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The effects of different types of physical exercise on physical and cognitive function in frail institutionalized older adults with mild to moderate cognitive impairment. A randomized controlled trial

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ABSTRACT

Background: The continuous increase in the life expectancy of older adults (elderly people) has generated interest in research into frail-aged people and their physical and mental well-being.
Objectives: To verify the different effects of two programs of physical exercise (strength training-TG, and callisthenic training-MG) on the cognitive state, functionality, stability and general health of frail-aged institutionalized older adults.
Design: This study was a block randomized controlled trial.
Setting: The study was conducted in geriatric units of the San Rosendo Foundation.
Participants: A total of 77 institutionalized frail-aged people (70.1% female, aged 84.8 ± 7.9) took part.
Interventions: The TG carried out a strength program with therabands®; The MG performed an exercise program of multi-callisthenics, and the CG did not carry out any physical exercise.
Measurements: The following measurements were used: Minimental test, Pfeiffer test, SF-12, Barthel test, Five times sit-to-stand and a pressure platform.
Results: The TG program generated some improvement in cognitive state and functional independence, while in the physical and mental component of the S-12, significant improvement was generated. The program undertaken by MG demonstrated a tendency to the stabilization of the above mentioned parameters, while the GC demonstrated a tendency to deterioration.
Conclusion: Physical exercise, whether it be the strength program, or the multi-calisthenics program, is an effective method for improving and maintaining health, cognitive state, functional independence and stability in frail-aged institutionalized people.

1. Introduction

The National Statistics Institute of Spain (INE), in its report of 2016 states that the population of over 65 s is 8.7 million and makes up 18.7% of the total Spanish population. Every year the number of centenarians, and therefore overall longevity, increases. Since 2002 this percentage has been increasing exponentially, and it has been estimated that the population aged 65 and above will more than double between 2012 and 2060. The continuous increase in the life expectancy of older adults has generated interest towards research into this demographic and in particular, the so-called ``frail- aged¨. Frailty is defined as a state of vulnerability that entails a higher risk of adverse results (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013); being as it is a transition phase between good health and bad health. To define a person as frail, they must meet at least three of the following criteria: involuntary weight loss, muscular weakness, slow walking speed, low levels of physical activity, exhaustion and a lack of energy (Fried et al., 2001). Frailty is more prevalent in the elderly and those with multiple medical conditions.

A physically inactive lifestyle decreases cardio-respiratory resistance, flexibility, muscular strength and mobility (balance and intra/intermuscular coordination). In this sense, physical inactivity (or a low level of physical activity) is one of the most significant indicators of a tendency to frailty (Levers, Estabrooks, & Ross Kerr, 2006). As a result, the effects of physical exercise on ageing and especially on frailty have been the subject of much recent scientific research. As a result, it has been shown that an increase in physical activity by elderly people is associated with a decreased risk of mortality, chronic diseases, institutionalization, and cognitive and functional decline (Izquierdo Gabarren, Cadore, & Casas Herrero, 2014). Therefore, physical training

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appears to be an important tool in improving the health of this population, as the aforementioned exercise can improve physiological factors such as strength, cardiovascular endurance and flexibility; mobility (balance and walking), and psychological issues such as the perception of health, fear of falling and general wellbeing (Barreto, 2009; Rolland, Dupuy, Abellan van Kan, Gillette, & Vellas, 2011).

Currently, there are disagreements about which is the most appropriate type of physical exercise to bring about the greatest benefits to the frail-aged population. However, the most effective preventive measure to delay the onset of sarcopenia and/or frailty in the elderly, is strength training. Several studies and systematic reviews have shown that even in the oldest and most frail elderly individuals, strength training increases muscle mass, power and muscle strength, in addition to improving some objective parameters of frailty, such as walking speed (Hasten, Pak-Loduca, Obert, & Yarasheski, 2000; Rolland et al., 2011; Seguin & Nelson, 2003). Although initially the results for functional improvement through strength training were unclear, it did demonstrate its effectiveness as an intervention for improving physical function and the delay of disability in the elderly, which is the main adverse effect of frailty (Liu & Latham, 2009). Therefore, strength training results in increasingly favorable outcomes in this population group, and its effects are also highlighted in other areas, such as the cognitive and functional. Currently there are discrepancies between whether multi-component programs or strength training programs are more effective in the elderly and frail population (Casas Herrero & Izquierdo, 2012).

The aim of this research is to investigate the different effects of two programs of physical exercise (strength training using therabands®, and multicomponent training by means of callisthenic exercise) on the cognitive state, motor function (ability to maintain, modify and control posture and movement patterns), stability (an individual's ability to maintain posture and center of gravity within stable limits and with a good basis of core stability) and general health (a complete state of physical, mental, and social well-being, and not just the absence of disease in frail institutionalized elderly adults.

2. Materials and methods

A block randomized controlled design in which three groups take part. One group undertook a program of muscular strength training by means of Therabands® (TG), a second group underwent a program of general training by means of Multi- Callisthenics and a third group, the control group (CG) did not perform any physical activity. The evaluations were carried out at the beginning and the end of the trial (12 weeks later). The same variables were collected in all evaluations. The evaluations were carried out by a physiotherapist and two physical exercise and health professionals with more than 5 years experience working with elderly institutionalized people, independent of the “Fundación San Rosendo”

