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Randomized Controlled Trial of Group Exercise Intervention for Fall Risk Factors Reduction in Nursing Home Residents

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Article

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Résumé

Objectif. Évaluer, chez des résidents de centres d'hébergement pour personnes âgées, l'efficacité d'une intervention multidimensionnelle en activité physique sur l'amélioration de facteurs de prévention liés au risque de chute, tels que la force et la flexibilité globales.
Méthodes. Un essai randomisé contrôlé multicentrique a été mené chez 40 personnes âgées (>65 ans) qui ont été réparties aléatoirement dans le groupe d'intervention ou le groupe contrôle (20 sujets dans chaque groupe). Le groupe d'intervention a suivi un programme d'exercices deux fois par semaine pendant huit semaines, afin d'améliorer la mobilité fonctionnelle. Le groupe témoin n'a reçu aucune intervention. Les mesures avant et après l'intervention comprenaient le test de la force de préhension des mains (*Hand Grip Strength testing*, HGS), le test assis-debout (*Sit to Stand Test*, SST), le test de grattage du dos (*Back Scratch Test*, BST) et le test position assise-atteinte (*Sit to Reach Test*, SRT).
Résultats. L'analyse par MANOVA a révélé des effets significatifs liés au temps [V=0,336, F(6,33)=2,78, p=0,027, η^2 partiel=0,336], au groupe [V=0,599, F(6,33)=8,22, p<0,001, η^2 partiel=0,599] et une interaction groupe*temps [V=0,908, F(6,33)=54,52, p<0,001, η^2 partiel=0,908]. Une analyse univariée subséquente n'a pas révélé d'effet significatif du temps, pour toutes les variables (p>0,05). Des effets de groupe significatifs ont été obtenus uniquement pour le SRT (p<0,05). Des interactions significatives groupe*temps ont été observées pour toutes les variables examinées (p<0,05). Les tests t dépendants ont montré que tous les paramètres étudiés se sont significativement améliorés chez les personnes âgées du groupe avec activité physique (p<0,05). À l'exception du SRT (p>0,05), tous les autres paramètres se sont détériorés de manière significative dans le groupe témoin (p<0,05).
Conclusion. Des améliorations significatives ont été démontrées en matière de force et de flexibilité chez des résidents de centres d'hébergement après un programme d'entraînement en groupe de huit semaines.

Abstract

Objective. The aim of this study was to assess the effectiveness of a multidimensional exercise intervention on improving fall risk deterrent factors, such as overall strength and flexibility in nursing home residents.
Methods. A multi-centre, randomized controlled trial was finally utilized in 40 older adults (>65 years) who were randomly allocated to the intervention or the control group (20 subjects in each). The intervention group attended an exercise program twice a week for eight weeks, to improve functional mobility. The control group did not receive any intervention. Measurements before and after intervention included the Hand Grip Strength (HGS) testing, the Sit-to-Stand test (SST), the Back Scratch Test (BST), and the Sit-and-Reach test (SRT).
Results. MANOVA revealed significant time effects, V = 0.336, $F(6, 33) = 2.78$, $p = 0.027$, partial $\eta^2 = 0.336$; group effects, V = 0.599, $F(6, 33) = 8.22$, $p < 0.001$, partial $\eta^2 = 0.599$; and group*time interaction, V = 0.908, $F(6, 33) = 54.52$, $p < 0.001$, partial $\eta^2 = 0.908$. A subsequent univariate analysis did not reveal a significant time effect for any variable ($p > 0.05$). Significant group effects were observed only for SRT ($p < 0.05$). Significant group*time interactions were observed for all the examined variables ($p < 0.05$). Dependent t-tests showed that the older adults in the exercise group were significantly improved in all the examined parameters ($p < 0.05$). Except for SRT ($p > 0.05$), all the other parameters significantly deteriorated in the control group ($p < 0.05$).
Conclusions. Significant improvements were demonstrated in strength and flexibility among nursing home residents following an eight-week group exercise training program.

