Effects of Resistance Training of Peripheral Muscles versus Respiratory Muscles in Institutionalized Older Adults with Sarcopenia: A Randomized Controlled Trial

Abstract

This study compares the effects of two resistance training programs in peripheral and respiratory musculature on muscle mass and strength and physical performance, and identify the appropriate muscle mass parameter for assessing the intervention effects. Thirty-seven institutionalized older Spanish adults with sarcopenia were analyzed: Control Group (n=17), Respiratory Muscle Training Group (n=9) and Peripheral Muscle Training Group (n=11). Pre and post-intervention, participants were assessed for Appendicular Skeletal Mass (ASM/height^2; ASM/weight; ASM/BMI), isometric knee-extension, arm-flexion and handgrip strength, Inspiratory and Expiratory Maximal Pressures (MIP and MEP), and gait speed. Trained groups participated in a 12-week program and improved in MIP, MEP, knee-extension and arm-flexion (p<.05), while nonsignificant changes were showed in gait speed and ASM indexes between pre and post-intervention in the three groups. In conclusion, resistance training improved skeletal muscle strength in the studied population, and any ASM index was found to be appropriate in detecting changes after physical interventions.

Keywords: aging, nursing homes, muscle strength, exercise training, prevention

The presence of comorbidity and other factors such as physical inactivity in older people favor the onset of sarcopenia (Cruz-Jentoft et al., 2010). The prevalence of this geriatric syndrome in institutionalized older adults is around 14-33% in Europe (Cruz-Jentoft et al., 2014), and even higher in Spain (37%) (Salvà et al., 2016).

The European Working Group on Sarcopenia in Older People (EWGSOP) defines this syndrome as a gradual and widespread loss of skeletal muscle mass and strength. As a result, mobility disorders appear, such as an increased risk of falls and fractures, impaired ability to perform daily living activities, loss of independence, a worsening of comorbidity and an increased risk of death (Cruz-Jentoft et al., 2010). Recently, the International Working Group on Sarcopenia (IWGSP) and Asian Working Group for Sarcopenia (AWGSP) shared this definition but both groups suggested working towards a more appropriate selection of diagnostic cut-off values (Wei-Ju, Li-Kuo, Li-Ning, Ming-Hsien & Liang-Kung, 2013; Chen et al., 2014). In this respect, recent studies (Meng et al., 2015; Ethgen et al., 2016; Kim et al., 2016) emphasize the need to personalize the cut-off values according to the characteristics of the studied population (anthropometrics, ethnic and clinical setting).

Previous literature points out that this loss affects the skeletal muscles involved in both mobility (limb or peripheral muscles, PMs) and ventilation (respiratory muscles, RMs). Enright et al. (1994) and Neder et al. (1999) corroborate the association between the strength of the PMs and RMs. In studies of institutionalized older adults, the prevalence of decreased strength of the PMs and RMs is clear (Simões, Castello, Auad, Dionísio & Mazzonetto, 2009; Simões, Dias, Marinho, Pinto & Britto, 2010; Cruz-Jentoft et al., 2010). Authors such as Newman et al. (2003) suggest that during aging the decline in lower limb muscle strength is greater than in upper limbs, and is associated with lower gait speed and increased risk of disability. Moreover, dysfunction of the RMs is accompanied by a reduced tolerance requirement associated with the basic activities of daily living, and in some extreme cases with respiratory failure (Bahat et al., 2014).

In addition, most Systematic Reviews and Meta-Analysis for Sarcopenia in older adults (Cruz-Jentoft et al., 2014; Beaudart, Zaaria, Pasleau, Reginster & Bruyère, 2017) suggest exercise interventions (mainly resistance exercises) can improve muscle strength and physical performance, with the majority of these studies being carried out in older adults living in the community. In this respect, it is worth considering extending the research to older adult groups living in other settings, such as hospitals and nursing homes. Currently, studies show high prevalence of sarcopenia in older adults residing in nursing homes (Landi et al., 2012; Henwood, Keogh, Reid, Jordan & Senior, 2014) and initial results regarding resistance training on sarcopenia in nursing care facilities are emerging. These are mainly focused on the improvement in the strength of only the peripheral muscles (Hassan et al., 2016) or of the respiratory muscles (Cebrià i Iranzo, Arnall, Igual Camacho, Tomás & Meléndez, 2013), but there is a lack of studies which compare both resistance training interventions.

