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## EFFECT OF RESISTANCE TRAINING COMBINED WITH CALORIC RESTRICTION ON LEAN BODY MASS OF POSTMENOPAUSAL WOMEN: A SYSTEMATIC REVIEW

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**Abstract: Objectives:** We conducted a systematic review of randomized controlled trials evaluating the effect of resistance training associated with caloric restriction on lean body mass of postmenopausal women. **Methodology:** The surveys were carried out at Pubmed, Embase and Web of Science from the beginning until June 2020. The data extracted included original articles that combined or not combined caloric restriction with resistance training. The risk of bias in RCTS was assessed using the Testex scale. **Findings:** The searches returned 158 articles and after the analysis, 5 articles were included in this review. The main results found demonstrated that the combination of resistance training to caloric restriction can preserve or attenuate the loss of lean body mass, while promoting similar loss of fat mass in postmenopausal women. **Conclusions:** Resistance training should be applied to postmenopausal women who are in the process of losing weight in order to preserve or mitigate lean body mass losses. More research must be carried out in order to obtain a better methodology in the prescription of exercises in this population. **Keywords:** Postmenopausal women - weight loss - resistance training – caloric restriction – lean body mass.

## INTRODUCTION

Excess in body fat increases the risk of the development of metabolic disorders, morbidity, and limitation in physical ability (Blüher 2019; Wearing et al. 2006). Postmenopausal women are at greater risk of weight gain and obesity (Jung et al. 2015). Moreover, hormonal changes occurring in this period can influence the migration of adipose tissue, from the extremities to the center of the body, and the reduction of lean body mass (Dmitruk et al. 2018). That said, reducing body weight and maintaining or gaining lean body mass are fundamental to lessening the risks of morbi-

dity and maintaining the metabolic and physical integrity of the target population (Cava, Yeat and Mittendorfer 2017; Brown 2015).

However, in practice, weight loss interventions generally result in body fat loss concomitant with an expressive loss of lean body mass (Weiss et al. 2016; Weinheimer, Sands and Campbellnure 2010). That, especially if added to all previously mentioned post-menopause hormonal and body changes, negatively impacts the target population's metabolic health and physical ability.

In this regard, previous work has shown that interventions that combine caloric restrictions (CR) with adequate protein ingestion and physical exercise practice (particularly strength training - ST) result in maintaining lean body mass and physical function improvement of obese individuals in the process of weight loss (Cava, Yeat and Mittendorfer 2017; Miller et al. 2013). A recent meta-analysis on postmenopausal women reproduced this result, showing that a combination of physical exercise and CR attenuated the loss or maintained the amount of lean body mass during the process of weight loss (Cheng, Hsu and Liu 2018). However, the study failed to sort the results by exercise type, and, as we have previously mentioned, ST combined with CR seems to offer the best effect on the preservation of lean body mass when compared to other training methods.

In the target population, some studies on clinical trials show that CR combined with ST, though reducing lean body mass, had an attenuated reduction when compared to the isolated CR (Bouchard 2009; Figueroa 2013). On the other side, other studies show that the combination resulted in the maintenance of the amount of lean body mass (Nahas et al. 2019; St-onge 2013). These inconsistencies trial by trial might be the result of methodological differences, intervention protocol, as well as in evaluating methods. That said, we

conducted the current systematical review to investigate the effects of combining CR with ST, paying close attention to the outcomes of this intervention model in lean body mass of obese postmenopausal women, and summarizing the data and results found.

## METHODS

This review was conducted according to the recommendations of PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses, and registered at PROSPERO, International Prospective Register of Systematic Reviews (protocol 2020: CRD42020197746). The analysis was systematic on the databases of Pubmed, Embase, and Web of Science, looking for original articles published before June of 2020. We used the following words, descriptions, terms, and their combinations in the search: (“postmenopausal” OR “postmenopause”) AND (“diet” OR “caloric restriction” OR “energy restriction”) AND (“resistance training” or “strength training” OR “weight training” OR “weight lifting” OR “strength training” OR “resistance exercise” OR “strength exercise” OR “resistance program” OR “strength program”) AND (“obesity” OR “overweight”).

