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# The effect of a six months multicomponent training in elderly's body composition and functional fitness – A before-after analysis

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ABSTRACT

The aim of this study was to assess the elderly's functional fitness and body composition effects between pre and post multicomponent training program with six months of intervention. The sample of this study was composed of 34 volunteered elders with 68 (±7.55) years old. The body composition was evaluated by a Tanita BC-545, and a functional fitness test assessed the elderly's functional fitness. The body composition did not present significant changes between the pre- and post-exercise program intervention. The training program increased the upper limbs' strength levels and upper body flexibility, and aerobic endurance. Different associations between body composition and functional fitness variables were found between pre and post multicomponent training program. In this study, body composition seems not to be affected. However, functional fitness in upper limbs strength, upper body flexibility, and aerobic endurance improved under six months of multicomponent training.

KEYWORDS: elders; functional fitness; body composition; multicomponent training.

## INTRODUCTION

In Portugal, the elderly represent more than 20% of the population (Instituto Nacional de Estatística [INE], 2016). Aging encompasses several changes in the human body, such as body composition, functional fitness decay, and the risk of disability, morbidity, and chronic disease incidence (Singh, 2002).

Body changes in the elderly are mainly in body composition (Daley & Spinks, 2000). Old people increase body fat and lose muscle mass, resulting in lower resistance, lower muscular strength, and less capacity to perform daily life activities (Kyle et al., 2001; Monteiro et al., 2019a; Monteiro et al., 2019b). The aging and the disuse phenomenon leads to individual resistance to perform different physical activities and a sedentary lifestyle (Singh, 2002). Elders may increase their limitation to perform daily life activities and a sedentary lifestyle due to the functional fitness decay (Kyle et al., 2001; Monteiro et al., 2019a, Singh, 2002). Moreover, aging is related to balance reduction and an increase in fear of falling. Improving physical fitness may also result in better static and dynamic balance (Monteiro et al., 2019c). Thus, this population may keep the physical fitness to maintain, as much as possible, independence in daily life tasks (Kloubec, Rozga, & Block, 2012; Hand et al., 2012). Some exercise programs have been designed to improve the elderly's strength, resistance, balance, and flexibility, overall aiming to improve functional mobility (Monteiro et al., 2019b; Carvalho et al., 2004; Lord, Ward, Williams, & Strudwick, 1995; Puggaard, Pedersen, Sandager, & Klitgaard, 1994).

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Several studies assessed elderly's functional fitness with intense training protocols (Carvalho et al., 2004; Lord et al., 1995; Puggaard et al., 1994). However, most are focused on strength and aerobic capacity (American College of Sports Medicine [ACSM], 2009; Cyarto, Brown, Marshall, & Trost, 2008; Takeshima et al., 2007). Moreover, some guidelines highlight the importance of training combinations to maintain physical fitness (ACSM, 2006; Nelson et al., 2007; Salem et al., 2009). Notwithstanding,the association between body composition and functional fitness after and before a training program may change. Physical fitness can be assessed by strength, balance, flexibility, and aerobic capacity evaluations (Rikli & Jones, 2001; ACSM, 2009; Cyarto et al., 2008; Takeshima et al., 2007).

Some studies have reported associations between elders' body composition and functional fitness (Brach et al., 2004). However, the associations between body composition and functional fitness in sedentary elders may differ from those active or trained (Silva et al., 2013; Gianoudis et al., 2015; Monteiro et al., 2019; Sternfeld et al., 2002). Multicomponent training methods have been used to improve the elders' functional fitness. This training type includes aerobic, resistance, static and dynamic balance exercises (Carvalho, Marques, & Mota, 2009; Monteiro et al., 2019). This training method may help to improve the different physical fitness components. However, only a few studies reported findings on this type of training (Carvalho et al., 2009; Monteiro et al., 2019).

As far as our understanding goes, there is no consensus about the intervention time of multicomponent training to influence physical fitness and body composition. Thus, the aim of this study was to assess the elderly functional fitness and body composition effects between pre and post multicomponent training program with six months of intervention. It was hypothesized that six months of multicomponent training intervention might improve community-dwelling elderly's functional fitness and body composition.

## METHOD

This is a longitudinal study with after and before analysis of multicomponent training in elders. A single evaluator performed all the evaluations, and two researchers made a blind data analysis.

### Participants

The present study was composed of 34 volunteered elders with 68 (± 7.55) years old. All the participants were community-living elders from the City Council (Bragança, Portugal). Individual invitation to participate in the exercise program was made by telephone. All the participants signed an informed consent prior to the study. The elders were informed about the study objectives and the voluntary contribution of that participation and absence costs or risks. Personal data confidentiality and anonymity were also guaranteed.

