J Nutr Health Aging. 2019;23(9):829-836

EFFECT OF A RESISTANCE TRAINING PROGRAM ON SARCOPENIA AND FUNCTIONALITY OF THE OLDER ADULTS LIVING IN A NURSING HOME

J. MARTÍN DEL CAMPO CERVANTES[1], M. HABACUC MACÍAS CERVANTES[2], R. MONROY TORRES[2]

1. Department of Nutrition; Autonomous University of Aguascalientes, Aguascalientes, México; 2. Department of Medicine and Nutrition; University of Guanajuato, Guanajuato, México. Corresponding author: Rebeca Monroy Torres, Department of Medicine and Nutrition, Universidad de Guanajuato, Campus León, Street Name & Number: Blvd. Puente del Milenio 1001; Fraccionamiento del Predio de San Carlos, City, State, Postal code, Country: León, Guanajuato, postal code 37670, México, Tel: +52 (477) 2674900, ext 3677, E-mail: rmonroy79@gmail.com

Abstract: *Importance:* There are currently few evidence about resistance training as a treatment for sarcopenia in the nursing home setting. *Objective:* To evaluate the effect of a resistance training program on the sarcopenia and functionality of the elderly living in a nursing home. *Design, Setting, and Participants:* A blinded longitudinal intervention study conducted in elderly people living in a nursing home from August to November 2016. Participants included a convenience sample of 19 older adults. *Intervention:* We prescribed a resistance exercise program three times a week for 12 weeks. The scheme was two to three sets with eight to 15 repetitions per exercise. *Main Outcome and Measures:* The primary outcome was an increase in muscle strength and an improvement in physical performance of the elderly people living in nursing homes. *Results:* 19 older adults between 77.7 ± 8.9 years old, completed the 12 week resistance exercise program achieving a significant increase in muscle strength to 5.7 Kg ($p = 0.0001$) as well as nutritional intake for the first four weeks ($p = 0.001$); we found an improvement in physical performance ($p = 0.0001$) in balance ($p = 0.0001$), chair stand ($p = 0.036$) and gait speed ($p = 0.0001$). Of the 47.4% that reached sarcopenia degree, in the end it was 33.3%. A relationship with nutritional status ($p = 0.004$) and age ($p = 0.019$) was found with the initial and final handgrip strength ($p = 0.041$). *Conclusions and relevance:* The resistance training program improves the functionality (muscle strength and physical performance), with the benefit of the decrease in severe sarcopenia.

Key words: Resistance exercise, elderly people, sarcopenia, community-dwelling.

Introduction

The older adults population shows a continuous and constant increase (1). Aging affects skeletal muscle due to changes in strength, endurance and amount of muscle (2). Physical limitations, functional, cognitive and emotional impairment (3) generates dependence, causing low productivity, increased risk of falls and fractures, and alterations to perform daily living activities (4).

Sarcopenia is a "syndrome characterized by progressive and generalized loss of skeletal muscle mass and muscle function (strength or performance) with a risk of adverse outcomes such as physical disability, poor quality of life and death" (5, 6). Prevalence of sarcopenia varies from 14 to 33% in nursing homes (6, 7).

One of the main treatment for sarcopenia is resistance exercise, which causes hypertrophy and an increase in muscle strength through training programs with progressive volumes and the use of different loads (8) as a result of neurological and metabolic adaptations (9).

There is a great diversity of training programs that differ in the intensity, the number of repetitions, the number of series, the loads, the duration and the frequency of the training according to the objective of the training (10). The current study aimed to evaluate the effect of a resistance training program on sarcopenia and functionality of the older individuals living in nursing homes.

Materials and Methods

Study design: Single blind longitudinal intervention study

The study protocol has been approved by the Bioethics Committee of the University of Guanajuato with the code CIBIUG-P06-2016. Subjects (or their guardians) have given their written informed consent.

Participants and setting

We studied 19 older people living in a nursing home from August to November 2016.

We included adults over 60 years old, without cardiovascular problems that limit physical activity, without substitute dialysis treatment (peritoneal dialysis or hemodialysis), senile dementia, severe arthropathy, muscular or joint diseases that limit physical activity or visual disability.

The participants who did not complete 70% of the sessions or who had an impairment in their health that caused the interruption of the program were eliminated.

Received March 27, 2019
Accepted for publication April 15, 2019

Published online September 27, 2019, http://dx.doi.org/10.1007/s12603-019-1261-3

Measurements

We used the cut-off points of the European Working Group on Sarcopenia in Older People (EWGSOP) (5):

- Muscle mass: Skeletal muscle mass index <8.87kg/m^2 in men and <6.42kg/m^2 in women.
- Muscle strength: handgrip strength <30 kg in men and < 20 kg in women.
- Physical performance: Short physical performance battery (SPPB) <8 points.