The PICOT strategy (population: overweight or obese postmenopausal women ( $\geq 25$  kg/m<sup>2</sup>); intervention: CR combined or not with ST; comparative: comparing results between CR and CR+ST; outcomes: fat body mass and lean body mass; study type: clinical trials) was used to define inclusion criteria for the articles in this review. The article selection had three separate stages: the first consisted of verifying unicity and excluding duplicated articles; the second consisted of reading titles and abstracts of the remaining articles and verifying if their content covered the inclusion criteria of this review; the third and last stage consisted of reading the entirety of the remaining articles and verifying if their study

followed the PICOT strategy, which we adopted in this review. Finally, the articles included in this review were analyzed through the Testex scale to evaluate the risks of bias.

Two researchers went through the articles independently, and in the case of disagreements, we invited a third researcher was to analyze the eligibility of the conflicted matter.

## RESULTS

Our initial search resulted in a total of 158 articles. However, 51 of those were duplicates, and we discarded them. After the second stage sorting, where we read titles and abstracts, only 12 articles were eligible for going forward, where we read the entirety. After thoroughly reading them, five articles passed our inclusion criteria and were featured in the final version of our review. We discarded seven articles because this results taken from the same sample.

### RISK OF BIAS ANALYSIS (TESTEX)

The quality of the included articles was very homogeneous, as shown in their scores on the Testex scale: two articles 10/15 (Figueroa et al. 2013; Campbell et al. 2009) and three articles 11/15 (Joseph et al. 2001; Sénéchal et al. 2012; Brochu et al. 2009).

### CHARACTERIZING INCLUDED STUDIES

Table 1 describes the characterizing of the included studies and the main results we found in the body composition. The mean age of the studies was between 54 and 67 years old, with a BMI greater than 28 kg/m<sup>2</sup>. The five studies intervened with women that were postmenopausal, sedentary, and without any comorbidities. In one of them (Sénéchal et al. 2012), the authors considered subjects with dynapenic-obesity. The length of the intervention varied across studies: three of them had a 12-week (Figueroa et al. 2013; Campbell et

al. 2009; Sénéchal et al. 2012), one other had a six-month (Brochu et al. 2009), and the last had a four-week (Joseph et al. 2001) duration. All of them followed a protocol of 3 sessions of ST a week for the groups CR+ST. The mean caloric intake considered in the restriction was between 500 and 800 kcal a day. Only one (Sénéchal et al. 2012) had the mean goal weight loss set to 0.5 to 1 kg of body weight a week, to base their CR intervention. Regarding diet composition: three studies (Joseph et al. 2001; Sénéchal et al. 2012; Brochu et al. 2009) adopted a 55%, 30%, and 15% relationship for carbohydrates, fat, and protein, respectively; one (Figueroa et al. 2013) had subjects consumed a larger proportion of proteins (20 to 25%); and the last (Campbell et al. 2009) did not report their diet composition. All ST protocols involved exercises in machines, with whole-body workouts, except that in one study (Figueroa et al. 2013) that had only lower body exercises. The mean weight load in the strength exercise varied between 65 and 80% of the 1 RM, except for one study (Figueroa et al. 2013) that used a lower weight load (50% of 1 RM). The 1RM test was estimated following the protocol proposed for Baechle and Earle (Baechle and Earle 2008). All studies except one had two to four series per exercise with a repetition margin of eight to 12, the remainder study (Figueroa et al. 2013) had a repetition margin of 18 to 22 per series.

For the body composition evaluated, three of the studies (Figueroa et al. 2013; Sénéchal et al. 2012; Brochu et al. 2009) used the *Dual-energy X-ray absorptiometry* (DEXA), where they were able to report the lean and fat body mass, and the two other (Campbell et al. 2009; Joseph et al. 2001) used plethysmography, where the authors reported fat-free and fat body mass, except that one of them (Joseph et al. 2001), added the creatinine exam to estimate the amount of muscle mass.