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Introduction

Falls and fall-induced injuries are extremely common among older adults and result in a considerable increase in morbidity and mortality in this age group (Davis et al., 2010; World Health Organization, 2021). Multiple fall-prevention strategies for older people include monitoring contributing factors. These factors may be either intrinsic (changes in the body with aging), extrinsic (environmental conditions, surfaces), or a combination of both (Bleijlevens et al., 2010; Huang, 2005; Mortazavi, Tabatabaeichehr, Taherpour, & Masoumi, 2018; Unguryanu, Grjibovski, Trovik, Ytterstad, & Kudryavtsev, 2020; Vondracek & Linnebur, 2009). One of the most deleterious outcomes of aging is musculoskeletal disorders mainly due to significant loss of muscle strength (atrophy, weakness) and flexibility (Phillips & Haskell, 1995; Raad, Agre, McAdam, & Smith, 1988; Stathokostas, Little, Vandervoort, & Paterson, 2012), reduction of postural control (loss of balance) (Nuzzo, 2020; Robertson, Collins, Elliott, & Starks, 1994), impaired vestibular function (Lin & Bhattacharyya, 2012), musculoskeletal efficacy and functional ability (Bruce, 1989; Lord, Murray, Chapman, Munro, & Tiedemann, 2002).

Physical activity programs can improve older adults' physical well-being (Eduardo, Ronei, Martim, & Mikel, 2014; Evan, Xiaoyang, & Mahdi, 2017). Results from a variety of studies have shown that physical therapy intervention can have a positive impact on functional mobility, improve balance in neurological and musculoskeletal disorders, and reduce the levels of pain and the frequency of heart diseases in nursing home residents (Barnett, Smith, Lord, Williams, & Baumand, 2003; Lazowski et al., 1999; Littbrand, Lundin-Olsson, Gustafson, & Rosendahl, 2009; Mimi, Tang, Wan, & Vong, 2014; Papathanasiou, 2020; Pepera, Mpea, Krinta, Peristeropoulos, & Antoniou, 2021). A systematic review by Valenzuela (2012) has demonstrated that progressive resistance training can significantly improve the overall functional status in nursing home older adults.

Exercise interventions may also potentially have an effect on reducing fall risks, though only a small number of randomized controlled trials have evaluated this factor, with no overall benefit identified on falls outcomes. A recent randomized controlled trial (Hewitt, Goodall, Clemson, Henwood, & Refshauge, 2018) demonstrated a significant reduction in falls in a large sample, including residents with cognitive impairment, in residential care facilities. On the other hand, there is evidence referring that exercise intervention overall makes small or no effect on falls in nursing home residents (Arrieta, Rezola-Pardo, Gil, Irazusta, & Rodriguez-Larrad, 2018; Cameron et al., 2018).

Similarly, there is a lack of well-controlled studies to capture a complete picture of the multidimensional exercise training program effectiveness, based on strength and flexibility, in residents of nursing homes. Only a few of them included different types of exercise in their program (Gomez-Cabello, Ara, Gonzalez-Aguero, Casajus, & Vicente-Rodriguez, 2004; Langoni et al., 2019; Rezola-Pardo et al., 2019), whereas the minimum period of intervention, which could be necessary to record changes in physical function in older adults, remains unclear. Despite evidence suggesting that multidimensional exercise training may affect hemodynamic, gait, and balance parameters (Pepera et al., 2021), little is known of the impact of such training intervention in the overall strength and flexibility status of the older population.

The purpose of the study was to prospectively explore the effectiveness of a short-term, eight-week multidimensional training program in overall strength and flexibility in nursing home residents and one that could be used by physical therapists in clinical practice. The hypothesis of this study was that a short-term, eight-week multidimensional training program can improve strength and flexibility in nursing home residents.

Methods

Research Design

A single-blind, randomized, parallel-group, multi-centre design with pretest and posttest study (NCT04358653, ClinicalTrials.gov) was used. All participants signed an informed consent prior to participation to the study. This study was conducted in five phases: (a) Recruitment, (b) Randomization, (c) Baseline assessment, (d) Intervention (eight weeks), and (e) Second assessment (eight weeks from the start of the intervention). The flow chart of the study design is shown in Figure 1.

The randomization into groups significantly reduced the bias and aimed to distribute evenly different participants' characteristics to the groups. The incorporation of a control intervention is helping reduce the internal validity threats (i.e., history effects, maturation effects) and more clearly understand the real effects of the experimental intervention. This study was a part of a bigger study that was approved by the ethics committee of the University of Thessaly (Pepera et al., 2021).