Weight, height and circumferences were obtained using the technique specified by the International Society for the Advancement of Kinanthropometry (ISAK) with a stadiometer (SECA® 217) and a fiberglass (FUTABA® R-280). Muscle mass and fat mass were measured using bioelectrical impedance analyses (TANITA® tetrapolar scale model BC-558).

The Mini Nutritional Assessment (MNA) was used to assess nutritional status.

Muscle mass was defined through the skeletal muscle mass index (5), which was calculated by the summed muscle mass of the four limbs or appendicular skeletal muscle mass (ASM) divided by height^2 (11).

Muscle strength was measured using handgrip strength (11); with a TAKEI® dynamometer (SMEDLEY III T-18A), it was performed with the technique used by Fragala et al (12).

The physical performance was evaluated through a short physical performance battery that includes three tests: balance, gait speed and chair stand.

- In the balance test, the participant tried to maintain three positions: feet together side-by-side, semi-tandem and tandem positions for 10 seconds each (5, 11).
- In the gait speed test the participant walked a distance of 4 m two times, the quickest of the two times was the one used for the analyzes (13).
- For the chair stand test, the participant was asked to fold his arms over his chest and get up from the chair in a single movement for five times as fast as he could; the total time used to do it was recorded (13).

Intervention

The resistance training scheme was developed based on the recommendation of the American College of Sports Medicine: three times a week for 12 weeks consisting of two to three sets at a moderate or high effort or intensity with one to three minutes of rest between sets for eight to 12 repetitions (1st and 2nd month) and 15 repetitions (3rd month) with one to three minutes of rest between sets (14, 15).

We used dumbbells of 0.5, 1 and 3 Kg, as well as elastic bands of three resistances (medium, strong and extra strong). According to the progression of the older adult the strength and the load were increased.

Statistical analysis

Statistical analyses were performed using SPSS version 20.

We used paired t test for the quantitative variables, X^2 for MNA and sarcopenia, repeated measurement ANOVA to compare variables over time using gender as an intersubject factor with a Bonferroni post-hoc procedure. Finally, multiple linear regression analysis were used to examine the factors that could influence the change (diet, nutritional status and age), for all statistical analyses significance was established at $p < 0.05$ with a confidence interval of 95%.

Results

We studied 14 women (73.7%) and five men (26.3%). The average age was 77.7 ± 8.9 years with an age range between 64 to 93 years.

Nutritional status and body composition

At the beginning of the study the MNA showed 38.9% of the participants with adequate nutritional status, with an increase to 50% in the end; the risk of malnutrition show a decrease to 50% (it was 61.1% in the beginning), we did not found any participant with malnutrition at any of the evaluations. No significant differences were found when comparing the nutritional status by gender in the initial (X^2 = 1.720, p = 0.423) or in the final evaluation (X^2 = 0.000, p = 1.000), nor when comparing the initial scores (22.7 ± 3.4 points) with the final scores (23.1 ± 2.5 points) of the MNA (t = -0.0581, p = 0.569).

When comparing the body mass index (BMI) on a monthly basis, no statistically significant differences were found (F = 2,409, p = 0.780). At the end of the intervention 66.7% of the participants presented an adequate BMI, 11.1% were overweight and 22.2% have obesity.

The differences in the values of weight, lean mass, percentage of fat and skeletal muscle mass index (SMI) among the monthly evaluations (Table 1) were not statistically significant (p> 0.05).

Physical performance and muscle strength

The handgrip strength showed a significant increase with time (p = <0.001).

The balance test showed a significant improvement (7.3 seconds) by keeping the positions longer, when comparing the initial values with the first, second and third months (p = <0.001).

In the chair stand test, the speed to perform the movement was improved by decreasing seven seconds; with a significant difference in the initial value with the first (p = 0.036) and third month (p = 0.009).

For the gait speed test, we found an improvement in the speed to walk 4 meters by significantly decreasing the time in all the measurements (p = <0.001), improving the time in 6.3 seconds when comparing the initial (12.6 ± 6.4 seconds) with the final value (6.3 ± 2.1 seconds).