The inclusion criteria to take part in this study were:

(i) to be at or above 65 years old;
(ii) not being a part of any regular physical activity session (i.e., moderate to vigorous exercise for at least 20min twice a week) in the past three months;
(iii) no history of chronic neuromuscular, cardiovascular and metabolic diseases that could lead to hazard or safety concerns during the classes and/or evaluation periods;
(iv) be available to participate in every 3-times-a-week session of physical exercise program as well as in the evaluation periods. Participation lower than 75% of the sessions and/or an absence for more than ten consecutive sessions was stated as exclusion criteria. The participants were advised to maintain their daily routines regarding physical activity.

### Instruments

The body mass was evaluated by a Tanita BC-545 (Tanita, Illinois, USA). For the evaluations, the participants were asked to have their regular breakfast at 8:00 am, at least two hours before the evaluations (10:00 am). For height evaluation, a digital scale with an attached stadiometer (SECA®) was used. The body mass index (BMI) reference values followed the World Health Organization (2006) for BMI (normal weight between 18.50 and 24.99 kg/m$^2$, pre-obese between 25 and 29.99 kg/m$^2$; obese class I from 30 to 34.99 kg/m$^2$ obese class II between 35 and 39.99 kg/m$^2$). The bioimpedance scale (Tanita, BC-545) enabled to assess the body fat percentage, muscle mass in kilograms, bone mineral mass in kilograms, basal metabolic rate in kilocalories, and visceral fat in levels (healthy: 1– 12; excessive: > 12). The nutritional habits and diet were not controlled.

Rickly and Jones (1999) recommended a set of non-invasive evaluations to assess the elderly's functional fitness by the functional fitness test. This instrument has been used in different training programs to assess strength, balance, flexibility, and aerobic capacity (Rikli & Jones, 2001; Monteiro et al., 2019b). The tests assess: lower limbs strength (30-second chair stand), upper body strength (arm curl), lower body flexibility (chair sit-and-reach), upper body (shoulder) flexibility (back scratch), agility/dynamic balance (8-fot up-and-go) and aerobic endurance test (2-minute step test). The tests were conducted in a circuit intending to minimize the fatigue effects. Before starting the evaluations, the subjects first completed an 8 to 10 minutes warm-up, and before each test, participants received instructions and demonstration (Monteiro et al., 2019b).

## Procedures

The multicomponent training program is underpinned by literature (Carvalho et al., 2009). The training sessions had about 50 to 60 minutes and consisted of:

(i) 5– 8 minutes of warm-up with slow walking combined with stretching exercises;

(ii) 15– 20 minutes of walking and aerobic exercises, jogging, aerobics, or dancing. A set of 2 exercises were chosen for at least 8– 10 minutes per exercise. The training intensity was between 12 and 14 in Borg's Rated Perceived Exertion scale;

(iii) 1– 3 sets of resistance exercises with rubber bands and weights in a circuit. In the circuit, the resting periods between sets were about 40 to 60 seconds. The selected exercises involved the major muscular groups such as knee flexors/extensors, shoulder abductors/adductors, elbow flexor/extensor, pectoral, abdominal, and backs. The resistance exercises were: squats, arm curl, pull down, peck deck, arm abduction and adduction, single-leg extension, and flection. The training intensity was lower at the beginning of the training program (10, first month) to allow a proper adaptation and execution of the exercises. The participants performed 8 repetitions in only one set and gradually progressed to 3 sets of 12– 15 repetitions;

(iv) the static and dynamic balance training was accomplished with bats, balls, and balloons for 5– 8 min;

(v) at the end of each session, there was a cool-down period of about 5 min involving breathing and stretching exercises (Monteiro et al., 2019).

The stretching exercises for the main muscular groups were as follows: the neck extensor with the right hand on the back of the head near the crown; the shoulder flexibility with fingers of both hands grabbed behind the back; the bend over, bending forward, starting at the waist until the back comes in the horizontal plane, with the feet together, arms hanging and the knees in extension; the hip flexion was made pulling one knee up to the chest, allowing the hip to flex completely, there should be contact between the thigh and abdominal area (on both sides); the knee flexion, holding the lower leg proximal to the ankle and pull it toward the buttocks (for both knees); finally the last stretch was in the sitting position with one/both legs extended and the ankles as close as possible, bending the waist and lower the head toward the legs. Two exercise professionals conducted the sessions and monitored the training intensity over the sessions.