It is assumed that the physical intervention in the institutionalized older adults is accompanied by lower benefits (Cruz-Jentoft et al., 2011). The clinical novelty of this study is showing that resistance exercise interventions in nursing homes may improve, or at least control, the deterioration that sarcopenia entails in older adults, as well as reduce the risk of mortality associated to muscle strength (Newman et al., 2006). On the other hand, it highlights the use of this exercise intervention as a routine in the socio-sanitary planning of nursing homes.

In light of the above, and considering the importance of preventing sarcopenia effects in institutionalized older people, the main objective of this study was to compare the effects of two resistance training programs in peripheral and respiratory musculature on muscle mass and strength and physical performance. And a secondary objective was to compare and identify which parameters relative to muscle mass are the appropriate for assessing the effects of resistance training programs in institutionalized older adults in Spain. We hypothesize that resistance training would improve muscle mass and strength, and physical performance in older adults with sarcopenia, although these effects would depend on the specific resistance training program (PM or RM training).

Method

Study design

This study was designed as a parallel group randomized controlled trial in which 81 institutionalized older Spanish adults with sarcopenia were randomized on a single sequence (simple randomization) to one of three balanced groups: One Control Group (CG) and two resistance training groups (Peripheral Muscle Training Group (PMTG) and Respiratory Muscle Training Group (RMTG)). A flow diagram (Figure 1) describes the participant eligibility, randomization, lost to follow-up and data analysis. A statistician who had no contact with the participants and/or the health care professionals who undertook the measurements and the intervention performed the random allocation sequence (random number generator in SPSS; SPSS, Inc, Chicago, Illinois). The three groups were followed in the same way and the only difference between them was the received care. CG participants obtained standard treatment and were asked to maintain their usual care and daily life activities at the nursing home (lying down, sitting, and walking short distances between rooms). Participants of the intervention groups (PMTG and RMTG) also carried out a resistance training program for 12 weeks.

INSERT FIGURE 1 ABOUT HERE

The University of XXXX Ethics Committee for Human Research (H1382044172319) approved this study. All participants were informed of the risks and benefits, and agreed to participate by signing a consent form. This study was performed between 2013 and 2016, and has been registered in the ClinicalTrials.gov (NCT ID: NCT02120586).

Participants

The sample was made up of all eligible older adults from four nursing homes located in XXXX, Spain. The nursing homes involved met similar criteria in relation to classification of the participants and had similar professional health services. Participants met the following inclusion criteria: (1) Older than 65 years; (2) clinically stable at least two months before the study; and (3) compliance of the sarcopenia diagnostic criteria proposed by Tyrovolas et al. (2015) which include: (a) Skeletal Muscle Mass Index (SMI = Appendicular Skeletal Muscle Mass/Body Mass Index) with cut-off points for Spanish population (≤ 0.93 for male and ≤ 0.57 for female) and (b) gait speed with cut-off points according to sex, height and age (between 0.95-0.66 m/s for male and 0.80-0-48 m/s for female). Exclusion criteria were as follows: (1) Those clinical situations (signs and/or symptoms) that could interfere in the proper performance of assessment and/or training protocols (i.e.: presence of edema or severe disorder of hydration status that could interfere in Bioelectrical Impedance Analysis (Rubbieri, Mossello, & Di Bari, 2014), malnutrition, muscle-joint pain, tremor or dyspnea at rest, recent fracture or surgery, etc.); (2) a terminal disease diagnosis; and (3) moderate or severe cognitive deterioration that could affect their proper collaboration (Mini-Mental State Examination score ≤ 20 points) (Lobo, Saz, & Marcos, 2002).

Measurements

Participants were assessed at enrollment phase (T1), after a 2-week familiarization (T2, baseline or pre-intervention) and at 12 weeks (T3, post-intervention). The reason for repeating two close assessments (T1 and T2) was to avoid the possible learning effect of tests. These assessments were conducted by researchers who were trained in the procedures by an expert before the data collection period and who were blind to the purpose of the study and the participants' group membership. Tests were performed over two consecutive days to avoid participant fatigue and to get the highest value.