Table 1
Anthropometric and functional characteristics (Mean and SD)

	Initial	1st month	2nd Month	3rd Month	F value	p value
Weight (Kg)	58.1 ±14.4	57.9 ±14.9	58.2 ±14.6	59.6 ±14.7	2.409	0.108
BMI (Kg/m^2)	24.8 ±4.9	24.7 ±5.0	24.9 ±4.9	25.6 ±4.8	2.409	0.078
MM (Kg)	38.8 ±8.9	38.6 ±8.8	38.6 ±9.3	39.1 ±9.3	0.911	0.442
Fat (%)	28.9 ±8.5	28.8 ±8.1	29.6 ±8.7	30.2 ±7.3	0.719	0.545
SMI (Kg/m^2)	7.1 ±1.3	7.0 ±1.2	6.9 ±1.3	7.1 ±1.2	0.665	0.527
FUNCTIONALITY VARIABLES						
Handgrip strength (Kg)	13.8 ±8.3	15.0 ±7.9	17.5 ±7.3$^{\#, \#\#}$	19.5 ±7.6$^{*, \#, \#, a}$	25.644	<0.001
Balance (Sec.)	20.0 ±6.6	22.8 ±5.5**	25.2 ±5.8$^{\#\#}$	27.3 ±4.3$^{*, \#}$	15.209	<0.001
Chair stand (Sec.)	27.3 ±9.5	23.0 ±7.5**	25.9 ±11.3	20.3 ±8.3*	11.44	<0.001
Gait speed (Sec.)	12.6 ±6.4	10.6 ±4.5**	8.3 ±3.8$^{\#, \#\#}$	6.3 ±2.1$^{*, \#, a}$	20.514	<0.001
SPPB (Points)	4.1 ±1.7	5.1 ±1.8**	6.2 ±2.3$^{\#, \#\#}$	7.5 ±2.3$^{*, \#, a}$	46.449	<0.001

n= 19 participants (5 men and 14 women), in the 3rd month n=18 participants (5 men and 13 women). One participant was eliminated secondary to a hip fracture in the third month; BMI: Body mass index; MM: Muscle mass, SMI: Skeletal muscle mass index, Sec: Seconds; SPPB: Short physical performance battery; Values of p using repeated measures ANOVA and post-hoc Bonferroni correction analysis; * p <0.01 between initial and final value. ** p <0.05 between initial and 1rst month value. # p <0.05 between 1rst month value vs 2nd and 3rd month value. ## p <0.01 between initial and 2nd month value. a .p <0.05 between 2nd and 3rd month value.

The initial mean score of the SPBB was 4.1 points, meaning a low performance; this improve significantly with time until, ending in an intermediate performance with 7.5 points (p = <0.001).

Diet

There was an average consumption of 0.9 g of protein per kilogram of weight and 1551.9 Kcal per day (Table 2). We found an elevated energy consumption when compared with the reference values (118.5 to 195.2%). When comparing the macronutrients values and the initial and final energy consumption, a significant increase in lipid consumption (p = <0.001) and energy (p = 0.001) was found; and a decrease in protein consumption (p = <0.001) and grams of protein per kilogram of weight (p = 0.001). No significant differences were found for carbohydrates.

A significant correlation was found between the amount of protein and total muscle mass only in the first month of the intervention (r = 0.565, p = 0.012, R^2 = 0.319).

Sarcopenia

At the beginning of the study we found severe sarcopenia in 47.4% (n = 9) of the participants; by the end of the intervention 33.3% of the population had some degree of sarcopenia.

We found that the final handgrip strength (table 3) was explained in a 17.6% by energy consumption (p = 0.042), in a 23.6% by nutritional status (p = 0.021) and in a 16.3% by age (p = 0.049). The initial handgrip strength is explained in a 35.6% by nutritional status (p = 0.004) and in a 19.2% by age (p = 0.017).

Age had a relationship with the initial (p = 0.29, R^2 = 0.195) and final gait speed (p = 0.030, R^2 = 0.204); the nutritional status was related to the short physical performance battery (p = 0.035, R^2 = 0.190) and the final seconds of chair stand (p = 0.32, R^2 = 0.241), not finding any relationship with the rest of the variables.

Energy consumption, nutritional status and age were not related to the short physical performance battery, gait speed, chair stand or balance (Table 4). We found a relationship between nutritional status and age with the initial handgrip strength, this explain 53.9% of the handgrip strength variability (p = 0.010, R = 0.770, R^2 = 0.593), indicating that the handgrip strength is lower at higher age (R = -0.493, p = 0.019) and with better nutritional status the handgrip strength is greater (R = 0.596, p = 0.004); we also found that MNA is a more important variable for predicting initial handgrip strength than age (beta-rated coefficient of 0.592 vs -0.487).

For the final handgrip strength, the multiple linear regression model with the successive steps method (Table 5) was significant with nutritional status (p = 0.021, R = 0.485, R2 = 0.236), the probability value of the nutritional status associated with the final handgrip strength is significant (p = 0.041) which indicates that the better nutritional the greater the handgrip strength.

We don't found a significant interaction between gender on the SPBB (F = 0.907, p = 0.445), the handgrip strength (F = 0.608, p = 0.524), the balance (F = 1.612, p = 0.219), chair stand (F = 0.890, p = 0.460) or the gait speed (F = 1.103, p = 0.339), which implies that the behavior of the variables is the same for men and for women.

Finally, adherence to the exercise program was 80.55%, with seven older adults who completed 100% of the sessions.