2.1. Participants

Participants in this study were recruited through a collaborative agreement between the University of Vigo (Spain) and “Fundación San Rosendo”, a management company of residential care homes for the elderly in Spain, from which in this study participated three Residential Care Homes (RCH) located in the city of XXXX (XXXX, XXXX), guaranteeing the homogeneity of the socioeconomic and cultural level of the participants. In addition, as the care homes belong to the same company, they have the same working methodology in all the centres, which means that they are equivalent. Individuals with the following criteria were included: (a) Frail-aged adults (Fried et al., 2001), (b) aged over 75 years, (c) diagnosed with mild to moderate cognitive impairment (Blesa et al., 2001; Lobo et al., 1999), (d) able to stand and walk for at least 30 m without shortness of breath (d) able to walk safely and independently without aid (e) resident of a geriatric long-term care home. Excluded were individuals with a clinical diagnosis of dementia and medical conditions that hindered or prevented a full and complete participation in the evaluation tests. A total of 77 subjects met the inclusion criteria, of which 25 subjects resided in Residential Care Home 1 (RCH1), 23 subjects resided in Residential Care Home 2 (RCH2) and 29 subjects resided in Residential Care Home 3 (RCH3). In order to assign the intervention to the subjects, it was verified that the sample of each of the centres was homogeneous. Intervention programs were randomly assigned by center. Randomisation was carried out using IBM SPSS Statistics Software following the sequence: Data/select cases/ random sample of cases/exact 1 case of the 3 total cases.

2.2. Procedures

All the participants and their families were previously informed about the characteristics of the research protocol. The study was approved by the Clinical Research Ethical Committee of XX (CE 14-1009-17) and all participants gave their informed consent. The research has been registered in the European Clinical Trials Data Base, and assigned the following number: 2018-001087-36

2.3. Instruments

The participants were assessed one week before the beginning of the program (week 0), and at the end of the intervention (week 12). The variables analyzed were the following:

2.3.1. Anthropometric measurement

Height (cm) and weight (kg) were measured without shoes and with light clothes. The body mass index (BMI) was calculated using the following formula: weight/height^2 (kg/m^2). The weight was assessed by means of electronic scales, using a Tanita TBF300 model with a tolerance of 0.1 kg. Height was assessed by using a stadiometer, a Handac model with a tolerance of 1.0 mm.

2.3.2. Evaluation of stationary balance

This was evaluated by means of the pressure platform E.P.S.-R1 of the LORAN-Engineering Company (Italy). The aforementioned platform is composed of 2304 sensors in an active surface of 2400 cm^2, with a thickness of 7 mm that facilitates the stationary bipedal analysis of the patients. The application protocol was as follows: 1. Mounting the platform barefoot. 2. Placing feet parallel and hip-width apart over the marks indicated on the platform. 3. Arms by sides. 4. Looking forwards observing a fixed point at eye level. 5. The patient must remain in this position for 15 s.

2.3.3. Functional assessment

This was evaluated by means of the Barthel index and Five times Sit-to-stand test (FTSTS). The Barthel index is a 10-point questionnaire which assesses the level of independence (Mahoney & Barthel, 1965). The FTSTS is a test that is part of the Short Physical Performance Battery (Guralnik et al., 2000). The test consists of getting up from and sitting down in a chair 5 times, in the least possible time, and evaluates strength-speed in the lower body.

2.3.4. General evaluation of the state of health

This was evaluated by means of the health questionnaire 12-Item Short Form survey (SF-12) short version and adapted for Spain (Alonso et al., 1998) from the 36 item Short Form Health Survey (McHorney, Ware, & Raczek, 1993).

2.3.5. Cognitive assessment

Cognitive ability was assessed by means of two texts: a Mini Mental State Examination text and a Pfeiffer text. The Mini Mental State Examination text, developed by Folstein, Folstein, and McHugh (1975), and revalidated in Spanish by Lobo et al. (1999), allows for screening of

dementia and is useful in monitoring the development of the patient´s cognitive state. The Pfeiffer test, developed by Pfeiffer (1975) and revalidated in Spanish by Martinez de la Iglesia et al. (2001), evaluates the cognitive deterioration by means of 10 questions.

2.4. Programs

Each of the three Residential Care Homes (RCH) was randomly assigned an intervention program, after checking their homogeneity. Thus, in RCH1 the program was carried out with Therabands® (TG), in RCH2 the Multi-Callistenics (MG) program was undertaken and in RCH3 the control program (CG) was used. The participants assigned to TG carried out a program of strength-based physical exercise focused on the lower limbs, by means of resistance elastic bands (TheraBands®). There were a total of 24 sessions, scheduled as 2 non-consecutive sessions a week for 12 weeks, with a duration of 60 min per session. The sessions consisted of 10 min of warm up exercises working on the mobility of the ankle, knee and hip joints; a main part of 45 min, which consisted of 10 strengthening exercises for the lower limbs (plantar and dorsal flexors, flexors and knee extensors, flexors, extensors, abductors and hip rotators) of which 2–4 are used per session; a 5 min cool-down, with stretching of the aforementioned muscles. During weeks 1&2, 2 exercises were undertaken in the main part, which were 2 sets of 10 repetitions with breaks of 40 s between sets, and of 60 s between exercises. During weeks 4–6, 3 series of 3 exercises were undertaken, this time of 15 repetitions, with the same intervals. During weeks 7–8, 2 exercises were performed with the same number of repetitions, sets and amount of rest. Weeks 10–12, 4 exercises were performed with the same number of repetitions and sets, but shorter periods of rest, of 30 s per set, and 50 s between exercises. This program was undertaken in three groups, made up of 8,8 and 9 participants respectively.

Participants in the MG took part in a traditional physical exercise program designed for institutionalized elderly people, aimed at increasing the range of mobility and coordination, specifically focused on the lower limbs. The exercises in this program of multi-calisthenics were performed mostly in the seated position. The exercises that were performed in the standing position required assistance. The participants in this program undertook a total of 24 sessions, scheduled as two sessions per week (1 session of calisthenics exercises and 1 session of playful callisthenic games), for 12 weeks with a duration of 60 min per session. It should be emphasized that the objectives of the session of playful callisthenic games were not only for enjoyment and social integration, but also for improvement in physical condition (strength, stamina, speed and flexibility). This program was undertaken in three groups, made up of 8,8 and 7 participants respectively.