## Statistical Analysis

The statistical analysis was made by comparisons between groups. The Kolmogorov-Smirnov test allowed to assess the normality of the distribution, and Levene's test assessed the homogeneity. The t-test allowed to compare the pre and post multicomponent intervention training program. The Cohen's d was used to calculate effect sizes and considered as small (Cohen's d= 0.2), medium (Cohen's d= 0.5), and large (Cohen's d= 0.8) (Lachenbruch, 1989). The Pearson's correlation test assessed the associations between body composition and functional fitness variables in the pre- and post-intervention program. The test significance was set at 5%.

# RESULTS

Table 1 and 2 presents the means, standard deviations, group comparison, and effect size between the pre- and post-training program for body composition and functional fitness.

The body composition did not present significant changes between the pre and post exercise program intervention. However, a small effect of the intervention program was found in fat mass (t= 0.347; $p$= 0.560; d= 0.202) and visceral fat (t= 0.581; $p$= 0.452; d= 0.262) reductions.

Between the pre and post training program, significant changes were found in upper limbs strength, upper body flexibility and aerobic endurance. The training program increased the upper limbs strength levels (t= 9.492; $p$= 0.004; d= 1.727) and upper body flexibility (T= 8.979; $p$= 0.005; d= 1.206) and aerobic endurance (t= 15.938; $p$< 0.001; d= 1.369) with a large effect. However, the training program presented no significant changes with a small effect in lower limbs strength (t= 1.578; $p$= 0.218; d= 0.430), lower body flexibility (t= 0.004; $p$= 0.950; d= 0.021) and the agility (t=1.532; $p$= 0.225; d= 0.426).

Different associations between body composition and functional fitness variables were found between pre and post multicomponent training program. In the post-intervention, age presented no significant association with visceral fat. The body mass showed a positive association with visceral fat and fat mass. The BMI presented no significant association with bone mineral mass and muscular mass in post-intervention. In pre-intervention, the fat mass presented a positive association with upper body flexibility. The metabolic rate, muscular and bone mineral mass presented an association with upper limbs strength in the program post-intervention.

Table 1. Means, standard deviations, group comparison, and effect size between the pre and post-training program for body composition.

| Variables | Pre-intervention (Mean± SD) | Post-intervention (Mean± SD) | t-test | p-value | Cohen's d |
|---|---|---|---|---|---|
| Body mass (kg) | 67.96 (± 10.16) | 67.65 (± 10.04) | 0.008 | 0.929 | 0.031 |
| Height (m) | 1.63 (± 0.06) | 1.63 (± 0.06) | 0.000 | 1.000 | 0.000 |
| BMI (kg/m²) | 25.42 (± 2.61) | 25.31 (± 2.64) | 0.015 | 0.902 | 0.042 |
| Fat mass (%) | 33.01 (± 6.16) | 31.74 (± 6.42) | 0.347 | 0.560 | 0.202 |
| Muscular mass (kg) | 43.06 (± 6.54) | 43.41 (± 5.81) | 0.027 | 0.871 | 0.057 |
| Bone mineral Mass (kg) | 2.29 (± 0.32) | 2.34 (± 0.30) | 0.151 | 0.700 | 0.161 |
| Water (%) | 48.46 (± 3.93) | 48.72 (± 4.30) | 0.034 | 0.856 | 0.063 |
| Basal metabolic rate (kcal) | 1342.88 (± 180.79) | 1359.76 (± 173.77) | 0.077 | 0.783 | 0.095 |
| Visceral fat (LVL) | 10 (± 2.40) | 9.41 (± 2.09) | 0.581 | 0.452 | 0.262 |

SD: standard deviation; BMI: body mass index; LVL: level.

Table 2. Means, standard deviations, group comparison, and effect size between the pre and post-training program for functional fitness.

| Variables | Pre-intervention (Mean± DP) | Post-intervention (Mean± DP) | t-test | p-value | Cohen's d |
|---|---|---|---|---|---|
| Upper L. Strength (Reps) | 18.18 (± 5.77) | 29.24 (± 6.98) | 9.492 | 0.004* | 1.727 |
| Lower L. Strength (Reps) | 18.47 (± 4.36) | 20.76 (± 6.14) | 1.578 | 0.218 | 0.430 |
| Upper B. Flexibility (cm) | - 8.29 (± 4.36) | -0.65 (± 7.83) | 8.979 | 0.005 | 1.206 |
| Lower B. Flexibility (cm) | 3.88 (± 12.57) | 3.65 (± 9.06) | 0.004 | 0.950 | 0.021 |
| Agility (s) | 4.93 (± 0.95) | 4.59 (± 0.61) | 1.532 | 0.225 | 0.426 |
| Aerobic endurance (Reps) | 44 (± 17.92) | 86.47 (± 40.03) | 15.938 | < 0.001* | 1.369 |

**p*< 0.005; SD: standard deviation; Upper L. Strength: upper limbs strength; Lower L. Strength: lower limbs strength; Upper B. Flexibility: upper body flexibility; Lower B. Flexibility: lower body flexibility.