Sample

The current study is part of a bigger study and the sample has been additionally described in a previous publication (Pepera et al., 2021). Eligibility criteria were (a) residents of long-term care facilities and (b) 65 years of age or above (World Health Organization, 2021). Exclusion criteria were (a) severe neurological diseases (e.g., multiple sclerosis, cerebrovascular disorders, stroke); (b) dementia; (c) severe heart failure (New York Heart Association class III, IV); (d) severe musculoskeletal diseases (e.g., severe rheumatoid arthritis); and (e) recent surgeries.

A diagnosis of dementia was reported in the participants' medical files kept in the nursing home files together with their prescribed medication treatment (psychotherapeutic drugs). The absence of dementia and other severe neurological diseases as exclusion criteria was based on the rationale to focus this research on the musculoskeletal disorders related to aging and their responses to an exercise program implementation. Moreover, the population of older adults with dementia is heterogeneous regarding the severity of dementia and number of comorbidities. In this case, more subgroup analyses would be required to detect clinical effects and enhance statistical power (Jongsma, van Bruchem-Visser, van de Vathorst, & Mattace Raso, 2016).

Participant recruitment

Participant recruitment occurred in three steps. Initially, 48 nursing home residents, both men and women, were recruited from three nursing homes, where they were provided nutritional, medical, and quality-of-life supplies and services. Potential participants were checked for eligibility based on their medical records. Finally, out of the 40 older adults meeting the previously mentioned criteria, 20 were randomly assigned (using random numbers generated by a computer) to the control group and 20 to the rehabilitation group. In both groups, half of the participants reported at least one

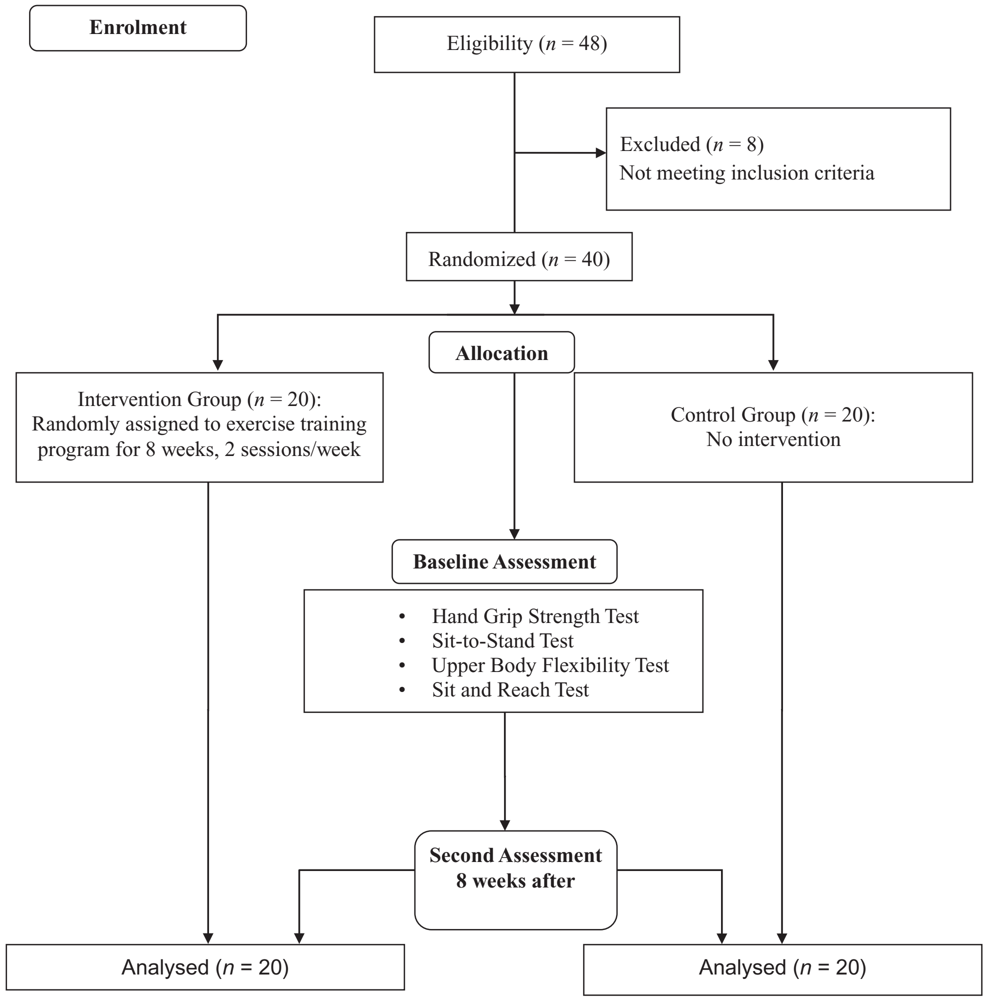

Figure 1. Flow chart of the study.

incidence of falling during the past year. A sample size calculation was performed with the software G*Power 3.1.9.4, and it was described in a previous publication (Pepera et al., 2021).

