the test of changes in physical performance measures at each follow-up month (compared with the previous visit) is indicated by p values.

In multivariate analysis, the mean number of arm curls increased by 2.20 repetitions at 4 months (95% CI: 1.85 to 2.54; $p < 0.0001$), an additional 0.95 repetitions at 8 months (95% CI: 0.57 to 1.32; $p < 0.0001$), and an additional 0.52 repetitions at 12 months (95% CI: 0.16 to 0.89; $p < 0.0051$). Other variables associated with arm curls in the analysis were age and gender, with males and participants <65 years showing greater improvement.

The number of seconds to complete the up-and-go test decreased by 0.85 seconds at 4 months (95% CI: 0.67 to 1.03; $p < 0.0001$) and another 0.24 seconds at 8 months (95% CI: 0.05 to 0.44; $p < 0.0001$). Control variables associated with improvement included age (with less improvement in individuals age 75 and older), marital status (with greater improvement for those married), living arrangements (with less improvement in those living alone), and presence of chronic conditions (Table 2).

As illustrated in Figure 1, participation in Enhance®Fitness was associated with improvement at 4 months and 8 months in all three physical performance measures, with maintenance of these gains at 12 months.

4. Discussion

In this longitudinal study of Enhance®Fitness in Hawai‘i, participants' physical performance measures improved between baseline and the 4-month and 8-months measures, and participants' higher physical performance levels were maintained at 12 months.

Improvements in physical performance were also found in multiple previous Enhance®Fitness studies, as shown in the scoping review of qualitative and quantitative studies conducted by Petrescu-Prahova and colleagues [20]. Other studies show its effectiveness with minority populations [15, 17, 18] and at a variety of Enhance®Fitness sites [16]. More specifically, most studies of Enhance®Fitness have observed positive physical performance findings after 4 to 8 months with the program [15, 16, 18, 20, 22]. This study adds to the literature by examining the longer-term impact of Enhance®Fitness in an Asian and NHPI population, controlling for baseline demographic and health variables.

As seen in previous studies, physical performance was significantly associated with age, chronic conditions, living arrangements, and social support, as well as participation in a physical activity program. For example, findings from a longitudinal cohort study in Taiwan found less functional improvement among older adults not living with spouses and with low social support [26]. A prospective cohort study of community-dwelling older Canadians found that decreased fitness and increased frailty were associated with greater age, poorer health, more comorbid conditions, and greater social isolation [27]. We also found that males had better performance measures than females at baseline and that gender was a significant covariate in the linear mixed-effects model of improvement for the chair-stand and arm-curl measures.

The findings also provide insights into long-term participation in exercise. We found that younger adults were more likely to drop out than older adults, perhaps suggesting that younger adults had more options for socialization and exercise and did not feel a need to continue. In this Hawai‘i-based sample, Japanese were more likely to maintain participation in the program than Caucasian. This is not a surprising finding in Hawai‘i, where Japanese have better health than Caucasians. For example, smaller proportions of Japanese elders are overweight or obese (44%) compared to Caucasian elders (57%), and life expectancy for Japanese is four years longer than for Caucasians in the state [28, 29]. Older Caucasians also may be temporary (winter) visitors to Hawai‘i from other states who join Enhance®Fitness on a short-term basis or may be more likely that other groups to relocate to the other states in old age to be closer to family and/or to escape the high cost of living.

A 2014 review of literature on older adult adherence to exercise programs found better adherence in older adults with higher socioeconomic status, fewer chronic conditions, better physical abilities, and fewer depressive symptoms [30]. In our study, baseline physical fitness was associated with adherence, with sustainers having higher fitness levels at baseline. Also, a greater proportion of dropouts reported depression. This is unfortunate finding, as group exercise programs could have antidepressive qualities. Research suggests that physical activity releases endorphins, which can increase feelings of well-being and enhance self-efficacy and self-esteem [31]. Group exercise has the additional potential benefit of increasing opportunities for socialization and friendship, thus a potential mitigation of social isolation.