The water percentage presented a negative association with upper body flexibility. The upper limb strength presented an association with lower limbs strength. The lower limbs strength presented a negative association with agility, and the lower body flexibility presented a positive association with upper body flexibility. Tables 3 and 4 present the significant associations between body composition and functional fitness variables in the pre- and post-training program.

## DISCUSSION

The aim of this study was to assess the influence of a multicomponent training program in body composition and functional fitness in community-dwelling elders after six months of intervention. The main results were:

(i) the body composition did not change with statistical significance between the pre- and post-multicomponent training;

(ii) the elders' functional fitness changed after six months of intervention.

The body composition presented no significant differences between the pre- and post-exercise program intervention. A small effect of the intervention program was found in fat mass and visceral fat reduction. Monteiro et al. (2019) assessed the changes in body composition under three different training programs (muscle power, multicomponent training, and resistance group) and reported no significant changes in fat and lean mass. Moreover, several studies presented no significant changes in the elderly body composition under different exercise programs (Kallinen, Sipila, Alen, & Suominen, 2002; Takeshima et al., 2007; Toraman, Erman, & Agyar, 2004; Tsuzuku et al., 2007). In our study, the unchanged body composition can be explained by the lack of specificity of the multicomponent training. The group did not have the recommended time of

Table 3. Significant associations between body composition and functional fitness variables in the pre-training program.

| | | Height | BMI | Fat mass | Muscular mass | Bone M. mass | Water (%) | Metabolic rate | Visceral fat | Upper limbs strength | Lower body flexibility |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | $r_p$ | - | - | - | - | - | - | - | 0.542 | - | - 0.522 |
| | p | - | - | - | - | - | - | - | 0.024 | - | 0.031 |
| Mass | $r_p$ | 0.770 | 0.898 | - | 0.770 | 0.751 | - | 0.853 | - | - | - |
| | p | < 0.001 | < 0.001 | - | < 0.001 | 0.001 | - | < 0.001 | - | - | - |
| Height | $r_p$ | - | - | - | 0.858 | 0.835 | - | 0.878 | 0.644 | - | - |
| | p | - | - | - | < 0.001 | < 0.001 | - | < 0.001 | 0.005 | - | - |
| BMI | $r_p$ | - | - | 0.627 | 0.504 | 0.490 | - 0.534 | 0.609 | - | - | - |
| | p | - | - | 0.007 | 0.039 | 0.046 | 0.027 | 0.009 | - | - | - |
| Fat mass | $r_p$ | - | - | - | - | - | - 0.939 | - | - | - 0.541 | - |
| | p | - | - | - | - | - | < 0.001 | - | - | 0.025 | - |
| Muscular mass | $r_p$ | - | - | - | - | 0.907 | - | 0.965 | 0.733 | - | - |
| | p | - | - | - | - | < 0.001 | - | < 0.001 | 0.001 | - | - |
| Bone mineral mass | $r_p$ | - | - | - | - | - | - | 0.960 | 0.600 | - | - |
| | p | - | - | - | - | - | - | < 0.001 | 0.011 | - | - |
| Water percentage | $r_p$ | - | - | - | - | - | - | - | - | 0.508 | - |
| | p | - | - | - | - | - | - | - | - | 0.037 | - |
| Basal metabolic rate | $r_p$ | - | - | - | - | - | - | - | 0.639 | - | - |
| | p | - | - | - | - | - | - | - | 0.006 | - | - |
| Visceral fat | $r_p$ | - | - | - | - | - | - | - | - | - | - 0.511 |
| | p | - | - | - | - | - | - | - | - | - | 0.036 |

$r_p$: Pearsons' r; BMI: body mass index; p: significance.

aerobic exercise to induce weight or fat loss. Thus, the session's duration may not induce changes in body composition (Pedersen & Saltin, 2006). However, due to aging, it is expected that the muscular mass might diminish over time (Yoo et al., 2018). That said, unchanged body composition may be understandable as a positive effect of the training program. Moreover, the food intake was not controlled, the diet may have a meaningful impact on body composition (Mitchell et al., 2017; Isanejad et al., 2018).