Data Collection and Blinding

All assessments and interventions were carried out by the same researchers (qualified physiotherapists). Before testing and training, researchers were trained in using tests and instruments. After each assessment, the data were stored and the researchers had no further access to them. Data were encoded in a spreadsheet and sent to another researcher to perform the data analysis. Lastly, the results were shared among the authors.

Intervention

The intervention program has been described in a previous publication (Pepera et al., 2021) (Table 1). The experimental group was designed to undergo a supervised exercise training program two days a week for eight consecutive weeks for 45–50 minutes per session. The intervention program was implemented at the nursing homes. The control group did not receive any intervention during that period, and the participants were instructed to pursue their habitual daily life activities.

Exercise intensity was monitored using the Borg CR10 scale (Foster et al., 2001). During the exercise intervention, participants were advised to keep up the exercise intensity between *3* (moderate exercise), *4* (somewhat hard exercise), and *5* (hard exercise) of the Borg scale. The Rating of Perceived Exertion (RPE) scale was positioned on the wall in the training room. The exercise intervention was designed to follow the exercise activity guidelines for older adults demonstrated by the American College of Sports Medicine (Garber et al., 2011) and American Heart Association (Nelson et al., 2007).

Participants were instructed to refrain from drinking alcohol and caffeine beverages 24 hours before testing and training. Dietary intake wasn't controlled; however, it was recommended they stay with their usual diet during the period of the study. They were advised to avoid participation in any other exercise program. All evaluations and intervention sessions occurred at the same time each day, between 8:00 a.m. and 10:00 a.m.

Throughout the duration of the study, the participants, as a whole, were supervised and assessed by a qualified physiotherapist and two final-year physical therapy students (20:3, participants to staff ratio). As an exception was the balance training. Participants were divided into five groups of four participants in each, so the participant to staff/supervision ratio was 3:4 each time. Chairs were positioned nearby the participants (not in front of them), and they were allowed to sit on them only while their awaiting the balance training exercises.

Table 1. Exercise training program

Exercise Training Program (50 minutes)		
Warm up (10 minutes)	Main component (30 minutes)	Cool down (10 minutes)
• Five minutes circular walking • Muscle strengthening exercise – upper extremity (deltoid, triceps, rotator cuff muscles) • Muscle strengthening exercise – lower extremity (quadriceps and hamstrings)	**Muscle strengthening exercise program (10 reps)** • Lower extremity strengthening program with low resistance bands (hip flexion, extension, abduction, adduction, knee flexion and extension, ankle dorsi and plantar flexion, using resistance bands) • Heel and toe rising • Upper limb strengthening using dumbbells (1 kg) **Balance training (10 reps)** • Standing on one leg • Shifting weight laterally from one foot to the other • Staggered stance • Sidestepping **Functional mobility training (10 reps)** • Walking upstairs and downstairs (five steps with handrails, 30 inches wide by 11 inches deep) • Standing up from sitting to upright position	• Five minutes circular walking • Muscle strengthening exercise – upper extremity (deltoid, triceps, rotator cuff muscles) • Muscle strengthening exercise – lower extremity (quadriceps and hamstrings)

Assessments and Outcome Measures

Assessment was based on physical functional measurements that have been shown to be related to falls. Participants were assessed at baseline and after the eight-week exercise program intervention. The following six primary outcome measures were assessed to evaluate the effectiveness of the multidimensional exercise program.

Outcome measures

Apart from the primary outcome measures, other baseline characteristics were measured: (a) anthropometric and demographic data (age, weight, height); (b) comorbid medical conditions; and (c) prior history of falls and fall-related injuries during the past year (World Health Organization, 2008).