Outcomes and Procedures

Each time-point measurements (T1-T3) recorded the following outcomes:

Skeletal Muscle Mass. Bioimpedance Analysis (BIA) technique was used to assess muscle mass (Kg) using a Bodystat® 1500MDD (Bodystat Ltd., Douglas, Isle of Man, UK). Measurements were obtained under recommended standard conditions (NIH, 1996): participants in supine position on their bed, on waking up and with an empty stomach, upper and lower limbs of predominant side abducted at least 30-degree angle from the medium line, and controlled bedroom temperature of 25 degree. The equipment calibration, individual data introduction (sex, age, height and weight) and skin preparation for the placement of the adhesive electrodes on the wrist and the ankle of the predominant side were prepared previously. According to Meng et al. (2015) and Kim, Jang & Lim (2016) the skeletal mass index was defined as Appendicular Skeletal Muscle Mass (ASM), after being adjusted in different ways: height (ASM/height^2), weight (ASM/weight) or Body Mass Index (ASM/BMI).

Peripheral Muscle Strength. Maximal isometric muscle strength (Kg) was assessed with the dynamometer MicroFet 2® (Hoggan Health industries, West Jordan, UT, USA) on the predominant side for three consecutive trials with at least a 1 minute resting period between them. Previous strength testing, a 5-minute warm-up for lower and upper limbs on the Monark® Rehab Ergometer Trainer (Monark 881E; Vansbro, Sweden) was performed. Participants remained in a seated position with the muscle to be evaluated in relative shortening position, maintaining a maximal and sustained contraction for at least 3 seconds. The movements tested were: knee-extension (*Quadriceps Femoris*) and elbow-flexion (*Biceps Brachii*) (Bean et al., 2002).

The maximal handgrip strength (Kg) was measured with a hydraulic hand dynamometer Jamar Plus+® (Patterson Medical, Sammons Preston, Bolingbrook, IL, USA). Participants remained seated, the dynamometer in the dominant hand, with the elbow locked at 90º and at their side. Predicted values (%) for handgrip strength were also registered (Luna-Heredia, Martín-Peña & Ruiz-Galiana, 2005). Three consecutive measurements were made on the predominant side upper limb with a between-measurement interval of 1 minute.

Respiratory Muscle Strength. Maximum static inspiratory pressure (MIP, cmH_2O) and maximum static expiratory pressure (MEP, cmH_2O) were measured using a MicroRPM® (Respiratory Pressure Meter, CareFusion, Hoechberg, Germany) according to the Black & Hyatt technique (1969). These strength measurements followed the standard guidelines established by the ATS/ERS Statement on respiratory Muscle Testing (2002). Predicted values (%) for both MIP and MEP were also registered by using the reference values reported by Enright, Kronmal, Manolio, Schenker & Hyatt (1994).

For peripheral and respiratory muscle strength data, the highest value was recorded.

Respiratory Muscle Endurance. Maximum Voluntary Ventilation test (MVV, L/min) was measured following the standard guidelines established by the ATS/ERS Statement on respiratory Muscle Testing (2002), using a portable Jaeger® spirometer as referred to above.

Physical Performance. Maximal gait speed (m/s) was collected as participants walked as fast as they safely could on a marked 14 m walkway. Participants started and finished walking two meters before and after the walkway to ensure the participants reached a steady state gait speed across the middle 10 meters (Tilson et al., 2010). Each participant performed two consecutive trials with a one minute resting period between them, and the highest value was recorded. Pulse oximetry was registered during the test and the participants were asked about their subjective effort perception by the Borg CR10 Scale (Borg, 2004).

Interventions

Both intervention groups participated in a 12-week training program, three times a week on alternate days, in groups of eight to ten participants. All training sessions were supervised by two physiotherapists not involved in assessments (T1-T3). Previously, familiarization consisted of six sessions to guarantee appropriate realization was performed with low training workload (5-10% of maximal muscle strength (Kg) for PMTG and 7-9 cmH_2O for RMTG). Since some of the participants could not remain standing, the training was performed in a sitting position. Each session was structured in four phases: (1) Record of resting blood pressure, heart frequency and oxygen saturation (SpO_2); (2) an initial 5-minutes warm-up; (3) resistance exercises with workload during 20 to 30 minutes; and (4) a final 5-minute cool-down to recover baseline condition. Individual training journals were kept on the progress of each participant documenting the increases in training workload as well as recording their perceived exertional efforts (Borg CR10 Scale) and any complaints related to training program reported by the participants. In order to ensure that each participant was training with the appropriate workload, a monthly measurement was performed. Participants who attended less than 80% of the sessions in both programs were dropped from the analyses.