Table 2
Comparison of energy requirements and ideal macronutriments with real consumption (Mean and SD)

Month	Nutriment	Real consumption	% RDI	p value
Initial	Energy (Kcal)	1286.0 ±355.4	118.5 ±41.8	0.123
	Carbohydrates (g)	199.1 ±67.4	126.1 ±51.9	0.069
	Fat (g)	31.2 ±10.4	103.5 ±42.2	0.973
	Protein (g)	55.0 ±10.9	123.9 ±34.6	0.021
	g Protein/Kg of weight	0.99 ±0.27	Same as g of proteins	
1rst month	Energy (Kcal)	1724.3 ±307.7	155.7 ±43.7	0.000*
	Carbohydrates (g)	251.5 45.2	156.3 ±48.2	00.000*
	Fat (g)	52.7 ±13.9	170.5 ±57.8	0.000*
	Protein (g)	63.4 ±11.3	140.9 ±26.6	0.000*
	g Protein/Kg of weight	1.12 0.21	Same as g of proteins	
2nd month	Energy (Kcal)	1543.3 ±264.9	138.2 ±31.6	0.000*
	Carbohydrates (g)	239.3 ±49.3	147.5 ±42.9	0.000*
	Fat (g)	49.9 ±12.1	159.2 ±38.9	0.000*
	Protein (g)	41.6 ±6.1	93.6 ±21.9	0.101
	g Protein/Kg of weight	0.74 ± 0.17	Same as g of proteins	
3rd month	Energy (Kcal)	1655.1 ±289.0	146.4 ±29.0	0.000*
	Carbohydrates (g)	237.0 ±54.5	145.0 ±40.0	0.000*
	Fat (g)	62.1 ±14.6	195.2 ±38.8	0.000*
	Protein (g)	43.8 ±7.5	95.1 ±19.7	0.148
	g Protein/Kg of weight	0.76 ±0.15	Same as g of proteins	

n= 19 participants (5 men and 14 women), a participant was eliminated in the third month n=18 participants (5 men and 13 women); RDI: Reference daily intake; Values of p using paired t-test to compare actual consumption with the ideal daily intake; * $p < 0.05$ between the real consumption and the ideal daily intake.

Table 3
Results of simple linear regression analysis of covariables on muscle strength and physical performance

	R	R^2	ß	95% CI	p value
Initial handgrip and initial MNA	0.596	0.356	0.596	0.419, 2.506	0.004
Initial handgrip and age	0.486	0.237	-0.486	-0.877, -0.037	0.017
Final handgrip and final energy	0.419	0.176	0.419	-0.002, 0.024	0.042
Final handgrip and final MNA	0.485	0.236	0.485	0.066, 2.857	0.021
Final handgrip and age	0.403	0.163	-0.403	-0.744, 0.069	0.049
Initial SPPB and initial MNA	0.436	0.19	0.436	-0.021, 0.475	0.035
Final sec. Of chair stand and final MNA	0.491	0.241	-0.491	-3.424, 0.107	0.032
Initial sec. Of gait speed and age	0.442	0.195	0.442	-0.013, 0.653	0.029
Final sec. Of gait speed and age	0.451	0.204	0.451	-0.005, 0.216	0.030

n = 18 participants (5 men and 13 women) ; MNA: Mini nutritional assessment; SPPB: short physical performance battery; R: Pearson correlation; R2: coefficient of determination; ß: Standardized regression coefficient; IC: Confidence interval.

Table 4
Models of multiple linear regression for initial handgrip strength

Model	Variable	B	B standard error	Standardized ß	t	Sig.
Model 1	Constant	-19.189	11.292		-1.699	0.109
	Initial MNA	1.462	0.492	0.596	2.972	0.009*
Model 2	Constante	16.604	15.241		1.089	0.293
	Initial MNA	1.452	0.404	0.592	3.594	0.003*
	Age	-0.457	.0154	-0.487	-2.958	0.010*
Excluded variables						
Model	Variable	Beta within	t	Sig.	Partial correlation	Collinearity statistics
Model 1	Age	-0.487	-2.958	0.010	-0.607	1.000
	Initial energy	-0.018	-0.087	0.932	-0.023	1.000
Model 2	Initial energy	0.077	0.445	0.663	0.118	0.964

n = 18 participants (5 men and 13 women); MNA: Mini nutritional assessment; B: Non-standardized coefficient; ß: Standardized regression coefficient; * Indicates that the value of the coefficients is significantly different from 0 (p <0.05); Based on multiple linear regression analysis with the method of successive steps including MNA, energy and age.