## RESULTS IN BODY COMPOSITION

Regarding lean body mass, the authors of one study (Brochu et al. 2009) reported that the intervention with CR+ST resulted in the maintenance of the subjects' lean body mass, even though in the remainder of studies (Figueroa et al. 2013; Sénéchal et al. 2012) reported a loss reduction in lean body mass, for the groups combining CR+ST, when compared to an isolated intervention with CR. On the studies that measured fat-free mass, both (Campbell et al. 2009; Joseph et al. 2001) reported that CR+ST interventions attenuated the loss in the fat-free mass when compared to the isolated CR. However, the study (Joseph et al. 2001) that calculated the muscular mass based on the excretion of creatinine in the urine, where they adopted 17.9 kg of muscle mass per gram of creatinine, reported maintenance of muscle mass in the CR+ST group, as opposed to an expressive loss in the CR group.

Regarding fat body mass, all studies included in the present review reported no significant differences between CR and CR+ST interventions in the loss of fat body mass, showing that both interventions are equally effective for this purpose.

## DISCUSSION

The goal of this review was to investigate the effects of the combination of CR and ST in body composition, specifically in the lean body mass of postmenopausal obese women. And the selected articles show that the combination help preserving or attenuating the loss of lean body mass while promoting a similar reduction in fat body mass to the isolated CR intervention.

At first, we wanted to verify if an isolated CR intervention had the potential to maintain or gain lean body mass. The findings of this review show that, in one study (Campbell et al. 2009), the CR promoted the maximum amount of absolute loss in lean body mass of

-1.6 kg, after an 11-week intervention. However, the mean absolute loss in the other studies was not higher than -1 kg of lean body mass. In general lines, the ratio of lean body mass loss when compared to the total weight loss was not greater than 28%, amounting to a mean across studies of 25%, corroborating with the data previously described in weight loss processes in obese subjects (Chaston, Dixon and O'Brien 2007).

A possible mechanism of this representative loss of lean body mass compared with bodyweight is that during short and prolonged periods of CR can lead to an inhibition of the synthesis of muscle protein and an increase in proteolysis (Cava, Yeat and Mittendorfer 2017). Therefore, since the preservation of lean body mass depends on the balance between the synthesis and degrading of proteins, an isolated CR intervention promotes muscular atrophy. Despite this, the scientific literature has described that the ingestion of protein between 2.3 and 3.1 g/kg/d can stimulate muscle protein synthesis and attenuated the protein degrading, even in isolated CR interventions (Stokes et al. 2018).

Even though the amount of ingested protein during a CR intervention influence in the lean body mass, some systematic reviews in obese elderly subjects reported that the combination of CR with ST offered positive effects in the lean body mass, both attenuating loss or preserving the amount of it when compared to interventions of isolated CR (Weinheimer, Sands and Campbellnure 2010; Sardeli et al. 2018). This review arrived at the same conclusion, except that we focused on the results of the weight-loss interventions in postmenopausal women. The target group commonly present an anabolic resistance due to age, sex, morbidities, and, mainly, low progesterone and estrogen levels, which are factors that challenge the preservation and gain of lean body mass (McCormick and Vasilaki 2018; Hansen 2018).

On the other hand, some more consistent mechanisms justify the inclusion of ST to the CR to preserve the lean body mass during the weight-loss process. One of these mechanisms describes that an acute stimulus of ST can potentialize the synthesis of proteins in superior levels than when resting (Witard et al. 2009), where after multiple training sessions the muscle proteins accumulate that causes hypertrophy. Another possible mechanism mentioned was the regulation of autophagy of muscle cells, which gets accentuated during intervention with isolated CR, but the addition of ST regulates cellular autophagy providing a positive balance between muscle repair and remodeling (Smiles et al. 2015).