Peripheral Muscle Training (PMT) consisted of ten isotonic resistance exercises, 12 repetitions for each one, completing the maximum mobility at a slow speed, working both concentric and eccentric phases and with two minutes recovery time between them. Resistance exercises were performed with a workload adjusted to 40- 60% of maximal isometric muscles strength (Kg), except when participants did not complete the maximum mobility, in which case the workload was reduced. Exercises were performed with dumbbells and ankle/wrist weights: four lower limb exercises (ankle flexion/extension, knee extension, and hip flexion/abduction/adduction) and six upper limb exercises (handgrip, wrist flexion/extension, forearm pronation/supination, elbow flexion/extension, and shoulder flexion/extension/adduction/abduction).

Respiratory Muscle Training (RMT) was carried out using a Threshold Inspiratory Muscle Trainer device (Respironics® Health Scan Inc. Cedar Grove, NJ, USA) with working range of 7–41 cmH_2O. An interval-based Inspiratory Muscle training program was performed consisting of seven 2-minute cycles of loaded breathing interspersed with a 1 minute period of rest between cycles (Hill, Cecins, Eastwood & Jenkins, 2010). The workload was adjusted to 40-60% of MIP (cmH_2O), except when participants did not complete the interval-training program, in which case the workload was reduced. The physiotherapists monitored the participants throughout the training session with a pulse oximeter (SpO_2 and heart frequency). In this way, each participant adopted their own and comfortable respiratory rate, avoiding undesirable desaturations and/or heart rate increases, as well as the occurrence of symptoms due to hyperventilation.

Statistical Analyses

A priori sample size calculations were obtained with the statistical program G*power 3.1 (Faul, Erdfelder, Lang & Buchner, 2007), with an expected effect size (f) from medium to large, alfa of .05 and statistical power of .80. This resulted in an a priori total sample size of 72 participants, or 24 per group.

Analyses were conducted using the statistical software Statgraphics Centurion XVI.II. All data were checked for outliers, normal distributions (Shapiro-Wilk test), and homogeneity of variance (Levene’s test).

Descriptive statistics were conducted for all variables at pre-intervention (T2). Moreover, pre-intervention differences of the variables between groups were examined to test whether any clinical or anthropometric variable could be included as a covariate in the analysis of variance (ANOVA). For this purpose, one-way ANOVA was conducted for all continuous variables and chi-square tests were used for categorical variables.

Treatment effects between the three groups (PMTG, RMTG, CG) were determined using one-way ANOVA on change from pre-intervention, defined as post-intervention (T3) minus pre-intervention (T2) values for each variable. Change analysis was used to offset possible differences of participants at pre-intervention and to minimize group data variability. Within-group differences were assessed using paired t tests to compare mean change values. Between-group differences were calculated using a three-way ANOVA with group cardiovascular disease and endocrine disease as factors. Cardiovascular disease and endocrine disease were included as (categorical) covariates to eliminate the variability attributable to these variables. *Post-hoc* analyses were performed using Tukey's highly significant difference test when a significant effect was found. Statistical significance was set at $p < .05$ for all tests.

Results

Participants

The analyzed sample was made up of 37 older adults. The flow diagram (Figure 1) shows 44 drop-outs, the main reasons being: deaths, exacerbations, attendance less than 80% of sessions in trained groups, and withdraws (i.e. changing to another nursing home, falls, personal reasons and complaints). Deaths during the study development were as a result of the participants' illnesses, and not from factors related to the measurements and/or training programs. Main complaints reported by participants occurred within the first two weeks of training and the most common were: difficulty in keeping the lips constrained in the mouthpieces of IMT device and nasal discomfort from nose clip placement during the session, in the RMTG; mild muscular discomfort and generalized fatigue that disappeared between sessions, in the PMTG.

Descriptive

Baseline characteristics

Pre-intervention characteristics of the three groups are presented in Table 1. Initially, the three groups did not show differences, except for cardiovascular (p = 0.02) and endocrine (p = .04) diseases. PMTG participants presented a higher number of cardiovascular and endocrine dysfunctions in comparison with the other two groups.