The multicomponent training program significantly increased the strength and flexibility levels of the upper limbs along with aerobic capacity. That might be explained by the number of exercises for upper limbs. The participants had more upper limbs exercises in comparison to the lower limbs. However, a small effect of the multicomponent training was observed in lower limbs strength, lower body flexibility, and agility (time-up-go test). These results seem to be in accordance with Monteiro et al. (2019) study. Multicomponent training programs seem to improve the strength of the upper limbs (Monteiro et al., 2019b; Nogueira et al., 2017; Bruderer-Hofstetter et al., 2018). Moreover, the physical activity levels were not controlled and so, for active elders, lower limbs strength might be difficult to improve (Monteiro et al., 2019b). As far as our understanding goes, there is no consensus about the improvements in flexibility levels after training programs. Takeshima et al. (2007) reported that flexibility might also improve with exercise with increasing strength levels. In our study, the upper body flexibility improved with the multicomponent training, and it is in accordance to literature (Monteiro et al., 2019b; DiBrezzo, Shadden, Raybon, & Powers, 2005; Cavani, Mier, Musto, & Tummers, 2002; Fatouros et al., 2006; Kalapotharakos et al., 2005). The intervention program also improved the aerobic resistance, supported by several studies (Monteiro et al., 2019; Bouaziz et al., 2016; Blinder et al., 2002; Smith et al., 2012; Villareal et al., 2011).

The present study suggests that body composition and functional fitness variables association may change whether being or not under an exercise program. Sardinha et al. (2015) presented different associations between sedentary

Table 4. Significant associations between body composition and functional fitness variables in the post-training program.

| | | Height | BMI | Fat mass | Muscular mass | Bone M. mass (Kg) | Water (%) | Metabolic rate | Visceral fat | Upper L . Strength | Lower L. strength | Upper L. flexibility | Column flexibility | Time-up-go |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | $r_p$ | - | - | - | - | - | - | - | - | - | - | - | - | 0.671 |
| | p | - | - | - | - | - | - | - | - | - | - | - | - | 0.003 |
| Mass | $r_p$ | 0.750 | 0.897 | 0.487 | 0.625 | 0.727 | - | 0.822 | 0.608 | - | - | - | - | - |
| | p | 0.001 | < 0.001 | 0.048 | 0.007 | 0.001 | - | < 0.001 | < 0.001 | - | - | - | - | - |
| High | $r_p$ | - | - | - | 0.833 | 0.867 | - | 0.875 | 0.743 | - | - | - | - | - |
| | p | - | - | - | < 0.001 | < 0.001 | - | < 0.001 | 0.001 | - | - | - | - | - |
| BMI | $r_p$ | - | - | 0.710 | - | - | - 0.563 | 0.558 | - | - | - | - | - | - |
| | p | - | - | 0.001 | - | - | 0.019 | 0.020 | - | - | - | - | - | - |
| Fat mass | $r_p$ | - | - | - | - | - | - 0.937 | - | - | - | - 0.582 | 0.570 | - | - |
| | p | - | - | - | - | - | < 0.001 | - | - | - | 0.014 | 0.017 | - | - |
| Muscular mass | $r_p$ | - | - | - | - | 0.945 | - | 0.931 | 0.775 | 0.561 | - | - | - | - |
| | p | - | - | - | - | < 0.001 | - | < 0.001 | < 0.001 | 0.019 | - | - | - | - |
| Bone M. mass | $r_p$ | - | - | - | - | - | - | 0.981 | 0.842 | 0.515 | - | - | - | - |
| | p | - | - | - | - | - | - | < 0.001 | < 0.001 | 0.034 | - | | - | - |
| Water (%) | $r_p$ | - | - | - | - | - | - | - | - | - | 0.503 | - 0.584 | - | - |
| | p | - | - | - | - | - | - | - | - | - | 0.040 | 0.014 | - | - |
| Metabolic rate | $r_p$ | - | - | - | - | - | - | - | 0.798 | 0.509 | - | - | - | - |
| | p | - | - | - | - | - | - | - | < 0.001 | 0.037 | - | - | - | - |
| Upper L. strength | $r_p$ | - | - | - | - | - | - | - | - | - | 0.605 | - | - | - |
| | p | - | - | - | - | - | - | - | - | - | 0.010 | - | - | - |
| Lower L. strength | $r_p$ | - | - | - | - | - | - | - | - | - | - | - | - | - 0.559 |
| | p | - | - | - | - | - | - | - | - | - | - | - | - | 0.020 |
| Lower B. slexibility | $r_p$ | - | - | - | - | - | - | - | - | - | - | 0.677 | - | - |
| | p | - | - | - | - | - | - | - | - | - | - | 0.003 | - | - |

Upper L. Strength: upper limbs strength; Lower L. Strength: lower limbs strength; Upper B. Flexibility: upper body flexibility; Lower B. Flexibility: lower body flexibility; BMI: body mass index; $r_p$: Pearsons' r; p: significance.

behaviour, breaks in sedentary time, and moderate-to-vigorous physical activity with physical function in older adults. Gianoudis et al. (2015) reported that sedentary behaviour was associated with reduced muscle mass and an increased risk of sarcopenia in older adults. Moreover, Monteiro et al. (2019a) reported that high levels of physical activity seem to increase lower limbs' muscular strength and decrease BMI and fat mass. These findings seem to support our results. The multicomponent training seems to influence the associations between body composition and functional fitness variables.