Regarding strength training, (ACSM 2014) recommends two to three sessions weekly with whole-body exercises, alternating between body segments, with one to three series per exercise and 10 to 15 repetitions for healthy middle age and elderly individuals. This review's findings are in agreement with the guidelines for strength training, where most studies included a strength training intervention of 80% of 1 RM, however, one study (Figueroa et al. 2013) stood out because they used only 50% of 1 RM and a higher number of repetitions, which agrees with previous results that show the smaller weight load percent can also result in hypertrophic gains (Schoenfeld et al. 2017). Though the findings in this review show the maintenance or the reduction in the loss of lean body mass in intervention protocols with combined CR and ST. The results presented adopted an evaluation of lean body mass in this review that might not be as reliable as a good quantitative representation of muscle mass, but it constitutes the majority of lean body mass. However, it is noteworthy that during the weight loss process there are changes in the body water quantity that can influence all results. Besides, the studies we reviewed used different evaluating models for lean body mass, duration of intervention, and

caloric restriction. Yet, we could not identify the amount of protein ingestion across studies. Thus, the results found here should be cautiously considered and directed only to obese postmenopausal women.

Finally, we recommend further investigation on the effects of an intervention CR and ST on obese postmenopausal women, but using different values of protein ingestion during CR, modulating different strategies for ST, given that different responses might be found with the manipulation of the training variables and verifying possible mechanisms that are related to methods combination in the muscle mass of postmenopausal women.

## CONCLUSIONS

The findings of this review show that a combination of CR and ST can preserve or attenuate the loss in lean body mass in obese postmenopausal women. Lastly, more research must be carried out in order to obtain a better methodology in the prescription of exercises in this population.

## CONFLIT OF INTERESSIS

The authors state they have no conflicts of interest.

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| Auteurs                 | Study quality |   |   |   |   |         |    |    |    |   | Study report      |    |   |    |    |    |         |       |
|-------------------------|---------------|---|---|---|---|---------|----|----|----|---|-------------------|----|---|----|----|----|---------|-------|
|                         | 1             | 2 | 3 | 4 | 5 | Parcial | 6a | 6b | 6c | 7 | 8a                | 8b | 9 | 10 | 11 | 12 | Parcial | Total |
|                         | (0 a 5)       |   |   |   |   |         |    |    |    |   | (0 a 10) (0 a 15) |    |   |    |    |    |         |       |
| Joseph et al. (2001)    | 1             | 1 | 0 | 1 | 0 | 3       | 1  | 1  | 1  | 1 | 1                 | 1  | 1 | 0  | 0  | 1  | 8       | 11    |
| Brochu et al. (2009)    | 1             | 1 | 0 | 1 | 0 | 3       | 1  | 1  | 1  | 1 | 1                 | 1  | 1 | 0  | 0  | 1  | 8       | 11    |
| Campbell et al. (2009)  | 1             | 1 | 0 | 0 | 0 | 2       | 1  | 1  | 1  | 1 | 11                | 1  | 1 | 0  | 0  | 1  | 8       | 10    |
| Figuerola et al. (2013) | 1             | 1 | 0 | 1 | 0 | 3       | 1  | 0  | 1  | 1 | 1                 | 1  | 1 | 0  | 0  | 1  | 7       | 10    |
| Senechal et al. (2012)  | 1             | 1 | 0 | 1 | 0 | 3       | 1  | 0  | 1  | 1 | 1                 | 1  | 1 | 1  | 1  | 1  | 8       | 11    |

Table 1. Testex Scale

Study quality: 1 = Eligibility criteria specified; 2 = Specified randomization; 3 = allocation concealment; 4 = Similar groups at baseline; 5 = Evaluator blinding (for at least one key result).

Study report: 6 = Outcome measures assessed in 85% of participants (6a = 1 point if completion rate <85%; 6b = 1 point if adverse events are reported; 6c = 1 point if exercise frequency is reported); 7 = Intention-to-treat analysis; 8 = Statistical comparisons between groups reported (8a = 1 point if statistical comparisons between groups are reported for the primary outcome measure of interest; 8b = 1 point if statistical comparisons between groups are reported for at least one secondary outcome measure); 9 = point measures and measures of variability for all reported outcome measures; 10 = Monitoring of activities in control groups; 11 = the relative exercise intensity remained constant; 12 = Exercise volume