INSERT TABLE 1 ABOUT HERE

Effects of the training programs

Results from the within-group and the between-group effects over the main outcomes are summarized in Table 2. No effects were found from endocrine and cardiovascular disease in any variables between pre and post-intervention in the three groups.

INSERT TABLE 2 ABOUT HERE

Skeletal Muscle Mass

No significant changes were detected in any of the skeletal muscle mass measures (ASM /height^2, ASM/weight and ASM/BMI) between pre and post-intervention in the three groups.

Peripheral Muscle Strength

A significant decrease occurred from pre to post-intervention in CG for *Quadriceps Femoris* (13.1%; t(11) = -2.33; p = .040) and *Biceps Brachii* (23.8%; t(11) = -2.84; p = .016). Nevertheless, results for the PMTG showed a significant increase in *Quadriceps Femoris* (51.9%; t(6) = 3.66; p = .011) and *Biceps Brachii* (17.4%; t(7) = 2.40; p = .048). For the RMTG, *Quadriceps Femoris* showed an increasing trend (9.1%; t(7) = .18; p = .859) while *Biceps Brachii* showed a significant decrease (16.7%; t(8) = -2.34; p = .048).

Moreover, significant differences in peripheral muscle strength between groups were also observed for both *Quadriceps Femoris* (p = .009) and *Biceps Brachii* (p = .003). Post hoc analysis for *Quadriceps Femoris* strength showed that increases were greater in PMTG than for CG participants. For *Biceps Brachii* strength, changes for the PMTG were greater than changes for the other two groups.

No significant changes were seen in dominant handgrip strength values between pre and post-intervention. The same effects were detected for handgrip strength predicted values.

Respiratory Muscle Strength

The within-group ANOVA revealed significant differences in MIP and MEP values for CG between pre and post-intervention. CG subjects decreased their MIP and MEP with a mean of 8.2% (t(12) = -2.62, p = .022) and 15.6% (t(12) = -2.32, p = .039), respectively. PMTG showed a nonsignificant ascending trend of 13.5% in MIP (t(8) = 1.86, p = .100) and of 3.9% in MEP (t(8) = 0.63, p = .548). Likewise, changes from pre to post-intervention in these variables for RMTG were also found to be statistically nonsignificant.

ANOVA comparisons between groups revealed significant differences for MIP (p = .007) and MEP (p = .040). Post hoc analysis showed greater changes for PMTG and RMTG compared to CG.

Similar effects were detected for MIP and MEP predicted values.

Respiratory Muscle Endurance

Changes in MVV were statistically significant in the CG (t(12) = -3.22, p = .007), showing a 19.6% reduction from pre to post-intervention, while no significant changes were detected for both intervention groups (RMTG and PMTG). However, ascending trend values of 8.8% were seen for MVV in the PMTG (t(8) = 1.80, p = .110).

Between-group ANOVA showed significant differences for MVV (p = .020). Post hoc analysis showed that changes in MVV for the PMTG and RMTG were greater than changes in the CG.

Physical Performance

Gait speed remained unchanged from pre to post-intervention in the three groups.

Training load

Training loads in RMTG (Table 3) significantly improved during the training sessions both for absolute values ($F_{11,220} = 130.2$, $p < .001$, $\eta^2 = .867$) and the percentages ($F_{11,220} = 33.3$, $p < .001$, $\eta^2 = .625$). Similar findings were obtained for PMTG (Table 3) in *Biceps Brachii* (absolute values $F_{11,55} = 14.9$, $p = .005$, $\eta^2 = .749$; percentages $F_{11,55} = 19.7$, $p = .002$, $\eta^2 = 0.797$) and *Quadriceps Femoris* (absolute values $F_{11,44} = 50.6$, $p < .001$, $\eta^2 = .927$; percentages $F_{11,44} = 41.0$, $p < .001$, $\eta^2 = .911$).

Discussion

This study revealed that resistance training mainly improved the skeletal muscle strength in institutionalized older people, while there were no significant changes in physical performance and muscle mass for both training groups. Therefore, the most relevant finding of this study remained in counteracting the loss of muscle strength in this population. This result suggests that muscle strength was more sensitive to change, which declines significantly in the Control Group throughout the 3-month intervention. The improvement in muscle strength is more remarkable in the peripheral muscles (where there is a significant increase in the specifically trained group) than in the respiratory ones. Moreover, there was no evidence to suggest that one specific muscle mass index (ASM/heigth^2, ASM/weight and ASM/BMI) was more appropriate than another when assessing the effects of the 3-month resistance training.