In both the TG and the MG, the activities were conducted and controlled by health and fitness professionals specializing in physical activity for older adults.

The participants assigned to the CG undertook the activities that the institutional center required of them (crafts, reading comprehension and cognitive stimulation), but no programs related to physical exercise. The crafts, reading comprehension and cognitive stimulation activities were also carried out by groups TG and MG, and coordinated by the San Rosendo Foundation, as the withholding of these activities was considered unethical by the research team. This program was undertaken by groups, the groups being made up of a variable number of participants (4–8) depending on the activity being undertaken. It should be noted that this cognitive stimulation program was applied twice a week with a duration of 60 min.

2.5. Statistical analysis

A descriptive analysis was carried out through measurements of central tendency (mean and standard deviation) and percentages of cognitive and functional variables and static balance both in a global form and by segmenting the database by type of program. The sample was randomly arranged into the groups using the statistical package IBM-SPSS v21 for Windows. The normality of the variables of the study was verified using the Kolmogorov-Smirnov test ($p > 0.05$). One-way analysis of variance (ANOVA) was performed to analyze the homogeneity of the sample populations at pretest. The analysis of the effect of the programs (TG, MG, CG) on the different variables analyzed was carried out through the application of the paired students´ *t*-test

A 2 × 3 repeated measures ANOVA was performed to determine the differences between time (pre vs. post) and programs (TG, MG, CG) as well as a possible interaction between the time and the intervention programs. Post-hoc analyses (Tukey-s test) were used to detect differences amongst groups. Data were analyzed using the statistical package IBM-SPSS v21 for Windows. The significance was considered for $p < 0.05$.

The sample size calculation was carried out by means of the statistical power analysis program G*Power 3.1.3 that allows for this type of analysis in studies designed with a variable program (TG, MG, CG) and repeated measurements (time). The calculation of the size of the sample was performed based on the effects that the training had on the strength levels in frail and pre-frail elderly people (d = 0.96) (Haider et al., 2017). We assumed an error type I = 0.05 (alpha), a power = 0.95 (1-Beta), and an average size of the effect = 0.96 (f). We took into account the need to form three groups (1.Therabands Group, 2. Multi-Calistenic Group 3. Control Group) and that the information would be collected on two occasions. To analyze the effects (programs and time) and the interaction between them, it is necessary that each group has a size of 29 people (n) in order to be able to identify differences between them. Nevertheless we assumed that there would be a 25% loss in the sample size of the group and, for this reason, the final number per group would be 30 people/program.

3. Results

From a total of 206 elderly people who qualified for the test, a total of 90 people from three different geriatric residences, were selected at random (Fig. 1). Each of the three centers was assigned the following groups of 30 at random: Geriatric A (TG, Therabands Group, n = 30), Geriatric B (MG, Multi-Calisthenic Group) and Geriatric C (CG, Control Group; n = 30). A total of 13 people did not complete the study, for the following reasons: death(2), illness (4), moved to another residence(5) and surgical intervention which made it impossible to continue in the program(2). A total of 77 elderly people completed the study (70.1% female) with an average age of 84.8 ± 7.9. The sample sizes of each of the groups were the following: (TG, n = 25; MG, n = 23; CG, n = 29). The descriptive characteristics of the sample are noted in Table 1, emphasizing the fact that the groups were homogenous in the beginning. In Tables 2a and 2b, the results obtained in the different variables are shown in each group before and after the intervention and comparing the programs (TG, MG, CG). As can be seen, with respect to the cognitive assessment, the CG is the only group which demonstrated significant deterioration in the Pfeifer test, while in the functional evaluation, no significant result is recorded for any group. In the Health evaluation, the TG showed significant improvement in 7 areas of the SF-12 questionnaire: (physical state, general health, social function, emotional state, mental health, physical and mental component), while the MG showed improvement in 4 areas (physical state emotional state, mental health and mental component). The CG, in contrast, shows significant deterioration in 4 areas (physical state, emotional state, mental health and mental component). For the static balance evaluation there were no significant differences for any of the variables in any of the groups.

The Tables 2a and 2b show the analysis comparing the programs, identifying the percentage of improvement and the size of the effect of each of the completed programs on cognition, function, health and static balance. For cognitive assessment the results show an improvement of 13.4% in the minimental test for the TG with a significant