Upper extremity strength. This was measured through hand grip strength (HGS) testing, using the SAEHAN hand grip dynamometer (Model SH5001; SAEHAN Corporation, Yangdeok-Dong, Masan, South Korea). The participants were seated on a standard chair with the elbow flexed at 90^{o}. When the participants were ready, they would begin to strain the device in a maximal isometric effort, maintaining, at the same time, high concentration, as this was a required condition for maximal results. No other body movement was allowed during testing (Romero, Bishop, Velozo, & Light, 2011). Test–retest reliability of HGS has been proven to be excellent (intraclass correlation coefficient [ICC] > 0.95, 95% CI), and minimum detectable change (MDC) scores for the hand was 5.0 kg in nursing home residents (Bohannon, 1998).

Lower extremity strength. This was assessed through the Sit-to-Stand test (STS). Participants were asked to sit on a chair, stand up, and return to the sitting position for five consecutive times at full speed, with no intervals between. The normal time expected for the successful completion of the trial was estimated at 24–27 seconds (Lin & Bhattacharrya, 2012; Oliveira Gonçalves et al., 2019). Reliability of the STS test has been found to be highly significant (ICC > 0.90), and the MDC has been estimated at 2.5 seconds (Bobos, Nazari, Lu, & MacDermid, 2020).

Upper body flexibility. This was assessed through the Back Scratch test (BST). Participants were instructed to bring their hand back as high as possible to reach the seventh cervical vertebra (C7) with the thumb. The distance between the thumb and the seventh cervical vertebra (C7) was measured (Oliveira Gonçalves et al., 2019). Reliability of the BST has been found to be excellent (ICC > 0.95, 95% CI), whereas the MDC has been estimated at 1.42 cm (Whitney et al., 2005).

Lower body flexibility. This was assessed using a modified Sit and Reach test (SRT). This test was performed in a standard chair with one leg fully extended and the other in a flexed position. Participants reached forward with one hand as far as possible and held this position for three seconds. The distance between fingers and toes was measured (Rikli & Jones, 2001). The test–retest reliability of RST has been found to be excellent (ICC > 0.95, 95% CI), whereas the MDC has been estimated at 1.56 cm (Goldberg, Chavis, Watkins, & Wilson, 2012).

Statistical Analysis

Data analysis

The normality of data was examined using Kolmogorov-Smirnov tests. The comparison of baseline characteristics of participants between study groups was examined with independent t-tests when the data were parametric and with an χ^2 when the data were from a nominal scale. The baseline characteristics were described by using means, SDs, number of observations, percentages, and p values.

Multivariate Analysis of Variance (MANOVA) was used to examine the main effects (group effects, time effects) and group*time interactions, considering that a degree of correlation exists between the four dependent variables (HGS, STS, BST, and SRT). MANOVA was performed on a design including two independent variables: one factorial (group: intervention, control) and one repeated measure (time: before, after). Univariate analysis followed multivariate analysis. The effects were expressed by using means, SDs, mean differences, 95 per cent CIs, F statistics, degrees of freedom (dfs), effect size η^2, observed power, and p values.

The effectiveness of the control and experimental intervention was also examined by using dependent t-test for each group and by comparing the pre- with the post-scores. The effects were expressed by using means, SDs, mean differences, 95 per cent CIs, per cent change, t statistics, dfs, pre-post correlations (r), and p values.

The significance level was set at $p = 0.05$. Statistical Package for Social Sciences (SPSS), version 25, was used for all data analyses.

Results

Data were normally distributed (Kolmogorov–Smirnov, $p > 0.05$). At baseline, the only significant difference between groups was found for SRT (higher in the control group, $M_{diff} = 1.5$ cm; $p < 0.05$). All the other characteristics were not significantly different between the groups ($p > 0.05$) (Table 2). None out of the 40 participants (20 for the intervention group and 20 for the control group) dropped out of the study (Pepera et al., 2021).

Using MANOVA, Box's Test was found to be non-significant ($p = 0.09$). Based on Pillai's Trace, MANOVA revealed a significant between-subjects (group) effect, V = 0.599, $F(6, 33) = 8.22$, $p < 0.001$, partial $\eta^2 = 0.599$, observed power = 1; a significant within-subjects (time) effect, V = 0.336, $F(6, 33) = 2.78$, $p = 0.027$, partial $\eta^2 = 0.336$, observed power = 0.808; and a significant group*time interaction, V = 0.908, $F(6, 33) = 54.52$, $p < 0.001$, partial $\eta^2 = 0.908$, observed power = 1.