Table 5
Models of multiple linear regression for final handgrip strength

Model	Variable	B	B standard error	Standardized ß	t	p
Model 1	Constant	-14.219	15.299		-0.929	0.367
	Final MNA	1.461	0.658	0.485	2.220	0.041*
Excluded variables						
Model	Variable	Beta within	t	Sig.	Partial correlation	Collinearity statistics
						Tolerance
Model 1	Age	-0.272	-1.187	0.254	-0.293	0.889
	Final energy	0.269	1.142	0.271	0.283	0.843

n = 18 participants (5 men and 13 women); MNA: Mini nutritional assessment; B: Non-standardized coefficient; ß: Standardized regression coefficient; * Indicates that the value of the coefficients is significantly different from 0 (p <0.05); Based on multiple linear regression analysis with the method of successive steps including MNA, energy and age.

Losses

There was a loss of a participant secondary to a fall that caused immobilization in the last weeks of the study; affecting the last measurement of the MNA and BMI.

Discussion

The main effect of the exercise program was the increase in the handgrip strength, the improvement in the seconds of the balance, chair stand and gait speed, as well as the score of the short physical performance battery.

Handgrip strength increased 5.7 Kg, which is consistent with that reported by several authors where there was an increase in upper train strength between 0.4 to 6.5 kg (16-18). Haider et al (18) demonstrated a 21.6% increase in muscle strength through handgrip strength; in our population the increase was greater at 41.3%. This improvement in muscle strength is associated, among other variables, with the exercise scheme and the planning of frequency, volume, repetitions and quantity of sets (19); the increase in strength is secondary to neuronal adaptations, voluntary muscular activation by the recruitment and the coding rate of motor neurons; agonist-antagonist coactivation and synchronization of synergistic muscles (15, 20, 21); in the first weeks of the exercise is when a greater change is identify as a result of the neuronal adaptation of motor neurons, which improves the carrying capacity and the time to maintain a position (10, 21).

With training, a modification in the structure of the muscle fiber is generated, this improves neuronal activity generating a gain in muscle strength, which can be achieved without an increase in muscle mass (17).

Theodorakopoulos et al (22) propose that resistance exercise (RE) improves the domains of muscle power and strength by the plasticity of the neuromuscular system, allowing the muscle to adapt to the prescribed physical activity (22, 23), this can happen even at advanced ages without the need for high loads exercise schemes or gym machines (22, 24).

Hofmann et al (25) reported an improvement in muscle strength of the lower extremities with an exercise scheme using elastic bands, this result is similar to the one found in this study by performing the chair stand more quickly in men and women.

When muscle mass decreases due to the aging process, the ability to walk and balance is also impaired increasing the frequency of falls and fractures (20, 26). Several autors (16, 17, 21) reported significant differences in gait speed and distance traveled; Santos et al (20) reported that the improvement in gait speed in their study was associated with an increase in muscular strength and muscle quality, but not with changes in muscle mass or in the amount of fat; Cancela et al (27) found an improvement in the balance of the older adults; these results are similar to those we obtained because there was not a significant increase in the muscle mass of the participants, but there was a 6.3 seconds decrease to walk four meters when compared to the initial value, in addition to a significant improvement in the older adults balance.

The score of the SPPB tests in our population showed a significant increase, which coincides with that reported by Abizanda et al (28) and Haider et al (18), it should be noted that our population had a lower initial SPBB score and showed a greater increase, this may be due to the differences in the training programs, as well as to the initial characteristics of our population (nursing home participants, with an age between 64 to 93 years, without physical impediments to perform physical activity, among others).

The lack in the improvement of skeletal muscle mass is an unexpected result in our study, various authors have reported the effect of resistance exercise on muscle mass; most resistance training programs report an increase in skeletal muscle mass (20, 29); in our population, lean mass increased 300g and SMI increased in both genders in the third month; this result although it was not statistically significant, shows a tendency toward an increase in the quantity of muscle mass.

Similar results were reported by Haider et al (18) where the improvement in muscular strength and functionality was due to an increase in the recruitment and the ability of motor neurons, they don't find changes in lean mass or skeletal appendicular muscle mass. While Marques et al (26) explain that the lack of increase in MM can be due to the fact that a greater frequency of exercise is required (more than three days a week), to generate a greater amount of muscular contractions that incite a greater muscle volume. Neurological adaptations occur rapidly, while hypertrophy occurs later once protein synthesis exceeds the rate of protein catabolism (30).

The lack of increase in lean mass should not be a limitation when planning an exercise scheme, but instead should focus on looking for exercises and protocols (duration, intensity, volume, frequency and load) that are specific to achieve this objective, without suppressing exercises that improve flexibility and balance (22).

When we evaluate the nutritional status with the MNA we found 50% of participants with adequate nutritional status at the end of the maneuver; this was similar to that reported by Strupeit (31) in a nursing home population with characteristics similar to our sample, where 55.7% of the population had an adequate nutritional status; the author concludes that it is important to recognize the states of malnutrition in the older adults through a frequent application of the MNA in order to use preventive measures that improve the nutritional status of older adults.