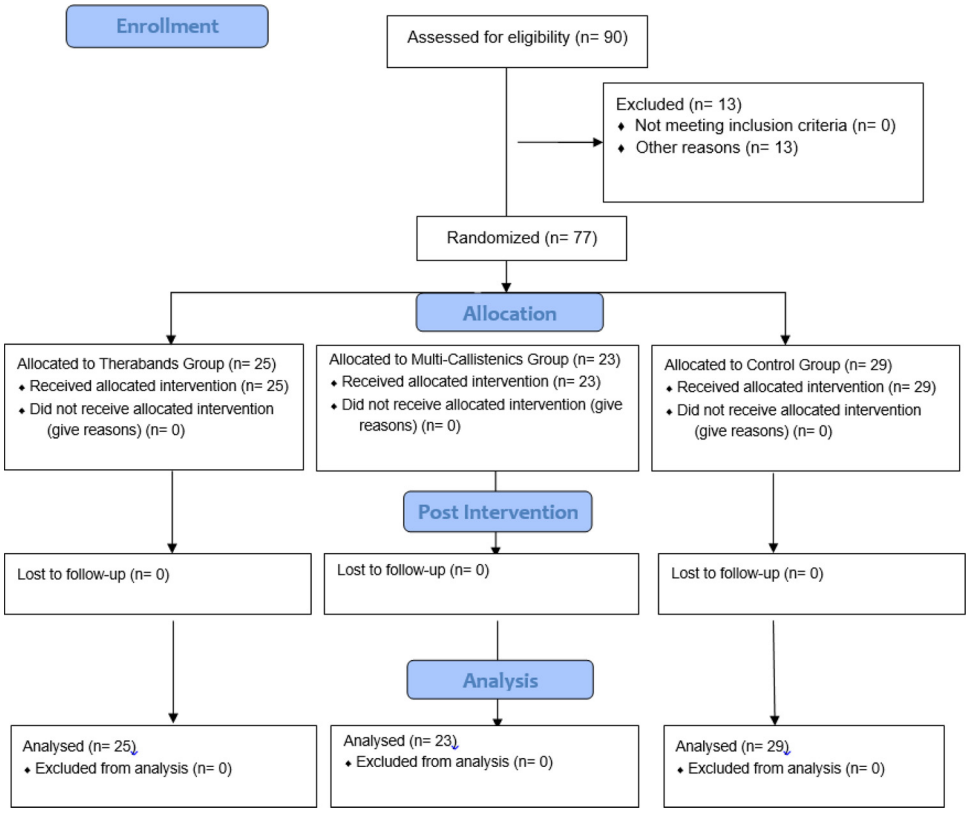

Fig. 1. Flow diagram.

difference between all the groups, while in the Pfeiffer test the CG shows a deterioration of 34.9%, with significant differences between the CG and the other two groups. For functional assessment the TG showed an improvement of 3.4% in the Barthel test and 15.9% in the ST, with some significant differences between this group and the others. The results of the health evaluation, particularly of the physical component, also showed some significant differences between the TG and the other two groups: There is an improvement of 54.9% for the TG, of 11.9% for the MG and a deterioration of 6.8% for the CG.

In the mental component there are significant differences between both the MG and TG groups with respect to the CG group: (31.7% of improvement for the TG and 30.9% of improvement for the MG, but 9.2% of deterioration for the CG).

With regard to static stability (Fig. 2), shows significant results for the TG and MG in comparison with the CG. In the variable movement speed there is a decrease in speed of 28.7% for the TG, 27.8% for the MG, and an increase of 28.6% for CG), in the variable OCP (being a decrease in the area of 28.9% for TG and 27.9% for the MG, and an increase of 28.4% of CG). For the variable SOBC the results show a significant difference between the groups, there being an increase in the surface of 58.63% for the TG, 58.3% for the CG and a decrease of 32.8% for the MG.

4. Discussion

The research examined the effects of physical exercise (strength training by means of Therabands® and multi component training by means of calisthenics exercises) that two programs had on the cognitive state, the functionality and the general health of the frail institutionalized elderly adult population. The results have revealed that the program undertaken by the TG generated a tendency of improvement in cognitive state and functional independence, while in the

Table 1
Descriptive analysis of the sample according to the assignment group.

		(n = 77)	TG (n = 25)	MG (n = 23)	CG (n = 29)
		mean (sd)	mean (sd)	mean (sd)	mean (sd)
Sex (female) n (%)		70.07%	78.28%	69.00%	6460%
Age (years)		84.76 (7.91)	85.54 (8.09)	83.76 (8.33)	85.17 (7.38)
Height (cm)		1.56 (0.08)	1.56 (0.09)	1.56 (0.08)	1.56 (0.08)
Weight (Kg)		63.68 (12.90)	68.26 (13.03)	60.78 (11.55)	62.35 (13.54)
BMI (Kg/m^2)		29.02 (2.89)	2885 (3.21)	29.14 (2.81)	29.04 (2.73)
Nº of falls years		0.39 (0.91)	0.28 (0.84)	0.34 (0.90)	0.57 (0.99)
Nº Medicine		9.14 (4.18)	9.12 (4.46)	8.86 (4.11)	9.52 (4.11)
DACS (Mets/h)		13.71 (2.30)	13.18 (3.17)	13.69 (1.75)	14.31 (1.63)
Academic Level (%)	Without studies	45.50	30.40	58.60	44.00
	Primary	28.60	43.50	20.70	24.00
	Secondary	13.00	21.70	6.90	12.00
	University	13.00	4.30	13.80	20.00

Obs. There was no significant difference between the three groups (Quantitative, Anova, $p > 0.05$); DACS = Daily Ambulation Calorie Spending.

Table 2a
Analysis of the difference between time (pre vs. post) and the interaction between the time and intervention per group on the cognitive, functional and health parameters.