Despite successful outcomes associated with long-term participation in Enhance®Fitness, further research is needed on why older adults drop out and strategies to keep them engaged. Burton and colleagues surveyed older adults on reasons for dropping out of a resistance training program. Half of respondents reported dropping out within 4 months of enrollment, and the most common reasons were injury, illness, holidays, and the feeling that the program was not suitable for them [32]. Several researchers have published on reasons and motivators of adults to continue in exercise trials. For example, Buchholz and colleagues found that women with more hardships and perceived poor health took more reminder phone calls to encourage their continued participation [33]. In a study of motivators to join and stay with an exercise trial, Viljoen and Christie found that participant motivators changed over time. Initially, participants were attracted to the exercise trial, because they wanted to join a structured exercise program. However, reasons for staying with the trial included a commitment to the researcher and the social aspects of the group exercise program [34]. These offer promising clues for future research.

There are several limitations of this study. First, participant data were collected by instructors and program staff. Although they were trained to correctly administer the Fitness Check, deviations over time and across the 19 sites may have occurred. Second, we did not have a control group for this study. All the participants in this study received medical clearance and chose to participate and participated as long as they desired.

Despite limitations, this study contributes to demonstrating the positive long-term impact of Enhance®Fitness on physical performance as well as risk factors associated with dropping out of an exercise program. Although no amount of physical activity can stop the biological aging process, regular participation in exercise increases active life expectancy by slowing physiological decline and development and progression of chronic disease and disabling conditions [4]. Health professionals and gerontologists who consider implementing evidence-based program should plan ways to sustain programs over the long term, educate elders and policy makers on the importance of exercise continuity, and develop strategies to keep participants, especially those with depression, in the program. Exercise programs, especially evidence-based programs like Enhance®Fitness, that can attract a variety of older adults, are a worthy investment.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

This manuscript was completed while the first author was with University of Hawai'i Office of Public Health Studies.

Conflicts of Interest

All authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

We acknowledge the Hawai'i Healthy Aging Partnership, a coalition of the Hawai'i Executive Office on Aging, the Area Agencies on Aging, the Hawai'i State Department of Health, the University of Hawai'i, and service providers dedicated to expand health promotion options for older adults in Hawai'i. Funding for the Hawai'i Healthy Aging Partnership has been received from U.S. Administration on Aging, National Council on Aging, State of Hawai'i, County of Kaua'i, and County of Maui. In addition, we recognize Sound Generations for sharing the raw data for analysis for this study. We also acknowledge Hā Kūpuna National Resource Center for Native Hawaiian Elders at the University of Hawai'i, which is funded by the US Administration for Community Living (no. 90OI0006/01), and Ola HAWAI'I (Health and Wellness Achieved by Impacting Inequalities) (grant no. 2U54MD007601-31), funded by the National Institute on Minority Health and Health Disparities and National Institutes of Health.

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Hindawi
Journal of Aging Research
Volume 2019, Article ID 9061839, 6 pages
https://doi.org/10.1155/2019/9061839

Research Article

Reliability of a Test for Assessment of Isometric Trunk Muscle Strength in Elderly Women

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Received 18 April 2019; Accepted 29 May 2019; Published 1 July 2019

Guest Editor: Ricardo Sampaio

Objective. The aim of this study was to analyze the reproducibility of a protocol using the maximal isometric strength test of the trunk in elderly women aged above 60 years, without low back pain. *Methods*. Twenty-one physically inactive elderly women, who had not engaged in any activity or exercise program in the past three months, participated in the cross-sectional study that consisted of two days of evaluations for the maximal isometric strength of the extensor and flexor muscles of the trunk, with a 48 h interval between the sessions. A platform with fixed seating was used, which allowed the fixation of the hip and lower limbs, with a load cell connected to a linear encoder. To verify the reliability of the test, the interclass correlation coefficient, variation coefficient, minimum detectable difference (MDD), standard error of measurement, and Bland–Altman graphs were calculated. *Results*. No statistical difference was observed between the first and second evaluation, which indicates that there was no learning effect. Interclass correlation coefficient values were classified as very high and high for extensor (0.98) and flexor (0.86) muscles, respectively, besides low variation (9% for both muscle groups) and acceptable values for minimum detectable difference (extensors = 51.1 N, flexors = 48.9 N). In addition, the Bland–Altman analysis revealed low bias and values within the limits of agreement. *Conclusion*. It is concluded that the test of maximum isometric strength of the trunk in healthy and trained elderly people presents high reliability. These values proved to be reliable if performed in at least two evaluation sessions, which confirms the hypothesis of the authors by the consistency of the measurement test.