| Article       | Sample Characterization (number of subjects) age                                                                            | Intervention Duration                           | Caloric Restriction/ Body- weight reduction Diet composition (Carbohydrates/ fat/protein | Training Protocol N° of weekly sessions N° of series and repetitions % of weight load                                                   | N° of % of | Body composition   |                    |
|---------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------|--------------------|--------------------|
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | CR                 | CR+ST              |
| Joseph et al. | 19 women CR<br>61± 2 years old<br>30.4 ± 1 kg/m <sup>2</sup><br><br>CR+ST<br>65± 2 years old<br>29.4± 0.9 kg/m <sup>2</sup> | 2 weeks of maintained diet + 4 weeks of CR + ST | -750 kcal/day (55%/ 30%/ 15%)                                                            | Exercises: unilateral leg extension, unilateral leg curl, leg press, bench press and seated cable row<br>3x/week 2x8 + 1x12 80% 1 RM NI |            | <b>Weight (kg)</b> | <b>Weight (kg)</b> |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Pre:80.8±2.6       | Pre:78.2±2.1       |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Post:77.8±2.7      | Post:75±2.2        |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | <b>%F</b>          | <b>%F</b>          |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Pre:47.2±1.4       | Pre:47±1.4         |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Post: 45.2±1.6     | Post:44.6±1.4      |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | <b>F (kg)</b>      | <b>F (kg)</b>      |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Pre:38.3±2.1       | Pre:36.9±1.9       |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Post:35.3±2.2      | Post:33.7±1.9      |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | <b>FFM (kg)</b>    | <b>FFM (kg)</b>    |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Pre: 42.5 ±1.3     | Pre:41.2±0.6       |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Post: 42.4±1.3     | Post:41.3±0.7      |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | <b>MM (kg)</b>     | <b>MM (kg)</b>     |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Pre: 16±1.3        | Pre: 17.9±0.8      |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Post: 15.4±1.3     | Post: 18.3±0.8     |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | <b>WC (cm)</b>     | <b>WC (cm)</b>     |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Pre:97.3±2.7       | Pre:90.9±2.1       |
|               |                                                                                                                             |                                                 |                                                                                          |                                                                                                                                         |            | Post:93.3±2.2      | Post:88.2±2.2      |