Measures	Group	Pre	Post	95% CI (Means diferent)	Improvement (%)	Factor Time x Group
Cognitive						
Minimental Test	TG	17.04(5.14)	19.32(7.10)	−1.123 to 5.681	13.38	$F_{2,143}$ = 4.412; p = 0.014 ([a,b,c])
	MG	20.48 (2.87)	20.68 (7.68)	−0.629 to 1.026	0.98	
	CG	17.34 (5.38)	15.44 (7.55)	−5.478 to -1.678	−10.96	
Pfeiffer Test	TG	4.28(3.319)	4.00 (3.39)	−1.017 to 0.457	−6.54	$F_{2,143}$ = 4.323; p = 0.015 ([c,e,f])
	MG	3.26 (3.09)	3.73 (3.18)	0.634 to 1.574	18.50	
	CG	4.03 (3.20)	5.44 (3.22*)	−1.567 to 4.387	34.99	
Functional						
Barthel Index	TG	69.60(26.10)	72.00(25.45)	−6.021 to 10.821	3.45	$F_{2,143}$ = 5.004; p = 0.008 ([a,b,c])
	MG	56.09 (24.45)	58.68 (24.46)	−15.543 to 15.543	22.10	
	CG	58.45 (29.55)	55.80 (24.69)	−13.572 to -8.272	−4.53	
FTSTS (s)	TG	16.44 (4.52)	13.96 (5.23)	−5.269 to 0.309	−15.09	$F_{2,143}$ = 2.125; p = 0.042 ([a])
	MG	16.63 (4.07)	14.26 (4.66)	−5.029 to 0.289	−19.13	
	CG	15.34 (3.34)	16.39 (7.06)	3.094 to 5.194	6.84	
Health						
SF12 Physical Health	TG	36.00 (17.98)	55.75 (14.08**)	−25.356 to 55.510	54.86	$F_{2,143}$ = 2.749 ; p = 0.042 ([a])
	MG	49.18 (20.32)	56.53 (15.73)	−13.656 to 28.356	11.78	
	CG	28.88 (19.29)	26.91 (13.96)	−26.770 to 61.010	−6.82	
Physical Function	TG	25.00 (28.879)	27.00 (28.80)	−13.506 to 17.506	8.00	–
	MG	36.96 (39.79)	36.36 (37.58)	−9.532 to 2.332	−48.00	
	CG	18.97 (31.80)	15.00 (22.82)	−9.714 to -1.774	−20.93	
Physical State	TG	26.00 (43.59)	56.00 (39.12**)	−31.567 to 91.567	115.38	–
	MG	67.39 (46.73)	68.43 (47.54*)	−49.677 to 51.757	20.34	
	CG	13.79 (35.09)	12.65 (27.69*)	−99.444 to 101.724	−8.26	
Body Pain	TG	58.00 (15.68)	53.00 (24.28)	−4.880 to 14.880	−8.62	–
	MG	56.52 (18.80)	50.00 (17.25)	−15.388 to -2.348	−6.64	
	CG	50.86 (14.15)	50.00 (19.09)	0.776 to -2.496	−1.35	
General Health	TG	35.00 (19.09)	43.00 (18.43*)	−14.478 to 30.478	22.86	–
	MG	35.87 (19.69)	39.77 (18.35)	−16.705 to 24.505	16.58	
	CG	30.17 (22.54)	30.00 (12.75)	−18.363 to 18.703	−0.56	
SF12 Mental Health	TG	50.50 (10.43)	66.50 (13.76**)	−22.254 to 54.254	31.68	$F_{2,143}$ = 4.001; p = 0.027 ([c])
	MG	45.92 (19.30)	58.09 (10.91*)	−20.596 to 44.936	30.95	
	CG	41.64 (16.24)	38.13 (10.05*)	−24.530 to 31.550	−9.20	
Energy	TG	44.80 (13.27)	44.80 (18.51)	−5.324 to 5.344	0.01	–
	MG	45.22 (20.20)	38.18 (17.36)	2.023 to -16.103	−0.94	
	CG	37.24 (17.50)	32.00 (14.14)	76.912 to -87.392	−14.07	
Social Function	TG	28.00 (15.00)	52.00 (29.69**)	−35.732 to 83.732	85.71	–
	MG	27.17 (28.12)	38.64 (24.06)	−25.356 to 48.296	47.75	
	CG	31.03 (20.76)	30.00 (26.10)	−23.237 to 25.357	−3.43	
Emotional State	TG	84.00 (37.429)	98.00 (32.14*)	−31.443 to 59.443	16.67	–
	MG	65.22 (48.70)	69.14 (47.60*)	−58.193 to 66.033	33.45	
	CG	48.28 (50.85)	47.12 (48.23*)	−26.770 to 24.450	−2.40	
Emotional Wellbeing	TG	45.20 (7.14)	69.20 (16.81**)	−31.629 to 79.629	53.10	–
	MG	46.96 (6.35)	55.00 (15.35*)	15.631 to 31.711	32.14	
	CG	44.48 (7.83)	43.40 (14.85*)	−23.237 to 55.077	−35.79	

Obs. **p < 0.001; *p < 0.05; FSTST = Five repetition sit to stands a Significant differences between theraband group, and calisthenic and control groups. b Significant differences between calisthenic group, and theraband and control groups. c Significant differences between Control Group, and Theraband and calisthenis groups. d Significant differences between theraband group and calisthenic group. e Significant differences between theraband group and control group. f Significant differences between calisthenic group and control group.

mental and physical component of the SF-12, it generated significant improvements. The program undertaken by the MG demonstated a tendency towards a stabilization of these parameters, while the CG demonstrated a tendency to deterioration.

Some of these results were not as expected, since the initial hypothesis proposed the achievement of a significant improvement in the Five times sit-to-stand test (FTSTS) for the TG, due to the focus of the program on strength work in the musculature of the lower limb, for which in this test the authors Seguins and Nelson (2003), y Thomas and Hageman (2003) obtained significant results. This may be due to problems of ambulation in the population in which the program was applied, and therefore it would require a higher weekly frequency, an intervention of longer duration or higher intensity. Even so, it should be noted that the intervention was positive, given that significant differences were obtained for the functional assessment of the TG with respect to the MG and CG. It is necessary to emphasize that significant differences in improvement in the Barthel scale were recorded when the programs were compared, but these differences are non-existent when comparing the time-scale (pre-post).Therefore, the strength program featuring exercises with TheraBands® is the best alternative for delaying as long as possible the loss of functional independence, in comparison with the other groups.

Regarding cognitive function we can report that there was a significant difference of improvement for the MG and TG in the minimental test, following the line of Tamura et al. (2015), who have concluded that mild intensity callisthenic exercise could prevent prefrontal volume reduction due to aging, and prevent cognitive decline. The TG showed some higher improvement percentages, as well as significant differences for both tests with respect to MG and CG, in line with Casas Herrero and Izquierdo (2012), who have concluded that strength training has increasingly more favorable outcomes on cognitive impairment in this population group. García García and Larrión Zugasti (2007) maintain that there is an inverse relationship between cognitive impairment and strength, with cognitive function improving

Table 2b
Analysis of the difference between time(pre vs. post) and the interaction between the time and intervention per group on the static balance parameters.