1. Introduction

Decreased muscle strength due to age is a determinant factor for the physical function in the elderly, which can lead to reduced functionality and performance and disability during daily life activities [1]. Previous studies investigating the relationship between the muscle strength and functional capacity in the elderly have focused on the peripheral musculature. However, more recent research has focused on changes related to trunk muscles, mainly due to their important role in performing activities of daily living (ADLs) and in terms of better functional performance [2, 3]; also the production of strength by the dorsal musculature constitutes an important parameter to evaluate the state of health of an individual [4].

Loss of functional capacity is associated with multiple factors; however, sarcopenia, characterized as the loss of muscle mass with consequent general functional decline leading to weakness, is the main contributor to this decline [5, 6]. As a consequence of sarcopenia, there is a reduction of maximal isometric strength, muscular power, and rate of strength development, that is, a reduced functional capacity during daily activities, such as walking, climbing stairs, squatting, or carrying something [7].

Strength assessment can also provide essential information on how the reduction of strength is related to the functional limitations of daily activities. However, the evaluation by isokinetic devices, despite being considered a gold standard for the measurement of muscle strength, is often not feasible due to the high cost of equipment and operational complexity [3, 8]. Therefore, the development of reliable and low-cost tests and protocols for evaluating the muscular strength of the trunk can facilitate the evaluation and monitoring of the force, especially in the elderly population. Thus, isometric dynamometry can be considered an accepted alternative tool to evaluate the maximum strength of the upper and lower limbs [9], as well as the trunk muscles [10]. Studies that investigated isometric trunk strength, assessed by dynamometry in the elderly, showed high to very high reliability for these measurements in test-retest studies [1, 10].

It should be noted, however, that relevant clinical aspects such as strength, balance, and force output are necessary to interpret the reliability of the isometric trunk test with the elderly population [11]. The inclusion of these measures allows for greater reliability of the method; therefore, the isometric dynamometry allows the measurement of muscle strength, whose decline as a result of aging generates incapacities to perform daily activities [12], besides being a safe tool for the evaluation of this population. This assessment instrument was used in a previous study [8] in order to assess the strength of the trunk in athletes and young people. However, no studies have been undertaken that used this instrument in the elderly.

Thus, the present study aimed to verify the reliability of an evaluation protocol using the maximal isometric strength test of the trunk in women older than 60 years [8]. Our hypothesis is that this protocol will demonstrate good reliability for the extensor and flexor muscles of the trunk, with a coefficient of variation (CV) within 10% of the mean.

2. Methods

2.1. Participants. The sample size was calculated using the G ∗ Power 3.1.9.2™ program and considering $\alpha = 0.05$, $\beta = 0.20$, ratio of power correlation to null hypothesis of 0.35, and ratio of power correlation to alternative hypothesis of 0.80 [13]. At least 20 participants were needed for the study. Considering a potential loss of 20%, 25 older adults were recruited. Four of them missed the second testing day due to personal problems. Therefore, 21 older women composed the final sample and completed the second-day assessment.

This study consisted of two sessions of evaluation of the maximal isometric muscle strength of the trunk in asymptomatic elderly women, with a 48-hour interval between the test sessions.

Twenty-one physically inactive elderly women, who had not engaged in any activity or exercise program in the past three months, participated in the study. But they had already participated in a regular strength training protocol. The following inclusion criteria were adopted to select the participants: (a) age above 60 years, (b) no limiting back pain in the previous year, and (c) no medical or physiotherapeutic treatment for back pain in the previous year. We excluded from the present study the subjects who presented limitations for the tests and those who did not attend one of the evaluation sessions at the dates and times previously scheduled.

Prior to the evaluation sessions, the participants were instructed to avoid exercise during the previous 24 h. All subjects were informed about the study, and they provided their signed written informed consent in accordance with resolution 466/2012 of the National Commission of Ethics in Research of the National Health Council in agreement with the ethical principles expressed in the Declaration of Helsinki (1964, restated in 1975, 1983, 1989, 1996, 2000, 2008, and 2013) of the World Medical Association. This study was approved by the Committee of Ethics in Research with Human Beings of the Federal University of Sergipe (number: 060568/2017).