Univariate analysis of variance did not reveal a significant time main effect on any variable ($p > 0.05$). Significant group main effects were observed for SRT ($p < 0.05$) but not for the other dependent variables ($p > 0.05$). Significant group*time interactions were observed for all the dependent variables (HGS, STS, BST, SRT) ($p < 0.05$). The results of univariate analysis and the corresponding pairwise comparisons are analytically presented in Table 3.

Dependent t-tests showed that all the variables significantly changed from baseline to the end of intervention in both groups ($p < 0.05$). The only exception was the change of the SRT for the control group, which was found to be non-significant ($p > 0.05$). Each variable, however, changed in a different direction for the experimental and control group. The effect sizes of the changes for all the variables were found to be small to medium (0.07–0.30) for both groups. The only exception was the effect sizes for the SRT, which were medium to high (0.46–0.93). The results of this pre-post analysis are analytically presented in Table 4.

No musculoskeletal (muscle strain or joint pain), suicide, cardiovascular, or respiratory adverse-related events to the intervention were reported.

Discussion

A multidimensional exercise program can improve hemodynamic function (blood pressure and heart rate resting), balance, and gait ability in nursing home residents (Pepera et al., 2021). The present study aimed to assess the effectiveness of a group exercise program in the reduction of important fall risk factors (such as overall strength and flexibility) in care-home residents and to develop a therapeutic exercise program for this population. All fall risk factors showed statistically significant improvement after an

Table 2. Baseline characteristics and differences between the groups

	Experimental Group	Control Group	*p*
Number of participants (*n*)	20	20	
Gender (m/f)	5 (35%) / 15 (75%)	6 (30%) / 14 (70%)	0.72
Age (years)	79.6 (7.4)	79.3 (5.5)	0.89
HGS (kg)	19.9 (7.2)	18.0 (5.1)	0.34
STS (sec)	61.7 (7.3)	59.3 (7.5)	0.31
BST (cm)	24.9 (7.1)	20.4 (9.1)	0.09
SRT (cm)	4.8 (2.2)	6.3 (2.3)	0.04

Notes. HGS = Hand Grip Strength; STS = Sit-to-Stand Test; BST = Back Scratch Test; SRT = Sit and Reach Test.

Table 3. Results from the univariate analysis of variance

						Pairwise Comparisons		
VARIABLES	EFFECTS	*F*	η^2	*p*	Observed Power	Mean difference	95% CI	*p*
	Group*Time	76.000	0.667	<0.001	1.000			
HGS (kg)	Group effect	2.197	0.055	0.146	0.304	2.875	−1.051, 6.801	0.146
	Time effect	0.900	0.023	0.349	0.152	0.175	−0.199, 0.549	0.349
	Group*Time	27.922	0.424	<0.001	0.999			
STS (sec)	Group effect	0.004	0.000	0.950	0.050	0.150	−4.659, 4.959	0.950
	Time effect	0.323	0.008	0.573	0.086	−0.100	−0.456, 0.256	0.573
	Group*Time	163.376	0.373	<0.001	1.000	–	–	–
BST (cm)	Group effect	1.408	0.036	0.243	0.212	3.000	−2.118, 8.118	0.243
	Time effect	2.000	0.050	0.165	0.281	0.250	−0.108, 0.608	0.165
	Group*Time	72.000	0.655	<0.001	1.000	–	–	–
SRT (cm)	Group effect	40.603	0.517	<0.001	1.000	−3.225	−4.250, −2.200	<0.001
	Time effect	3.673	0.088	0.063	0.463	0.675	−0.038, 1.388	0.063
	Group*Time	22.618	0.811	<0.001	0.996	–	–	–

Notes. HGS = Hand Grip Strength; STS = Sit-to-Stand Test; BST = Back Scratch Test; SRT = Sit and Reach Test.