Measures	Group	Pre	Post	95% CI	Improvement (%)	Factor Time x Group
Static balance						
Right foot pressure (Kpa)	TG	168.94 (39.60)	158.37 (32.79)	−3.131 to -24.271	−6.26	$F_{2,143}$ = 3018; p = 0.027 ([c])
	MG	165.52 (32.36)	158.55 (32.04)	−19.839 to 25.899	−4.51	
	CG	163.22 (41.08)	177.22 (51.84)	−6.843 to -34.843	7.90	
Left foot pressure (Kpa)	TG	159.97 (37.339)	150.83 (27.54)	−16.716 to 18.436	−0.54	$F_{2,143}$ = 3.059; p = 0.049 ([c])
	MG	173.29 (32.40)	161.20 (28.83)	−26.520 to 50.701	−0.23	
	CG	170.74 (32.52)	182.28 (38.43)	−8.608 to -31.688	6.33	
BSRF (mm^2)	TG	9.75 (9.23)	20.27 (35.27)	−92.008 to 113.048	7.90	$F_{2,143}$ = 9.718; p = 0.002 ([a,b,c])
	MG	12.71 (17.50)	19.78 (32.97)	−84.994 to 99.134	37.30	
	CG	18.23 (52.58)	76.26 (37.27)	−88.320 to 204.380	76.09	
BSLF (mm^2)	TG	12.71 (12.57)	40.26 (137.84)	−93.221 to 148.321	68.43	$F_{2,143}$ = 10.298; p = 0.002 ([b])
	MG	11.16 (13.87)	11.80 (16.88)	93.125 to -94.405	70.69	
	CG	10.81 (15.06)	41.43 (138.55)	−92.439 to 153.679	73.90	
BSBB (mm^2)	TG	52.60 (52.15)	83.44 (148.86)	9.257 to 70.937	58.63	$F_{2,143}$ = 19.144 ; p = 0.001 ([a,b,c])
	MG	56.09 (78.01)	63.23 (78.83)	2.737 to 17.017	−32.78	
	CG	56.67 (78.13)	135.95 (287.19)	−124.492 to 283.052	58,31	
Surface Right Support (mm^2)	TG	9288 (1961)	9124 (2314)	−7.435 to 335.435	−1.80	$F_{2,143}$ = 3.074; p = 0.049 ([a])
	MG	7745 (2276)	8432 (2606)	68.783 to 1442.783	−16.61	
	CG	8148 (2410)	9083 (2419)	−21.097 to -1891.097	10.29	
Surface Left Support (mm^2)	TG	9912 (1538)	9824 (1363)	−45.999 to -221.99	−0.89	$F_{2,143}$ = 4.608 ; p = 0.013 ([b])
	MG	9300 (2045)	8469 (2143)	0.689 to 1662.689	−13.79	
	CG	9120 (2548)	9700 (1909)	−166.562 to -1326.562	5.98	
Speed of movement (m/s)	TG	9.24 (12.34)	7.18 (4.12)	−7.246 to 11.366	−28.69	$F_{2,143}$ = 2.956; p = 0.047 ([c])
	MG	7.59 (3.38)	6.67 (3.18)	−2.060 to 3.900	−27.81	
	CG	7.00 (3.74)	9.00 (7.13)	−5.752 to 9.752	28.57	
OPC (mm)	TG	46.24 (61.80)	35.88 (20.60)	−36.316 to 57.036	−28.87	$F_{2,143}$ = 2.876; p = 0.046 ([c])
	MG	37.76 (16.96)	33.32 (15.90)	−10.083 to 18.963	−27.94	
	CG	35.04 (18.77)	45.01 (35.71)	−28.828 to 48.768	28.45	
Surface Distance (mm)	TG	1.08 (0.77)	0.99 (0.64)	0.165 to -0.345	−8.33	$F_{2,143}$ = 3.099; p = 0.042 ([c])
	MG	1.30 (1.18)	0.96 (0.50)	−0.690 to 1.370	−3.03	
	CG	1.21 (0.67)	1.32 (1.28)	−0.945 to 1.165	9.09c	

Obs. **p < 0.001; *p < 0.05; BSRF = Balancing surface right foot; BSLF = Balancing surface left foot; BSBB = Balancing surface of the body's barycenter; OPC = Oscillation of the pressure center; [a] Significant differences between theraband group, and calisthenic and control groups. [b] Significant differences between calisthenic group and, theraband and control groups. [c] Significant differences between control group and, theraband and calisthenis groups.

through strength programs for patients with dementia. The CG presented a significant deterioration in the Pfeiffer test, when compared to the others groups (TG, MG) and when analyzing the time (pre-post), therefore we can conclude that physical exercise in frail institutionalized people is important for the delay of cognitive impairment in this population.