These results, as stated in a recent systematic review about sarcopenia by Cruf-Jentoft et al. (2014), reinforce the need to perform peripheral muscle resistance training in older adults. For example, Binder et al. (2005) obtained an improvement in voluntary knee-extension force through progressive resistance training in frail older adults living in the community. In our study, the peripheral muscle strength was assessed by maximal isometric *Quadriceps Femoris* and *Biceps Brachii* strength and also showed an improvement, while there was no significant effect seen in handgrip strength. In this respect, a recent pilot study implemented in nursing home participants (Hassan et al., 2016) demonstrated an improvement in muscle strength (dominant handgrip measurement) as a consequence of a longer period of intervention (six months), including balance training. Tieland et al. (2015) doubt if handgrip is a good measurement to detect changes in muscle strength derived from resistance training in frail older people because measurements could vary depending on age, sex and nutrition, as also pointed out by Budziareck, Roig, & Barbosa (2008). In the present study, the improvement in *Quadriceps Femoris* and *Biceps Brachii* strength was important for two reasons; firstly, because there was a substantial reversion of the muscle strength loss in Control Group, and secondly because there was a significant increase in the peripheral trained group.

The present study demonstrated nonsignificant improvement in RM functioning in the RMTG. However, when compared with the CG values, it showed a significant improvement. This result suggests that respiratory muscle training has a preventive function as RM values were maintained in institutionalized older adults with sarcopenia. This is relevant, bearing in mind the high prevalence of RM strength decline in this group of the population (Simões, Castello, Auad, Dionísio & Mazzonetto, 2009; Simões, Dias, Marinho, Pinto & Britto, 2010). According to Bahat and colleagues (2014), the decline affects more inspiratory than expiratory muscle strength in sarcopenic older adults. Another explanation for this nonsignificant improvement in RM functioning in the trained group could be the short program duration or amount of sessions (Cebrià i Iranzo, Arnall, Igual Camacho, Tomás & Meléndez, 2013). Despite following recommendations for an Inspiratory Muscle Training program (intensity, frequency and duration) for Chronic Obstructive Pulmonary patients proposed by Hill, Cecins, Eastwood & Jenkins (2010) and Gosselink et al. (2011), these have been insufficient for the characteristics of our study population. Moreover, Current recommendations for resistance training in sarcopenic older adults (Cruz-Jentoft et al., 2014) point out that the time of intervention should be at least 3 months.

As it has been commented in the Results section, the rise in the training load was observed both for the inspiratory muscle strength (MIP) and for peripheral muscle strength (maximal isometric muscle strength of *Biceps Brachii* and *Quadriceps Femoris*). This shows that the intensity of training increased progressively. Moreover, this increase has exceeded the percentage of load that has been considered high enough to achieve the training adaptations. Although the planning contemplated training at loads between 40 and 60%, the participants trained with the load they were able to lift.

The current study revealed a maintenance of gait speed after training, as was also demonstrated in the study carried out by Hassan et al. (2016). A possible explanation could be that our training program did not include specific exercises to improve mobility, such as aerobic training and balance reeducation. These authors combine resistance and balance training without obtaining significant gain in the gait speed. Nevertheless, there was an improvement in standing capacity.

As mentioned above, the evolution of the muscle mass indexes along time (pre-post-intervention) was similar in both the control group and the trained ones. That is, it remained relatively stable for all three groups. In this respect, a pilot study implemented in nursing home participants also obtained similar results (Hassan et al., 2016). Though the result in muscle mass after training was unexpected, the improvement of muscle strength is a positive result because this could help prevent disability in institutionalized older adults. Ivey et al. (2000) and Hassan et al. (2016) suggest that the resistance training might induce functional (consequence of neural and/or metabolic muscle responses) versus structural (muscle cross sectional area) adaptations.