2.2. Protocol. The tests were carried out in the same place, administered in the same order, and supervised by the same researchers. Before the tests, the researchers adjusted the devices (according to the anthropometric characteristics of the participants) and instructed them about body positioning.

The body mass of the participants was measured in kilograms (kg) using a digital platform scale (Filizola 2002, São Paulo, SP, Brazil) calibrated from 0 to 150 kg and with a precision of 0.1 kg. The participants' height was measured with a stadiometer fixed to the wall (Sanny ES2040, São Bernardo do Campo, SP, Brazil), and the average of three measurements was recorded as the final result. Height measurements were recorded with a precision of 0.1 [14].

To evaluate the maximal isometric strength of the trunk muscles, a fixed seat platform with an adjustable support for hip and lower limbs was adjusted according to the height of each individual, in order to isolate the trunk muscles to perform the test. The subjects were placed sitting on the platform with an anterior pelvic tilt to avoid compensatory activation of the lower limbs. The legs were fastened to the seat platform by a Velcro strap [8, 15]. From this position, the muscle strength of trunk extensors and flexors was measured by a precalibrated digital loading cell (Kyoto, 333 A, Hown Dong, South Korea), connected to the MuscleLab software (Ergotest Innovation, Porsgrunn, Norway). A familiarization of the test was made for each condition (flexors/extensors). After the familiarization, three measures were performed with rest of 30 s between each one. If there was a discrepancy of more than 100 N in one of the three values, this measure was repeated. In addition, for statistical purposes, the average of the three measures was calculated. The values of the force in newton (N) and the rate of force development (RFD) in newton/second (N/s) were recorded.

To evaluate the extensors of the trunk, the participants were positioned with the trunk at 0° of flexion (Figure 1(a)). The load cell was attached to the wall by an adjustable tensioner and connected to the individual by a Velcro strap positioned at the level of the xiphoid process. From this positioning, a maximal isometric contraction was performed in the trunk extension. For the evaluation of the trunk flexors, the load cell was fixed to the wall behind the participant, with the strap attached to the trunk at the height of the scapula. From the initial position, the trunk flexion was performed to measure the maximum isometric force (Figure 1).

Participants performed a warmup that consisted of at least three submaximal slow dynamic motions throughout the range of trunk movement and performed 1 or 2 isometric contractions, according to the test protocol, at submaximal loads. Thereafter, volunteers generated their maximum isometric contraction by gradually increasing their torque moment up to their maximum within the first 2-3 s of each contraction. The entire test protocol was performed under the supervision of the previously trained examiner. The best value obtained out of 2 attempts was recorded. When a variation greater than 10% was observed between the two trials or when the peak force was reached after three seconds of maximal isometric action duration, retesting was performed until the test criteria were satisfied. The intervals between each trial were at least 15 s, and the flexor and extensor tests were separated by a resting period of 5 min. The instructions for conducting the test and the verbal stimuli of encouragement were standardized. The order of different muscle group tests was kept constant, with back extension tests first, followed by trunk flexion tests [10, 12].

2.3. Statistical Analysis. The normality of the data was assumed by the Shapiro–Wilk test. Descriptive analysis was performed with data presented as mean ± standard deviation and confidence interval (95%). Considered as of the parametric statistics, the comparison of the values for trunk muscle strength was performed by Student's *t*-test for dependent samples. The interclass correlation coefficient (ICC) was considered small (up to 0.25), low (0.26–0.49), moderate (0.50–0. 69), high (0.70–0.89), and very high (above 0.90), according to the description of the previous studies [16]; the coefficient of variation (CV) was considered optimal for values below 10% [9], and the graphical plots of Bland–Altman were used to verify the agreement between the measurements from the bias analysis and limits of agreement to 95% [17]. The standard error of measurement (SEM) was also calculated through the following equation: $\text{SEM} = \text{SD} * \sqrt{(1 - \text{ICC})}$, where SD corresponds to the standard deviation. The minimum detectable difference (MDD) was calculated using the following equation: $\text{MDD} = 1.96 \times (\text{SEM} \times \sqrt{2})$.