The quality of the elderly's diet is poorly studied, most studies focus on the amount of protein that the older individuals consumes, without evaluating the diet as a whole (energy and macronutrients); Khattab and Al-Saadoun (32) studied feeding in an institutionalized older adults population through a seven-day food recall; finding that the average energy consumption was 2038.37 ± 446.50 Kcal, which represents 151.65% of the RDI; this result was similar to what we found in our population in relation to the energy percentage of adaptation in the first month (155.7 ± 43.7%).

When assessing the macronutrients Khattab and Al-Saadoun (32) found a tendency towards excess of them compared to the DRI, varying for HC between 140.33 to 191.57%, for lipids from 121.6 to 147.25, and for proteins of 210.6 to 238.4%, this could also be observed in our population. Khattab and Al-Saadoun (32) explain that this tendency to increase both energy and macronutrients has already been reported in the literature; in the case of its population, they speculate that the excesses are due to the type of food available in the region. In our case, the type of food offered to the older adults depends on the donations received in the nursing home, this is why the food is often monotonous, mainly including refined flours (bread, pasta, rice), legumes, corn tortillas, egg, milk and junk food (chips and soda). This is the reason why the food is hypercaloric and the percentages of macronutrients are high.

In relation to the amount of protein Khattab and Al-Saadoun (32) report that the protein of animal origin represents two thirds of the total protein intake; while in our population the protein sources were legumes, dairy and egg.

The excess in fat is mainly explained by the use of whole milk products and the way food is prepared, as well as by the bakery products; this agrees with that stated by Khattab and Al-Saadoun (32) in its population.

In this study there was a prevalence of sarcopenia of 47.4% at the beginning of the maneuver, which at the end decreased to 33%, this was similar to that reported by Theodorakopoulos et al (22), Hassan et al (17) and Marzetti (6) for the older adults living in nursing homes where the prevalence varies from 14 to 35.7%. As reported by Lee and Park (33), the time devoted to RE is a predictive factor for reversing the stages of sarcopenia; in our population the participants were sedentary before the maneuver, maintaining an average of 120 minutes of exercise per week for 3 months, which apparently led to decrease of sarcopenia at the end of our maneuver. This implies that performing some type of moderate exercise is a predictor for the improvement of sarcopenia (33).

Several authors have shown that physical activity programs in the older adults are effective, feasible, safe and have low cost; they have a protective effect against the functional decline associated with age independently of the presence of diseases, having a positive impact on the quality of life, as well as on psychological aspects when generating accompaniment and competition in the older individuals (34).

There are few studies that focus on older adults living in nursing homes, where RE can be studied to improve function, strength, flexibility, balance, lean mass; furthermore, it is necessary to thoroughly investigate the quality of the older adult nutrition and its interaction with the RE.

Conclusion

A resistance training program significantly improves handgrip strength (5.7 Kg), seconds of balance (7.3 sec.), chair stand (7.3 sec.) and gait speed (6.3 sec.), as well as the score of the short physical performance battery tests (3.4 points); furthermore, there is a tendency to decrease the frequency of severe sarcopenia. This confirms the improvement of the functionality of the elderly through a resistance training program, also showing a decrease in sarcopenia. These types of strategies must be permanent and commonly used in nursing homes due to the demonstrated benefits of resistance exercise on the quality of life of the older adults living in nursing homes.

Limitations

The main limitations of the study were the size of the sample, the absence of a control group and the lack of control in the feeding of the participants.

Acknowledgment: Nursing home Casa Hogar Tepeyac, to the students of the PREPP of the OUSANEG (Andres Castañeda, Karen Medina) and of the Social Service University students of the Bachelor of Nutrition and the Bachelor's Degree in Science of Physical Activity (Jonathan Roldán) and and Health of the University of Guanajuato for the support in the evaluations and to the Laboratory of Environmental Nutrition and Food Safety for the support with the equipment used. To CONACYT for the grant granted No. 418592.

Conflict of interest: The authors have no conflicts of interest to declare.