The presented study presented the following limitations:

(i) there was not a control group to compare the results after the multicomponent training program;
(ii) the physical activity levels were not taken into account to justify functional fitness and body composition changes;
(iii) the tests were performed two hours after the breakfast;
(iv) the breakfast type and quantity were not evaluated, and so, effects on body composition were not controlled in this research.

## CONCLUSIONS

This study concluded that body composition of elderly seems not to be affected after six months of multicomponent training. However, functional fitness in upper limbs strength, upper body flexibility, and aerobic endurance seem to improve after six months of multicomponent training. The associations between body composition and functional fitness may vary by being or not under a multicomponent training program.

## REFERENCES


American College of Sports Medicine [ACSM]. (2006). *ACSM's guidelines for exercise testing and prescription* (7th ed.). Baltimore: Lippincott Williams & Wilkins.

American College of Sports Medicine [ACSM]. (2009). American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Medicine & Science in Sports & Exercise, 41*(3), 687-708. https://doi.org/10.1249/mss.0b013e3181915670

Binder, E. F., Schechtman, K. B., Ehsani, A. A., Steger-May, K., Brown, M., Sinacore, D. R., ... & Holloszy, J. O. (2002). Effects of exercise training on frailty in community-dwelling older adults: results of a randomized, controlled trial. *Journal of the American Geriatrics Society, 50*(12), 1921-1928. https://doi.org/10.1046/j.1532-5415.2002.50601.x

Bouaziz, W., Lang, P. O., Schmitt, E., Kaltenbach, G., Geny, B., & Vogel, T. (2016). Health benefits of multicomponent training programmes in seniors: a systematic review. *International journal of clinical practice, 70*(7), 520-536. https://doi.org/10.1111/ijcp.12822

Brach, J. S., Simonsick, E. M., Kritchevsky, S., Yaffe, K., Newman, A. B., & Health, Aging and Body Composition Study Research Group. (2004). The association between physical function and lifestyle activity and exercise in the health, aging and body composition study. *Journal of the American Geriatrics Society, 52*(4), 502-509. https://doi.org/10.1111/j.1532-5415.2004.52154.x

Bruderer-Hofstetter, M., Rausch-Osthoff, A. K., Meichtry, A., Münzer, T., & Niedermann, K. (2018). Effective multicomponent interventions in comparison to active control and no interventions on physical capacity, cognitive function and instrumental activities of daily living in elderly people with and without mild impaired cognition–a systematic review and network meta-analysis. *Ageing research reviews, 45*, 1-14. https://doi.org/10.1016/j.arr.2018.04.002

Carvalho, M. J., Marques, E., & Mota, J. (2009). Training and detraining effects on functional fitness after a multicomponent training in older women. *Gerontology, 55*(1), 41-48. https://doi.org/10.1159/000140681

Carvalho, J., Oliveira, J., Magalhães, J., Ascensão, A., Mota, J., & Soares, J. M. C. (2004). Força muscular em idosos I: Será o treino generalizado suficientemente intenso para promover o aumento da força muscular em idosos de ambos os sexos. *Revista Portuguesa de Ciências do Desporto, 2004*(1), 51-57. https://doi.org/10.5628/rpcd.04.01.51

Cavani, V., Mier, C. M., Musto, A. A,. & Tummers, N. (2002). Effects of a 6-week resistance-training program on functional fitness of older adults. *Journal of aging and physical activity, 10*(4), 443-452. https://doi.org/10.1123/japa.10.4.443

Cyarto, E. V., Brown, W. J., Marshall, A. L., & Trost, S. G. (2008). Comparison of the effects of a home-based and group-based resistance training program on functional ability in older adults. *American Journal of Health Promotion, 23*(1), 13-17. https://doi.org/10.4278/ajhp.07030120

Daley, M. J. & Spinks, W. L. (2000). Exercise, mobility and aging. *Sports Med, 29*(1), 1-12. https://doi.org/10.2165/00007256-200029010-00001

DiBrezzo, R., Shadden, B. B., Raybon, B. H., & Powers, M. (2005). Exercise intervention designed to improve strength and dynamic balance among community-dwelling older adults. *Journal of aging and physical activity, 13*(2), 198-209. https://doi.org/10.1123/japa.13.2.198