Sarcopenia is related to factors such as comorbidity, mobility disorders and malnutrition, thus experts (EWGSOP, IWGSP, AWGSP y el FNIH) recommend combining exercise and nutrition interventions. Recent literature reviews (Denison, Cooper, Sayer & Robinson, 2015; Yu, Khow, Jadczak & Visvanathan, 2016) highlight inconsistent results mainly due to heterogeneity of population (age, sex, anthropometrics, settings, etc.) and intervention characteristics (resistance versus aerobic, diversity in nutrition supplementation, etc.). The majority of published trial findings were carried out on healthy older adults living in the community (Bell et al., 2017) and in sarcopenic older adults (Rondanelly et al., 2016). In settings such as nursing homes or hospitals there is still a lack of these combined interventions (Bauer, Kaiser & Sieber, 2008), and their results are also inconsistent (Carlsson et al., 2011).

The EWGSOP (Cruz-Jentoft et al., 2010) define sarcopenia as low muscle mass and /or both low muscle strength and low gait. Nowadays, there is an important debate on muscle mass cut-off (Pagotto y Silveira, 2014; Studensky et al., 2014; Moon et al., 2016), arguing that they should be considered and adapted to older population characteristics and settings (Tyrovolas et al., 2015; Meng et al., 2015; Kim, Jang & Lim, 2016), in order to avoid the infra-diagnostic of sarcopenia. For this reason, our study has included different muscle mass parameters (ASM/height^2; ASM/weight; ASM/BMI) as proposed by Tyrovolas et al., (2015). With regards to the characteristics of our studied population (Spanish, institutionalized and obese, BMI > 30 Kg/m^2), we considered the appropriate parameters to be those related to weight (ASM/weight; ASM/BMI) instead of the one usually applied (ASM/height^2). We assessed which of these parameters was more sensitive for showing an improvement after resistance training in sarcopenic institutionalized older adults, and the findings were unclear because all parameters behaved similarly.

Our study has several limitations. The analyzed sample diminishes considerably with respect to the participants' characteristics (Table 1) such as high comorbidity and advanced age (M_{age} > 80 years), functional impairment and whether they live in a nursing home. This lost in the follow-up is common in other nursing home research studies (Mody et al., 2008; Hassan et al., 2016). We consider only the sarcopenia status for inclusion criteria and outcomes rather than the Fragility status, which contemplates additional functional parameters. We did not include follow-up of maintenance of resistance training effects. Despite ASM being a variable used infrequently in previous clinical trials, which makes it difficult to make direct comparison with our trial, we decided to use ASM indexes proposed by Tyrovolas et al. (2015) which are specific cut-offs for Spanish population. Furthermore, ASM might be more appropriate for detecting possible changes in upper and lower limbs muscles. Finally, this trial did not collect physical activity as outcome.

Nonetheless, this study has some distinctive strengths. We compared two resistance training protocols: One in respiratory muscles and one in peripheral muscles, both skeletal muscles affected by sarcopenia syndrome. Following the current international debate on reviewing the definition of sarcopenia, we have used the criteria of Tyrovolas et al. (2015) for muscle mass measurement (ASM/BMI) specific for older Spanish people. Finally, as a relevant clinical finding, the improvement of muscle strength may be associated to a lower risk of mortality, as suggested by Newman and colleagues (2006). In this line, the improvement of peripheral muscle strength, as well as the absence of loss of this in the respiratory musculature in our study, may lead to a lower risk of mortality.

Mainly this clinical trial shows an improvement in the skeletal muscle strength in institutionalized older adults with sarcopenia. This benefit can be extended to the older population with sarcopenia, both at the community and nursing homes. To achieve this, health professionals' collaboration might be necessary in order to inform, encourage and supervise the training programs (health promotion programs in primary care and the improvement of rehabilitation programs in nursing homes).

Conclusion

This resistance training has demonstrated an improvement in skeletal muscle strength (MR and MP) in institutionalized older adults with sarcopenia, indicating its preventive character and the potential benefit in carrying out the training in presarcopenic institutionalized older adults. However, there was no significant improvement in muscle mass, in spite of measuring it through different parameters to avoid sarcopenia infra-diagnosis and detect the training effects appropriately. Consequently, there are two fundamental considerations rising from this study: Firstly, the necessity to adapt the physical exercise program by taking into account the specificity of the population and the desired functional outcome (improvement in muscle strength, walking speed, transfers, etc.); secondly, to combine physical exercise intervention with nutritional supplementation.

Finally, regarding the debate around cut-offs, this study does not clarify which muscle mass parameter is the appropriate for detecting changes after physical interventions. As a result, the discussion continues on how to propose interventions and how to measure their effects on sarcopenia in the institutionalized older adult population.

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