For all analyses, the statistical significance considered was $p < 0.05$. Statistical procedures were performed using SPSS® software version 22.0.

3. Results

The general characteristics of the 21 participants were 64 ± 4 years old, 70 ± 11 kg, and 154.0 ± 4.8 cm. No statistically significant differences ($p > 0.05$) were observed between test and retest in the maximal isometric force of the extensor (day 1 : 281.7 ± 69.7; day 2 : 281.8 ± 73.3) and flexor (day 1 : 271.1 ± 47.2; day 2 : 266.1 ± 46.6) muscles of the trunk (Figure 2).

Thus, the calculations of the reliability indexes for the evaluated muscle assessments with ICC and CV were performed, followed by the calculation of the SEM and MDD for the values obtained between the first and second evaluation days (Table 1). The concordance analysis between the first and second testing days for the strength of the extensor and flexor trunk muscles is presented in Figures 3 and 4, respectively.

In Figure 3, when analyzing the extensor muscles, it was possible to observe a low dispersion of the points and that all the individuals are present within the acceptable limits of agreement, with the exception of only one participant.

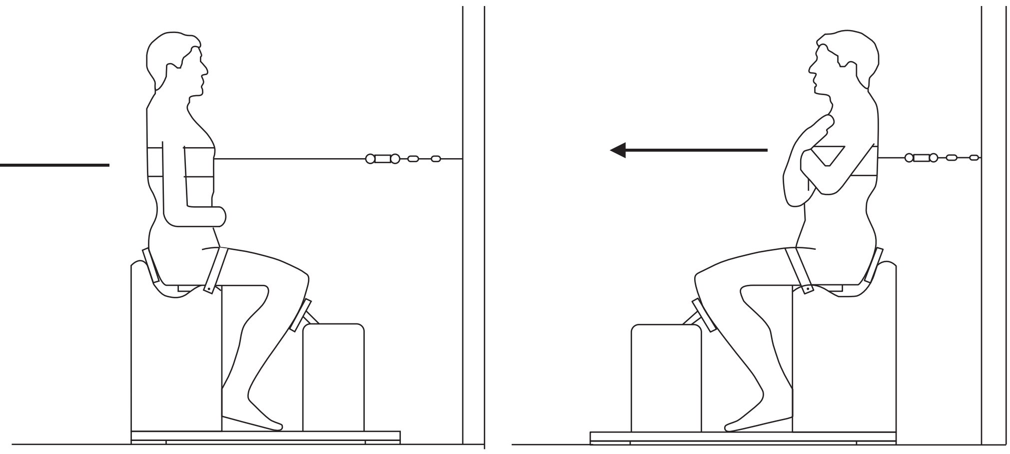
Similarly, when analyzing the flexor muscles (Figure 4), it was possible to verify similar behavior where the points are close to the difference of the means and again all the individuals are within the limits of agreement, except for two of them.

4. Discussion

The reliability of the results of the muscular strength tests is crucial in order to accurately evaluate the performance [18]. The results of the present study indicated that the test protocol used to evaluate the maximal isometric strength of the trunk muscles in the elderly presents acceptable reliability considering the stabilization of the values measured in the test and retest.

The test was well tolerated by the study subjects, with no associated adverse events, which demonstrates that this evaluation protocol can be safely used for assessing trunk strength in the elderly. These results corroborate an investigation that verified the reliability of the isometric strength of the trunk in the elderly population [10].

The high reliability of the test, observed through high ICC and low CV and SEM, is presumably related to several factors, including the standardization of the instructions to the evaluated ones, the adoption of familiarization procedures, the adjustment of the fixed seat platform according to the size of the members of each individual, the fixed order of the tests, and the supervision of experienced evaluators. It should be noted that only two participants reported the sensation of muscle fatigue on the second day of evaluation, which did not affect their performance during the test.



(a) (b)

Figure 1: Side view during (a) extension and (b) flexion of the trunk.