Fatouros, I. G., Kambas, A., Katrabasas, I., Leontsini, D., Chatzinikolaou, A., Jamurtas, ... & Taxildaris, K. (2006). Resistance training and detraining effects on flexibility performance in the elderly are intensity-dependent. *Journal of Strength and Conditioning Research, 20*(3), 634-642. https://doi.org/10.1519/00124278-200608000-00027

Gianoudis, J., Bailey, C. A., & Daly, R. M. (2015). Associations between sedentary behaviour and body composition, muscle function and sarcopenia in community-dwelling older adults. *Osteoporosis international, 26*(2), 571-579. https://doi.org/10.1007/s00198-014-2895-y

Hand, B. D., Cavanaugh, S., Forbes, W., Govern, J., & Cress, M. E. (2012). Changes in health-related quality of life and functional fitness with exercise training in older adults who attend senior centers. *Activities, Adaptation & Aging, 36*(1), 29-54. https://doi.org/10.1080/01924788.2011.647530

Instituto Nacional de Estatística [INE]. (2016). Portal do INE. Available at: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=277695619&DESTAQUESmodo=2&xlang=pt

Isanejad, M., Sirola, J., Mursu, J., Rikkonen, T., Kröger, H., Tuppurainen, M., & Erkkilä, A. T. (2018). Association of the Baltic Sea and Mediterranean diets with indices of sarcopenia in elderly women, OSPTRE-FPS study. *European journal of nutrition, 57*(4), 1435-1448. https://doi.org/10.1007/s00394-017-1422-2

Kalapotharakos, V. I., Michalopoulos, M., Tokmakidis, S. P., Godolias, G., & Gourgoulis, V. (2005). Effects of a heavy and a moderate resistance training on functional performance in older adults. *Journal of Strength and Conditioning Research, 19*(3), 652-657. https://doi.org/10.1519/00124278-200508000-00028

Kallinen, M., Sipila, S., Alen, M. & Suominen, H. (2002). Improving cardiovascular fitness by strength or endurance training in women aged 76-78 years. A population-based, randomized controlled trial. *Age and Ageing, 31*(4), 247-254

Kloubec, J. A., Rozga, M., & Block, M. (2012). Balance improvements in independent-living elderly adults following a 12-week structured exercise program. *Activities, Adaptation & Aging, 36*(2), 167-178. https://doi.org/10.1093/ageing/31.4.247

Kyle, U. G., Genton, L., Hans, D., Karsegard, V. L., Michel, J. P., Slosman, D. O., & Pichard, C. (2001). Total body mass, fat mass, fat-free mass, and skeletal muscle in older people: cross-sectional differences in 60-year-old persons. *J Am Geriatr Soc, 49*(12), 1633-1640. https://doi.org/10.1111/j.1532-5415.2001.49272.x

Lachenbruch, P. A. (1989). Statistical power analysis for the behavioral sciences. *Journal of the American Statistical Association, 84*(408), 1096-1097. https://doi.org/10.2307/2290095

Lord, S. R., Ward, J. A., Williams, P. & Strudwick, M. (1995). The effect of a 12-month exercise trial on balance, strength, and falls in older women: a randomized controlled trial. *Journal of the American Geriatrics Society, 43*(11), 1198-1206. https://doi.org/10.1111/j.1532-5415.1995.tb07394.x

Mitchell, C. J., Milan, A. M., Mitchell, S. M., Zeng, N., Ramzan, F., Sharma, P., ... & Cameron-Smith, D. (2017). The effects of dietary protein intake on appendicular lean mass and muscle function in elderly men: a 10-wk randomized controlled trial. *The American journal of clinical nutrition, 106*(6), 1375-1383. https://doi.org/10.3945/ajcn.117.160325

Monteiro, A. M., Bartolomeu, R. F., Forte, P. M. G., & Carvalho, J. (2019). The Effects of three different types of training in functional fitness and body composition in older women. *Journal of Sport and Health Research, 3*(11), 289-304. Available at: https://www.researchgate.net/publication/336617266

Monteiro, A. M., Silva, P. M., Forte, P., & Carvalho, J. (2019). The effects of daily physical activity on functional fitness, isokinetic strength and body composition in elderly community-dwelling women. *Journal of Human Sport and Exercise, 14*(2), 385-398. https://doi.org/10.14198/jhse.2019.142.11

Monteiro, A. M., Forte, P., Carvalho, J., Barbosa, T. M., & Morais, J. E. (2019). Relationship between fear of falling and balance factors in healthy elderly women: A confirmatory analysis. *Journal of Women & Aging, 33*(1), 57-69. https://doi.org/10.1080/08952841.2019.1681244

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., Macera, C. A., & Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association (ACSM/AHA). *Geriatric Nursing*, 28(6), 339-440. https://doi.org/10.1016/j.gerinurse.2007.10.002