With regard to the assessment of health, the present study follows the line of several studies, which have shown that strength training is beneficial for emotional health and vitality which can be an important factor in the prevention of disability and early mortality (Penninx et al., 2000). While the MG did not show significant results with TG or with CG, it does do so when we analyze the time (pre-post) and therefore, it is shown to be an effective tool for the improvement of health, as shown by Kara, Pinar, Uğur, and Oğuz (2005) where the population studied

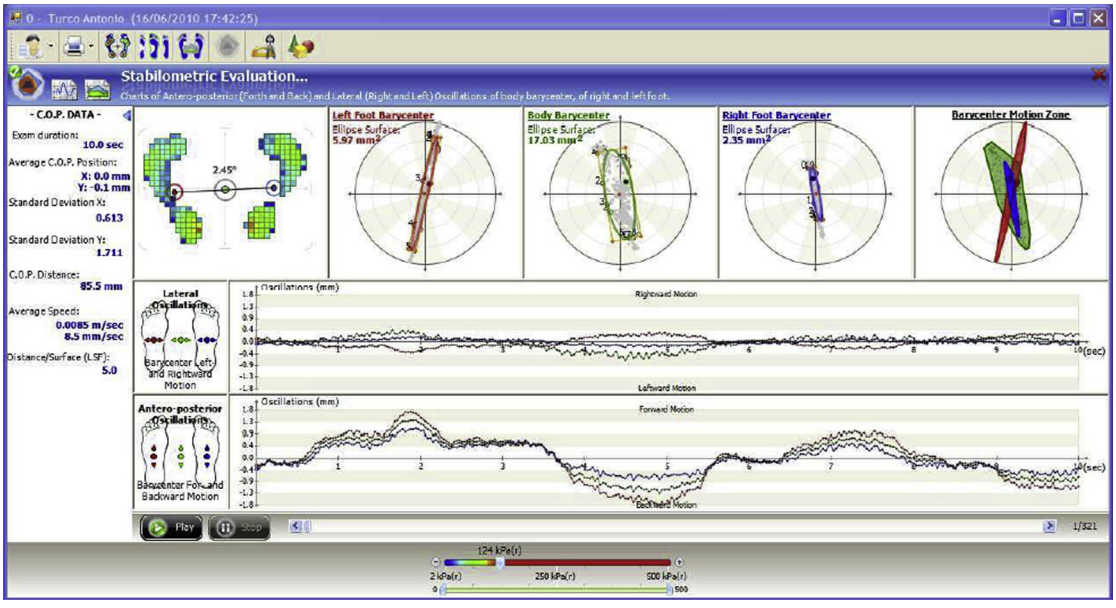

Fig. 2. Assessment of static balance by platform of pressures.

expressed their happiness and well-being during their callisthenic program. Therefore, a strength training program improves the physical component of frail institutionalized people, while callisthenic training shows a tendency to improvement. Both programs are therefore opportune for the improvement of health.

Postural stability, evaluated by the strength platform does not show significant differences in data depending on the program, so therefore the physical exercise programs did not have differential effects on this variable. Regarding the comparison of the programs, some significant differences were found. It should be noted that the amplitude and frequency of the oscillations at pressure centres are fundamental parameters for the assessment of postural stability; large amplitudes and high frequency being symptoms of instability in the subject (Guimaraes & Isaacs, 1980; Low, Walsh, & Arkesteijn, 2017). The TG and MG both showed a decrease in the speed of the movement, while the CG showed an increase. On the other hand, the surface of oscillation on the center of pressure increased for the CG, and decreased for the TG and MG, reflecting significant differences in all these results between the CG and the other two experimental groups. Therefore, it can be observed that individuals belonging to the CG are more unstable than those belonging to another group, for which the physical exercise programs have had effects on postural stability, but not significantly. This may be due to the fact that most of the exercises were carried out in the seated position.

It should be noted that the sample on which the intervention was carried out, ie: the frail institutionalized population, tends towards regression, therefore stability or any significant improvement in the variables will always be of benefit for this population, since the tendency is towards their functional capabilities and cognitive state diminishing over time. It should be noted that as well as physical exercise programs based on conditional abilities such as strength, and training programs based on callisthenic exercises, which have shown very favorable results, new tendencies are emerging in the training of the elderly, such as multi-component and combined exercise. These should be compared in future research to find the most suitable exercise tools for this population.

Finally, active or healthy ageing seeks to extend the life expectancy and quality of life of older people, with the priority of improving their autonomy and health. This has a direct impact on those closest to the elderly, since family members and carers will be positively affected if the person is better able to manage on his or her own, or with less help. Therefore, regular participation in moderate physical activity programs may slow functional decline. In addition, an active lifestyle improves mental health and often promotes social contacts. Staying active can help these people maintain greater independence over a longer period, as well as reducing the risk of falls (Landinez-Parra, Contreras-Valencia, & Castro Villamil, 2012).

4.1. Study limitations

This study presents a number of limitations, such as the contents of the MG´s intervention, since although it performed two weekly sessions of activities, like the TG, one of them was a playful session, composed of games, and even though it was not an exclusive session of physical activity, it required that subjects take part cognitively and physically, thus carrying out physical exercise in a collateral way. Another limitation is the platform of pressures used, since there are still no studies that indicate standardized values for this population. In addition, another limitation is that both the MG and TG received the same cognitive stimulation intervention as the CG, so the results could be regarded as being influenced by this. Lastly, this information is only comparable to frail individuals showing signs of cognitive impairment.

5. Conclusions

Therefore, we can conclude that physical exercise, be it undertaken either as a strength program or a multi-callisthenic program, is an effective measure for the improvement and maintenance of health and cognitive state, functional independence and stability in frail institutionalized people. It should be emphasized that the highest percentage of improvements were obtained in the strength program undertaken with Therabands®.

Suppliers

SPSS version 24.9 IBM Corp.

Conflicts of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this paper.

References

Alonso, J., Regidor, E., Barrio, G., Prieto, L., Rodríguez, C., & de la Fuente, L. (1998). Valores poblacionales de referencia de la versión española del Cuestionario de Salud SF-36. *Medicina Clínica Barcelona, 111*, 410–416.

Barreto, P. S. (2009). Exercise and health in frail elderly people: A review of randomized controlled trials. *European Review of Aging and Physical Activity, 6*, 75.

Blesa, R., Pujol, M., Aguilar, M., Santacruz, P., Bertran-Serra, I., Hernández, G., et al. (2001). Clinical validity of the a mini-mental state for Spanish speaking communities. *Neuropsychologia, 39*, 1150–1157.