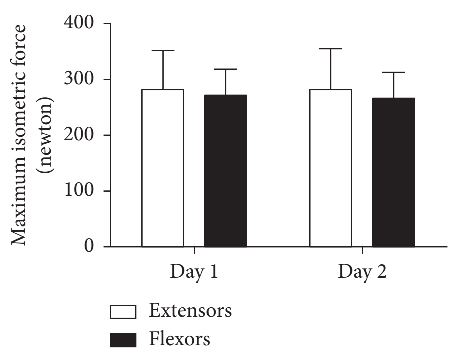


Figure 2: Values of the maximal isometric strength of the extensor and flexor muscles of the trunk obtained in the two days of evaluation ($n = 21$). The data are expressed as mean ± standard deviation (SD).

Table 1: Values of the isometric dynamometry tests of back muscle extensors and flexors, between days 1 and 2 ($n = 21$), followed by ICC, CV, SEM, and MDD values.

Variables	Day 1	Day 2	Days 1 and 2			
	Mean ± SD	Mean ± SD	ICC	CV	SEM	MDD
Extensors	281.7 ± 69.7 N (250.0–313.4)	281.8 ± 73.3 N (248.4–315.2)	0.93	8.9%	18.4	51.1
Flexors	271.0 ± 47.2 N (249.6–292.6)	266.0 ± 46.6 N (244.9–287.3)	0.86	8.9%	17.6	48.9

Data are expressed as mean ± standard deviation (SD). N: newton; ICC: interclass correlation coefficient; CV: coefficient of variation in %; SEM: standard error of measurement in newton; MDD: minimum detectable difference in newton. The values of 95% confidence interval (lower-upper) are shown in parentheses.

For the ICC between the first and second day of evaluation in the trunk extensor (0.93) and flexor (0.86) muscles, we observed values classified as very high and high, respectively, according to the scale used by Jonson et al. [19]. In addition to the low coefficient of variation of trunk extensors and flexors between days (CV = 9%), the test used had good reliability for the tracking of measures for research [11]. To our knowledge, only two studies in the literature have investigated the reliability of the maximum isometric strength test in the elderly [1, 10]. However, measures of the absolute reliability of the evaluation instrument were not considered [1, 10]. In addition, most studies have investigated only the association between changes in trunk muscle strength and reduction in functional performance in the elderly, such as sit and stand tests, 6-minute walk, and Berg balance [2, 3, 20].

Thus, similar to the findings of this study, Roth et al. [18] compared the reliability of back muscle strength in isometric and isokinetic conditions and reported high reliability of both methods for trunk strength in youngsters. Despite investigating a homogeneous group of youngsters, the study demonstrates that isometric trunk strength is as reliable as an isokinetic condition. The study by Kienbacher et al. [10] who performed a test-retest for isometric strength of the

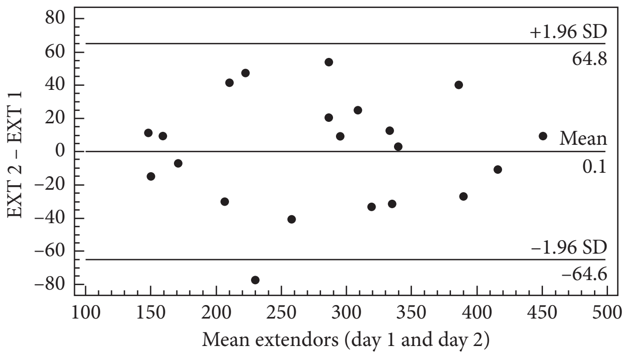


Figure 3: Graphical representation of Bland–Altman plot for visualization of the differences and averages between the first and second day of evaluation, obtained by the maximum strength (N) of the muscle trunk extensors (EXT) ($n = 21$).

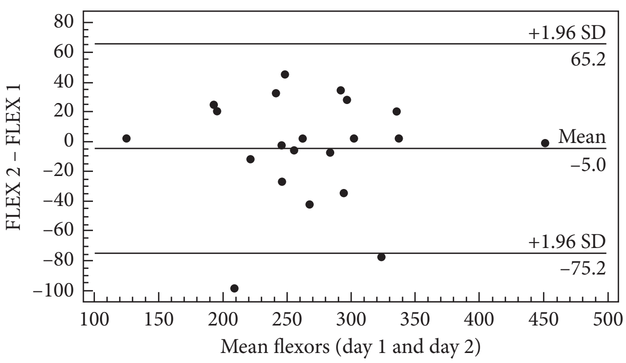


Figure 4: Graphical representation of Bland–Altman plot for visualization of differences and averages between the first and second day of evaluation, obtained by maximum strength trunk muscle flexor (FLEX) ($n = 21$).

trunk extensors and flexors in healthy individuals (>50 years old) observed ICC values ≥0.75 for both muscle groups. Thus, these measures had good reliability [10].