Table 4. Pre–post differences for each examined variable

VARIABLE	GROUP	M_{pre} (SD)	M_{post} (SD)	Mean Difference	95% CI	% Change	t	df	r	Effect Size	p
HGS (kg)	Experimental	19.9 (7.2)	20.7 (7.2)	−0.8	−1.27, −0.33	-4	−3.56	19	0.99	0.11	0.002
	Control	18.0 (5.1)	16.9 (4.8)	1.1	0.54, 1.76	5.6	3.93	19	0.97	0.22	0.001
STS (sec)	Experimental	61.7 (7.3)	59.5 (7.2)	2.2	1.69, 2.61	3.6	9.73	19	0.99	0.30	<0.001
	Control	59.3 (7.5)	61.6 (8.0)	−2.3	−2.92, −1.78	−3.9	−8.57	19	0.99	0.30	<0.001
BST (cm)	Experimental	24.9 (7.1)	23.1 (7.0)	1.8	1.23, 2.27	7.2	7.00	19	0.99	0.26	<0.001
	Control	20.4 (9.1)	21.6 (8.6)	−1.2	−1.77, −0.73	−6.9	−5.00	19	0.99	0.14	<0.001
SRT (cm)	Experimental	4.8 (3.5)	2.4 (1.1)	2.4	1.68, 3.02	50	7.38	19	0.84	0.93	<0.001
	Control	6.3 (2.3)	7.3 (2.0)	−1.0	−2.32, 0.32	−15.9	−1.59	19	0.13	0.46	0.13

Notes. HGS = Hand Grip Strength; STS = Sit-to-Stand Test; BST = Back Scratch Test; SRT = Sit and Reach Test.

eight-week, short-term multidimensional exercise program. Specifically, both strength and flexibility in the lower and upper body were improved in the exercise group, whereas the same rates worsened in the control group.

Functional fitness level is shown to be lower among institutionalized older adults compared with those living independently (Bhattacharya, Deka, & Roy, 2016). Thus, there is no surprise that an exercise program will enhance their physical abilities. According to the World Health Organization, 28–34 per cent of people ages 65 years and older will experience at least one incidence of falling every year, a rate that is increased with age and frailty level. With an annual cost of €25 billion EUR in the European Union, falls create a significant negative impact in the society as a whole (Carande-Kulis, Stevens, Florence, Beattie, & Arias, 2015; Davis et al., 2010; World Health Organization, 2021). Understanding ways to reduce the risk of falling and frailty, especially in the older population, is vital since it can significantly reduce their morbidity and mortality (World Health Organization, 2021).

Many studies have shown that both individual and group programs can similarly reduce the intrinsic risk factors of falling, such as strength, balance, range of motion, and functional mobility in both nursing home settings (Arrieta et al., 2018; Hewitt et al., 2018; Rezola-Pardo et al., 2019; Sherrington et al., 2017) and community settings (Cameron et al., 2018; Carter, Campbell, Sanson-Fisher, Redman, & Gillespie, 1997; De Vries et al., 2012; Furtado, Sousa, Simao, Pereira, & Vilaca-Alves, 2015; Gillespie et al., 2012; Hill & Schwarz, 2004; Patel & Pachpute, 2015). Taking into consideration that in most cases of falling there is a combination of factors that lead to the fall accident, it is logical that the more factors coexist, the more the risk increases (Gomez-Cabello et al., 2004). A prevention program that addresses more risk factors is more effective than one that focuses on just one factor alone (Eduardo et al., 2014). Since exercise can have many positive results on physical, cognitive, and social elements, it is highly surprising that these programs are not commonly used as a standard practice in nursing home residents.

In our study, we found that an eight-week, multidimensional exercise program was capable enough to improve fall risk factors and enhance overall strength and flexibility. In comparison with another study, with a similar sample size, equivalent results in strength, balance, and functional mobility were observed, although in that study the exercise program was far more frequent (Zhuang, Huang, Wu, & Zhang, 2014).

The intervention of this study demonstrated that the magnitude of changes was lower in upper extremity strength (0.8 than 5 kg), lower extremity strength (2.2 than 2.5 kg) than the reported MCD values. In contrast, the same intervention exercise program showed higher magnitude of changes in upper body flexibility (1.8 than 1.42 cm) and lower body flexibility (2.4 than 1.56 cm) than the reported MCD values. It was concluded that clinically meaningful changes were observed in flexibility components only.

A systematic review by Arietta et al. (2018) suggested that, although there was considerable heterogeneity among studies (seven finally included), multidimensional physical exercise programs are effective on improving physical functioning mobility in nursing home residents. It is also worth mentioning that, based on the results of this study and the similar ones from the study of Hewitt et al. (2018), the need to intergrade such multidimensional exercise programs as fall prevention strategies in nursing home residents is highly recommendable.

A systematic review showed that exercise programs based on functional exercises were correlated to an improvement of physical function. However, the impact of the coexistence of visual impairments on fall frequency isn't clearly defined (Gleeson, Sherrington, & Keay, 2014). Similarly, another meta-analysis of 12 studies with 1,292 participants living in nursing homes concluded that exercise programs can prevent falls but not fractures, in this population (Silva, Eslick, & Duque, 2013).