References

1. Instituto Nacional de Estadística Geografía e Informática. Censo de Población y Vivienda 2010 [base de datos en Internet]. Aguascalientes: INEGI; 12 de junio de 2010, [actualización: 3 marzo 2011, citado 10 febrero 2015]. Disponible en: http://www3.inegi.org.mx/sistemas/mexicocifras/default.aspx?src=487.
2. Sakuma K, Aoi W, Yamaguchi A. Current understanding of sarcopenia: Possible candidates modulating muscle mass. Pflugers Arch - Eur J Physiol. 2015; 467(2): 213–229. doi: https://doi.org/10.1007/s00424-014-1527-x.
3. Laffon de Mazières C, Morley JE, Levy C, Agenes F, Barbagallo M, Cesari M, De Souto Barreto P, Donini LM, Fitten J, Franco A, Izquierdo M, Kane RA, Martin FC, Onder G, Ouslander J, Pitkälä K, Saliba D, Sinclair A, Manas LR, Vellas B, Rolland Y. Prevention of functional decline by reframing the role of nursing homes?. J Am Med Dir Assoc. 2017; 18(2):105-110. doi: https://doi.org/10.1016/j.jamda.2016.11.019.
4. Hammar M, Östgren CJ. Healthy aging and age-adjusted nutrition and physical fitness. Best Practice & Research Clinical Obstetrics & Gynaecology. 2013; 27(5): 741-752. doi: https://doi.org/10.1016/j.bpobgyn.2013.01.004
5. Cruz-Jentoft AJ, B aeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E, Vandewoude M, Zamboni M; European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis. Age and Ageing. 2010; 39(4): 412–423. doi: 10.1093/ageing/afq034.
6. Marzetti E. Calvani R, Tosato M, Cesari M, Di Bari M, Cherubini A, Collamati A, D'Angelo E, Pahor M, Bernabei R, Landi F, SPRINTT Consortium. Sarcopenia: An overview. Aging Clin Exp Res. 2017; 29 (1):11-17. doi: 10.1007/s40520-016-0704-5.
7. Miyazaki R, Takeshima T, Kotani K. Exercise intervention for anti-sarcopenia in community dwelling older people. J Clin Med Res. 2016; 8(12):848-853. doi: 10.14740/jocmr2767w.
8. Cartee GD, Hepple RT, Bamman MM, Zierath JR. Exercise promotes healthy aging of skeletal muscle. Cell Metabolism. 2016; 23(6): 1034-1047. doi: https://doi.org/10.1016/j.cmet.2016.05.007.
9. American College of Sports Medicine, Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, Skinner JS. American College of Sports Medicine. Position stand: Exercise and physical activity for older adults. Med Sci Sports Exerc. 2009; 41(7):1510-30. doi: 10.1249/MSS.0b013e3181a0c95c.
10. Mayer F, Scharhag-Rosenberg F, Carlsohn A, Cassel M, Müller S, Scharhag J. The intensity and effects of strength training in the elderly. Dtsch Arztebl Int. 2011; 108 (21): 359-364. doi: 10.3238/arztebl.2011.0359.
11. Cooper C. Fielding R, Visser M, Van Loon LJ, Rolland Y, Orwoll E, Reid K, Boonen S, Dere W, Epstein S, Mitlak B, Tsouderos Y, Sayer AA, Rizzoli R, Reginster JY, Kanis JA. Tools in the assessment of sarcopenia. Calcif Tissue Int. 2013; 93(3): 201–210. doi: https://doi.org/10.1007/s00223-013-9757-z.
12. Fragala M, Fukuda D, Stout J, Townsend J, Emerson N, Boone C, Beyer K, Oliveira L, Hoffman J. Muscle quality index improves with resistance exercise training in older adults. Experimental Gerontology. 2014; 53:1–6. doi: https://doi.org/10.1016/j.exger.2014.01.027.
13. Guralnik JM, et al. A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. Journal of Gerontology: Medical Sciences. 1994; 49(2):M85-M94. doi: https://doi.org/10.1093/geronj/49.2.M85.
14. Westcott WL. Resistance exercise protocols for older adults. ACSM'S Certified news. 2011; 21(4): 12-13.
15. Signorile J. Targeted resistance training to improve independence and reduce fall risk in older clients. ACSM's Health & Fitness Journal. 2016; 20(5): 29–40. doi: 10.1249/FIT.0000000000000238.
16. Oesen S, Halper B, Hofmann M, Jandrasits W, Franzke B, Strasse EM, Graf A, Tschan H, Bachl N, Quittan M, Wagner KH, Wessner B. Effects of elastic band resistance training and nutritional supplementation on physical performance of institutionalized elderly – A randomized controlled trial. Experimental Gerontology. 2015; 72:99-108. doi: https://doi.org/10.1016/j.exger.2015.08.013.
17. Hassan BH, Hewitt J, Keogh J, Bermeo S, Duque G, Henwood T. Impact of resistance training on sarcopenia in nursing care facilities. Geriatric nursing. 2016; 37(2):116-121. doi: https://doi.org/10.1016/j.gerinurse.2015.11.001.
18. Haider S, Dorner TE, Luger E, Kapan A, Titze S, Lackinger C, Schindler KE. 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. 2017; 12(1): e0169613. doi: https://doi.org/10.1371/journal.pone.0169613.
19. Huang SW, Ku JW, Lin LF, Liao CD, Chou LC, Liou TH. Body composition influenced by progressive elastic band resistance exercise of sarcopenic obesity elderly women: A pilot randomized controlled trial. Eur J Phys Rehabil Med. 2017; 53(4):556-563. doi: 10.23736/S1973-9087.17.04443-4.
20. Santos L, Ribeiro AS, Schoenfeld BJ, Nascimento MA, Tomeleri CM, Souza MF, Pina F, Cyrino ES. The improvement in walking speed induced by resistance training is associated with increased muscular strength but not skeletal muscle mass in older women. European Journal of Sport Science 2017; 17(4): 488-494. doi: 10.1080/17461391.2016.1273394.
21. Da Boit M, Sibso R, Meakin J, Aspden R, Thies F, Mangoni A, Gray SR. Sex differences in the response to resistance exercise training in older people. Physiol Rep. 2016; 4 (12) e12834: 1-8. doi: 10.14814/phy2.12834.
22. Theodorakopoulos C, Jones J, Bannerman E, Greig CA. Effectiveness of nutritional and exercise interventions to improve body composition and muscle strength or function in sarcopenic obese older adults: A systematic review. Nutrition research. 2017; 43:3-15. doi: https://doi.org/10.1016/j.nutres.2017.05.002.
23. Shad B, Wallis G, Van Loon L, Thompson J. Exercise prescription for the older population: The interactions between physical activity, sedentary time, and adequate nutrition in maintaining musculoskeletal health. Maturitas. 2016; 93: 78–82. doi: https://doi.org/10.1016/j.maturitas.2016.05.016.
24. Martone AM, Lattanzio F, Abbatecola AM, Carpia DL, Tosato M, Marzetti E, Calvani R, Onder G, Landi F. Treating sarcopenia in older and oldest old. Curr Pharm Des. 2015; 21(13):1715-1722. PMID: 25633117.
25. Hofmann M, Schober-Halper B, Oesen S, Franzke B, Tschan H, Bachl N, Strasser EM, Quittan M, Wagner KH, Wessner B. Effects of elastic band resistance training and nutritional supplementation on muscle quality and circulating muscle growth and degradation factors of institutionalized elderly women: the Vienna Active Ageing Study (VAAS). Eur J Appl Physiol. 2016; 116(5):885-897. doi: https://doi.org/10.1007/s00421-016-3344-8.
26. Marques EA, Figueiredo P, Harris TB, Wanderley FA, Carvalho J. Are resistance and aerobic exercise training equally effective at improving knee muscle strength and balance in older women?. Arch Gerontol Geriatr. 2017; 68:106-112. doi: https://doi.org/10.1016/j.archger.2016.10.002.
27. Cancela J, Pallin E, Orbegozo A, Ayán C. Effects of three different chair-based exercise programs on people over 80 years old. Rejuvenation Res. 2017; 20(5):411-419. doi: 10.1089/rej.2017.1924.
28. Abizanda P, López MD, García VP, Estrella J de D, da Silva González Á, Vilardell RNB, Torres KA. Effects of an oral nutritional supplementation plus physical exercise