When analyzing the SEM of the instrument, low values ranged from 17.6 to 18.4% for the trunk extensors and flexors. A similar study, while examining the intraobserver reliability of the isometric trunk strength in subjects with chronic low back pain, indicated a high reliability of isometric dynamometry (0.93–0.97) and SEM that ranged from 26 to 51.7% for the strength of the back muscle flexors and extensors [5]. However, the population recruited in the aforementioned research cannot be compared to that in our study since the individuals with lower back pain have a distinct pattern of muscular recruitment, arising from the mechanism of the pain [21]. Alternatively, our findings are consistent when compared to the research by Kienbacher et al. [10] when analyzing the SEM for maximal isometric strength in women aged above 50 years, with values of 13.7 and 5.0% for the trunk extensors and flexors, respectively [10].

In addition to the reproducibility analysis, the MDD values were evaluated. According to Hopkins [11], the probability of finding the performance changes after an intervention depends on the absolute reliability; therefore, it becomes important to quantify the measurement error. Large variations of force in the repeated tests reduce the detection of changes over time. Thus, as many studies aim to detect the changes resulting from the interventions, it is important to adopt methods that allow the identification of minimal changes [11].

The MDD results of the trunk extensors (51.1 N) and flexors (48.9 N) of the test did not occur due to evaluation error. According to the data, a change value observed in a postintervention situation that is lower than the MDD is not distinguishable from the measurement error; it means that there was no change in the parameter evaluated. Similarly, if the value obtained is equal or above the values given in the table, this means that there was a true change in the maximum trunk strength assessed by the test. This study is the first one reporting absolute reliability statistics associated with maximal trunk strength tests in the older people; therefore, no comparison of these variables could be made. However, a similar study of maximal limb strength in older adults determined MDD for measurements of knee flexion and extension in individuals over 50 years old and observed an MDD between 46 and 79 N [22].

Considering the information obtained from the Bland–Altman plot, we observed uniform variability of mean performance for the two muscle groups tested, where the bias between the first and second day remained close to zero for a majority of the subjects. Therefore, the low dispersion observed results from the fact that all subjects presented values within the acceptable limits of agreement. Although a greater limit of concordance was observed for the measurement of the strength of the trunk flexor muscles, the outliers did not influence the homogeneous distribution of the point dispersion. Such a difference in distribution is common for measures of physical performance, which can be explained by both physiological and psychological phenomena [23].

Thus, it is important to emphasize that professionals need to be able to interpret the measurement changes of an evaluation instrument and consequently determine the effectiveness of different interventions. The test-retest studies provide information about relative reliability (ICC), that is, the degree to which the repeated measures reveal consistent classification of the individuals' scores within a group [24]. Absolute reliability measures (SEM and MDD) describe individual variability and measurement error. They are important in determining levels of clinically significant changes resulting from intervention processes [24]. Therefore, it is suggested that the fixed seating platform can be used to evaluate the isometric strength of the trunk muscles of the elderly, requiring only one evaluation session.

Our study has as a limitation regarding the extrapolation of data to force applied at other angles because it is an evaluation of isometric force. However, tests that evaluate different angulations, such as isokinetics, are usually costly. Thus, the main contribution of this study is to offer a simple and low-cost protocol that makes it possible to investigate a cause-and-effect relationship from different types of training, without the results being derived from a learning effect of the sample.

It is concluded that the test protocol for evaluation of the maximal isometric force of the trunk flexor and extensor muscles in elderly women presents high reliability. The reproducibility of the data in the test and retest, performed with an interval of 48 h between them, confirms the hypothesis of the authors regarding the consistency of the measuring instrument.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors thank the participants for their availability. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Brazil (Finance Code 001).

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