Contrary to the results in nursing homes, exercise intervention seems to have a positive impact on fall reduction in community-dwelling older individuals. Specifically, a meta-analysis of 19 studies including 649 participants living in the community, published recently, showed significant improvements in strength and flexibility after exercise programs using elastic bands (Yeun, 2017). In another study in 56 community-dwelling people ages 60–80 years, statistical significant improvement in the timed up and go test (TUG) and the chair stand test of this population was reported (Zhuang et al., 2014). Similarly, a recent randomized longitudinal clinical trial study demonstrated that a home-based balance and strength exercise training program significantly reduced the rate of falls in community-dwelling older people with a history of falling (Liu-Ambrose et al., 2019). This, however, was a single-centre study and such bias can limit ability for generalization.

Okubo et al. (2014) compared two exercise groups, one of a walking and one of a balance training. They found small but significant changes in lower extremity strength and dynamic balance levels in both groups; however, walking alone managed to increase the number of daily steps and the fall self-efficacy score (Okubo et al., 2014). The majority of the studies related with small effect sizes in community-dwelling settings (Crocker et al., 2013). Similarly, our study showed small to medium effect size changes in physical function components.

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There are a few randomized controlled trials that have shown that exercise can improve mobility, but it can be unsuccessful in reducing falls (Cameron et al., 2018; Gardner, Robertson, & Campbell, 2000). Moreover, some recent systematic reviews in the nursing home setting have not provided strong evidence of the benefits of exercise on the older residents' physical performance or falls outcomes. Nevertheless, physical and functional gains of exercise are not to be doubted, but it is suggested that further research is needed to take the next step in order to determine whether a multidimensional exercise program actually does reduce risk of falls.

Limitations of the Study

Among the limitations of this study are the (a) small duration of the study, which was completed in eight weeks; (b) possibility of research bias, since the investigators had a role in the study design; (c) data collection and analysis; and (d) small sample size. Despite the initial sample randomization, substantial baseline differences in the groups were recorded, negatively affecting the homogeneity of the sample. Additionally, by setting the presence of cognitive impairment as an exclusion sample criteria, a significant number of home care residents, also at a high risk of falls, were left out. Furthermore, it needs to be determined whether the positive outcomes observed on physical performance measures, as a result of exercise implementation, can translate to a reduction of falls in the older residents. Additionally, the fact that the control group did not receive any exercise intervention may have affected the results of the study. Lastly, the population was exclusively nursing home residents, and their results cannot be generalized to other settings.

Conclusion

Despite the beneficial effects of an exercise program on the older population's strength and flexibility status demonstrated in this study, further evidence is needed in a larger sample, by using stratified normative outcomes for age and gender, so as to make safe conclusions. Additional studies are also needed to examine the long-term benefits of this exercise intervention program and to identify the time-dependent effects of a longitudinal exercise program on fall risk factor reduction. In addition to the assessment of the upper and lower extremities' strength and flexibility, a comprehensive assessment of the trunk function, including the lumbar extensor muscles, should be incorporated in future studies (Vlažná et al., 2021). Within the exercise group, the study should resume comparing the reduction of risks between the older adults who actually had previous falls and those who had not. Furthermore, the role of Information and Communication Technologies (ICT) through telephone communication, telemonitoring, and tele-exercise programs, in a home fall prevention program, could be beneficial in improving patients' compliance, as well as adopting a more personally prescribed exercise prevention program based on each patient's risk profile (Bernocchi et al., 2019; Giordano et al., 2016). Especially nowadays, with the current COVID-19 pandemic affecting the entire world, the use and integration of mobile technologies as fall prevention strategies are highly recommended for future research. Lastly, the safe implementation of fall prevention exercise programs in older residents with dementia should be considered and examined in future research.

The findings of the present thesis are important with regard to clinical practice in physiotherapy. Small but significant improvements were demonstrated in strength and flexibility among nursing home residents following a low intensity and short-duration multidimensional group exercise training program. The program described in this study has been proven to be efficient, easy to be implemented, and inexpensive, as it requires only simple equipment and thus it appears to be an ideal choice for the training of older people in nursing homes on clinical physiotherapy practice. It would be of value to extend the exercise program to a long-term investigation with follow-up, before trying to generalize the findings.

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