intervention on the physical function, nutritional status, and quality of life in frail institutionalized older adults: The ACTIVNES Study. J Am Med Dir Assoc. 2015; 16(5):439.e9-439.e16. doi: https://doi.org/10.1016/j.jamda.2015.02.005.
29. Watanabe Y, Tanimoto M, Oba N, Sanada K, Miyachi M, Ishii N. Effect of resistance training using body weight in the elderly: comparison of resistance exercise movement between slow and normal speed movement. Geriatr Gerontol Int. 2015; 15(12): 1270-1277. doi: 10.1111/ggi.12427.
30. Egan B, Zierath JR. Exercise metabolism and the molecular regulation of skeletal muscle adaptation. Cell Metab. 2013; 17(2):162-84. doi: https://doi.org/10.1016/j.cmet.2012.12.012.
31. Strupeit S, Meyer S, Buss A, Gräske J, Worch A, Wolf-Ostermann K. Influence of living situation on vulnerable elderly: focus on nutritional status. J Nutr Health Aging. 2014; 18(9):787-91. doi: 10.1007/s12603-014-0495-3.
32. Khattab HA. Al-Saadoun ET. Nutritional assessment of institutionalized elderly in Makkah region, Saudi Arabia. Bioscience Research. 2016;13(1): 43-64.
33. Lee MH, Park YH. Changes in sarcopenia stages and its related factors among community-dwelling older adults in South Korea. Ageing Int. 2017: 1-14. doi: https://doi.org/10.1007/s12126-017-9280-z.
34. Pedersen MT, Vorup J, Nistrup A, Wikman JM, Alstrom JM, Melcher PS, Pfister GU, Bangsbo J. Effect of team sports and resistance training on physical function, quality of life, and motivation in older adults. Scand J Med Sci Sports. 2017; 27(8):852-864. doi: 10.1111/sms.12823.