Casas Herrero, A., & Izquierdo, M. (2012). Phisical exercise as an efficient intervention in frail elderly persons. *Anales del Sistema Sanitario de Navarra, 35*, 69–85.

Clegg, A., Young, J., Iliffe, S., Rikkert, M. O., & Rockwood, K. (2013). Frailty in elderly people. *Lancet, 381*, 752–762.

Folstein, M. F., Folstein, S. E., & McHugh, B. R. (1975). Mini-mental state. A pratical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189–198.

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., et al. (2001). Frailty in older adults: Evidence for a phenotype. *The Journals of Gerontology Series A Biologicals Sciences and Medical Sciences, 56*, 146–156.

García García, J., & Larrión Zugasti, J. L. (2007). *Deterioro cognitivo y fragilidad. Jesús María Lopez Arrieta, Francisco José García Garcia. El anciano con demencia*. Madrid: Sociedad Española de Medicina Geriátrica59–83.

Guimaraes, R. M., & Isaacs, B. (1980). Characteristics of the gait in old people who fall. *International Rehabilitation Medicine, 2*, 177–180.

Guralnik, J. M., Ferrucci, L., Pieper, C. F., Leveille, S. G., Markides, K. S., Ostir, G. V., et al. (2000). Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *The Journals of Gerontology Series A Biologicals Sciences and Medical Sciences, 55*, 221–231.

Haider, S., Dorner, T. E., Luger, E., Kapan, A., Titze, S., Lackinger, C., et al. (2017). Impact of A home-based physical and nutritional intervention program conducted by lay-volunteers on handgrip strength in prefrail and frail older adults: A randomized control trial. *PloS One,* 12.

Hasten, D. L., Pak-Loduca, J., Obert, K. A., & Yarasheski, K. E. (2000). Resistance exercise acutely increases MHC and mixed muscle protein synthesis rates in 78-84 and 23-32 year olds. *American Journal of Physiology-Endocrinology and Metabolism, 278*, 620–626.

Izquierdo Gabarren, M., Cadore, E., & Casas Herrero, A. (2014). Ejercicio físico en el anciano frágil: una manera eficaz de prevenir la dependencia. *Kronos,* 13.

Kara, B., Pinar, L., Uğur, F., & Oğuz, M. (2005). Correlations between aerobic capacity, pulmonary and cognitive functioning in the older women. *International Journal of Sports Medicine, 26*, 220–224.

Landinez-Parra, N. S., Contreras-Valencia, K., & Castro Villamil, Á. (2012). Proceso de envejecimiento, ejercicio y fisioterapia. *Revista Cubana de Salud Pública, 38*, 562–580.

Levers, M. J., Estabrooks, C. A., & Ross Kerr, J. C. (2006). Factors contributing to frailty: Literature review. *Journal of Advanced Nursing, 56*, 282–291.

Liu, C. J., & Latham, N. K. (2009). Progressive resistance strength training for improving physical function in older adults. *The Cochrane Database of Systematic Reviews,* 8.

Lobo, A., Saz, P., Marcos, G., Día, J. L., De la Camara, C., Ventura, T., et al. (1999). Revalidation and starization of the cognition mini-exam (first Spanish versión of the mini-mental status examination) in the general geriatric population. *Medicina Clínica Barcelona, 112*, 767–774.

Low, D. C., Walsh, G. S., & Arkesteijn, M. (2017). Effectiveness of exercise interventions to improve postural control in older adults: A systematic review and meta-analyses of centre of pressure measurements. *Sports Medicine, 47*, 101–112.

Mahoney, F. I., & Barthel, D. (1965). Functional evaluation: The barthel index. *Maryland State Medical Journal, 14*, 61–65.

Martinez de la Iglesia, J., Duenas Herrero, R., Onis Vilches, M. C., Aguado Taberne, C., Albert Colomer, C., & Luque Luque, R. (2001). Adaptación y validación al castellano del cuestionario de Pfeiffer (SPMSQ) para detectar la existenica de deterioro cognitivo en personas mayores de 65 años. *Medicina Clínica Barcelona, 117*, 129–134.

McHorney, C. A., Ware, J. E., & Raczek, A. E. (1993). The MOS 36-item short form health survey (SF-36): ll. Psychometric and clinical tests of validity in measuring physical

and mental health constructs. *Medical Care, 31*, 247–263.
Penninx, B., Guralnik, J., Bandeen-Roche, K., Kasper, J. D., Simonsick, E. M., Ferrucci, L., et al. (2000). The protective effect of emotional vitality on adverse health outcomes in disabled older women. *Journal of the American Geriatrics Society, 48*, 1359–1366.
Pfeiffer, E. (1975). A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. *Journal of the American Geriatrics Society, 23*, 433–441.
Rolland, Y., Dupuy, C., Abellan van Kan, G., Gillette, S., & Vellas, B. (2011). Treatment Strategies for sarcopenia and frailty. *Medical Clinics of North America, 95*, 427–438.
Seguin, R., & Nelson, M. E. (2003). The benefits of strength training for older adults. *American Journal of Preventive Medicine, 25*, 141–149.
Tamura, M., Nemoto, K., Kawaguchi, A., Kato, M., Arai, T., Kakuma, T., et al. (2015). Long-term mild-intensity exercise regimen preserves prefrontal cortical volume against aging. *International Journal of Geriatric Psychiatry, 30*, 686–694.
Thomas, V. S., & Hageman, P. A. (2003). Can neuromuscular strength and function in people with dementia be rehabilitated using resistance-exercise training? Results from a preliminary intervention study. *The Journals of Gerontology Series A Biologicals Sciences and Medical Sciences, 58*, 746–751.