Nogueira, A. C., de Resende Neto, A. G., Santos, J. C. A., da Silva Chaves, L. M., Azevêdo, L. M., Teixeira, C. V. L. S., ... & Da Silva-Grigoletto, M. E. (2017). Effects of a multicomponent training protocol on functional fitness and quality of life of physically active older women. *Motricidade, 13*(S1), 86-93. Available at: https://www.researchgate.net/publication/323855249

Pedersen, B. K. & Saltin, B. (2006). Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian Journal of Medicine & Science in Sports, 16*(Suppl 1), 3-63. https://doi.org/10.1111/j.1600-0838.2006.00520.x

Puggaard, L., Pedersen, H. P., Sandager, E., & Klitgaard, H. (1994). Physical conditioning in elderly people. *Scandinavian Journal of Medicine & Science in Sports, 4*(1), 47-56. https://doi.org/10.1111/j.1600-0838.1994.tb00405.x

Rikli, R. E. & Jones, C. J. (1999). Development and validation of a functional fitness test for community-residing older adults. *Journal of aging and physical activity, 7*(2), 129-161. https://doi.org/10.1123/japa.7.2.129

Salem, G. J., Skinner, J. S., Chodzko-Zajko, W. J., Proctor, D. N., Fiatarone Singh, M. A., Minson, C. T., & Nigg, C. R. (2009). Exercise and Physical Activity for Older Adults. *Medicine & Science in Sports & Exercise, 41*(7), 1510-1530. https://doi.org/10.1249/MSS.0b013e3181a0c95c

Sardinha, L. B., Santos, D. A., Silva, A. M., Baptista, F., & Owen, N. (2015). Breaking-up sedentary time is associated with physical function in older adults. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences, 70*(1), 119-124. https://doi.org/10.1093/gerona/glu193

Silva, A. O., Karnikowski, M. G. O., Funghetto, S. S., Stival, M. M., Lima, R. M., de Souza, J. C., ... & Prestes, J. (2013). Association of body composition with sarcopenic obesity in elderly women. *International journal of general medicine, 6*, 25. https://doi.org/10.2147/ijgm.s36279

Singh, M. A. (2002). Exercise comes of age: rationale and recommendations for a geriatric exercise prescription. *The Journal of Gerontology: Series, 57*(5), M262-282. https://doi.org/10.1093/gerona/57.5.M262

Smith, G. I., Villareal, D. T., Sinacore, D. R., Shah, K., & Mittendorfer, B. (2012). Muscle protein synthesis response to exercise training in obese, older men and women. *Medicine and science in sports and exercise, 44*(7), 1259-1266. https://doi.org/10.1249/mss.0b013e3182496a41

Sternfeld, B., Ngo, L., Satariano, W. A., & Tager, I. B. (2002). Associations of body composition with physical performance and self-reported functional limitation in elderly men and women. *American journal of epidemiology, 156*(2), 110-121. https://doi.org/10.1093/aje/kwf023

Takeshima, N., Rogers, N. L., Rogers, M. E., Islam, M. M., Koizumi, D., & Lee, S. (2007). Functional fitness gain varies in older adults depending on exercise mode. *Medicine & Science in Sports & Exercise, 39*(11), 2036-2043. https://doi.org/10.1249/mss.0b013e31814844b7

Toraman, N.F., Erman, A., & Agyar, E. (2004). Effects of multicomponent training on functional fitness in older adults. *Journal of aging and physical activity, 12*(4), 538-553. https://doi.org/10.1123/japa.12.4.538

Tsuzuku, S., Kajioka, T., Endo, H., Abbott, R. D., Curb, J. D., & Yano, K. (2007). Favorable effects of non-instrumental resistance training on fat distribution and metabolic profiles in healthy elderly people. *European journal of applied physiology, 99*, 549-555. https://doi.org/10.1007/s00421-006-0377-4

Villareal, D. T., Smith, G. I., Sinacore, D. R., Shah, K., & Mittendorfer, B. (2011). Regular multicomponent exercise increases physical fitness and muscle protein anabolism in frail, obese, older adults. *Obesity, 19*(2), 312-318. https://doi.org/10.1038/oby.2010.110

World Health Organisation [WHO]. (2006). *BMI Classifications*. Available at: http://www.who.int/bmi/index.jsp?introPage=intro_3.htm. 2006

Yoo, S. Z., No, M. H., Heo, J. W., Park, D. H., Kang, J. H., Kim, S. H., & Kwak, H. B. (2018). Role of exercise in age-related sarcopenia. *Journal of exercise rehabilitation, 14*(4), 551-558. https://doi.org/10.12965%2Fjer.1836268.134