|                 |                                                                   |                                                          |                                                     |                                                                                                                                             |                                               |                                               |
|-----------------|-------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Brochu et al.   | CR (71)<br>58.0± 4.7 years old<br>32.2± 4.6 kg/m <sup>2</sup>     | 6 months                                                 | -500~800 kcal/day<br>(55%/ 30%/ 15%)                | Exercises: legpress, bench press, upright row, overhead press, biceps curl e pushdown 3x/week                                               | Weight (kg)<br>Δ:-5.1 ± 4.7<br>%F             | Weight (kg)<br>Δ:-5.6 ± 5.0<br>%F             |
|                 | CR+ ST (21)<br>57.6± 4.1 years old<br>32.6± 5.0 kg/m <sup>2</sup> |                                                          |                                                     | Phase 1 (3weeks): 2-3x15<br>65% 1RM 90-120s                                                                                                 | Δ:-2.5 ± 2.7<br>F (kg)                        | Δ:-4.4 ± 3.5<br>F (kg)                        |
|                 |                                                                   |                                                          |                                                     | Phase 2 (5 weeks): 2-3x12<br>70% 1RM 90s                                                                                                    | Δ:-4.0 ± 3.5<br>LBM (kg)                      | Δ:-5.6 ± 4.7<br>LBM (kg)                      |
|                 |                                                                   |                                                          |                                                     | Phase 3 (9 weeks): 2-4x8-10<br>75-80% 1RM 120-180s                                                                                          | Δ:-0.9 ± 2.4<br>WC (cm)                       | Δ:0.00 ± 1.5<br>WC (cm)                       |
|                 |                                                                   |                                                          |                                                     | Phase 4 (8 weeks): 3-4x10-12<br>70-75% 1RM 60-90s                                                                                           | Δ:-4.3 ± 3.8                                  | Δ:-6.9 ± 4.3                                  |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             |                                               |                                               |
| Campbell et al. | CR (8)<br>67± 1 years old<br>28.9± 1.2 kg/m <sup>2</sup>          | 3 weeks of maintenance diet +11 weeks of CR with/ out ST | -500 kcal/day (NI)                                  | Exercises: leg extension, leg curl, leg press, bench press e upright row 3x/week (2x8) + (1x12) 80% 1RM 60-120s                             | Weight<br>Δ%:-7.7±0.8<br>%F                   | Weight<br>Δ%:-6.1±0.3<br>%F                   |
|                 | CR+ ST(8)<br>70± 2 years old<br>29.5± 1.2 kg/m <sup>2</sup>       |                                                          |                                                     |                                                                                                                                             | Δ%:-5.4±2.4<br>F (kg)                         | Δ%:-6.3±1.1<br>F (kg)                         |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | Δ%:-12.8±2.9<br>FFM (kg)                      | Δ%:-12.1±1.2<br>FFM (kg)                      |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | Δ%:-4.2±1.2                                   | Δ%:-0.5±1.0                                   |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             |                                               |                                               |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             |                                               |                                               |
| Figueroa et al. | CR (13)<br>54±1years old<br>34.8±1.2Kg/m <sup>2</sup>             | 12 weeks                                                 | Ingestion of 1250 kcal/day (55~60%/ 20~25%/ 20~25%) | Exercises: leg press, leg extension, leg curl, standing calf raise 3x/week                                                                  | Weight (kg)<br>Pre: 89.0±4.4<br>Post:83.4±4.6 | Weight (kg)<br>Pre: 86.7±2.7<br>Post:81.9±2.5 |
|                 | RC+ST (14)<br>54±1 years old<br>32.7±1.1Kg/m <sup>2</sup>         |                                                          |                                                     | Phase 1 (2weeks): 2x18-22<br>50% 1                                                                                                          | F (kg)                                        | F (kg)                                        |
|                 |                                                                   |                                                          |                                                     | Phase 2 (10 weeks) 3x18-22<br>50% 1 RM                                                                                                      | Pre:44.1±2.9                                  | Pre:41.9±2.0<br>Post:37.5±2.0                 |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | LBM (kg)                                      | LBM (kg)                                      |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | Pre: 42.4±1.3<br>Post: 39.7±3.1               | Pre: 41.6±1.2                                 |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | LML (kg)                                      | LML (kg)                                      |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | Pre :43.6±1.6<br>Post:42.3±1.8                | Pre: 14.9±0.6<br>Post:14.6±0.5                |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | LML (kg)                                      | LML (kg)                                      |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             | Pre:15.6±0.8<br>Post:14.6±0.9                 |                                               |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             |                                               |                                               |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             |                                               |                                               |
| Senechal et al. | CR (9)<br>62.6± 4.1 years old NI                                  | 12weeks                                                  | -0.5~1 kg/week<br>(55%/ 30%/ 15%)                   | Exercises: leg press, leg extension, standing calf raise, crunch, bench press, seated cable row, pushdown e biceps curl 3x8 80% 1 RM 60-90s | Weight (kg)<br>Δ:-4.3 ± 2.7<br>%F             | Weight (kg)<br>Δ:-3.8 ± 1.8<br>%F             |
|                 | CR+ ST(9)<br>62.6± 4.1 years old NI                               |                                                          |                                                     | Δ:-1.8 T 1.3<br>F(kg)                                                                                                                       | Δ:-2.2 ± 1.8<br>F (kg)                        |                                               |
|                 |                                                                   |                                                          |                                                     | Δ: -3.2±2.0<br>LBM (kg)                                                                                                                     | Δ:-3.1±1.8<br>LBM (kg)                        |                                               |
|                 |                                                                   |                                                          |                                                     | Δ:-0.8±1.2<br>WC (cm)                                                                                                                       | Δ:-0.4±0.9<br>WC (cm)                         |                                               |
|                 |                                                                   |                                                          |                                                     | Δ:-6.1±3.9                                                                                                                                  | Δ:-5.3±5.7                                    |                                               |
|                 |                                                                   |                                                          |                                                     |                                                                                                                                             |                                               |                                               |

Table 2. Main results of articles

CR: caloric restriction; ST: strength training; 1 RM: 1 maximum repetition; %F: fat percentage; F: body fat; FFM: fat-free mass; MM: muscle mass; LBM: lean body mass; LML: lean mass in the leg; WC: waist circumference.

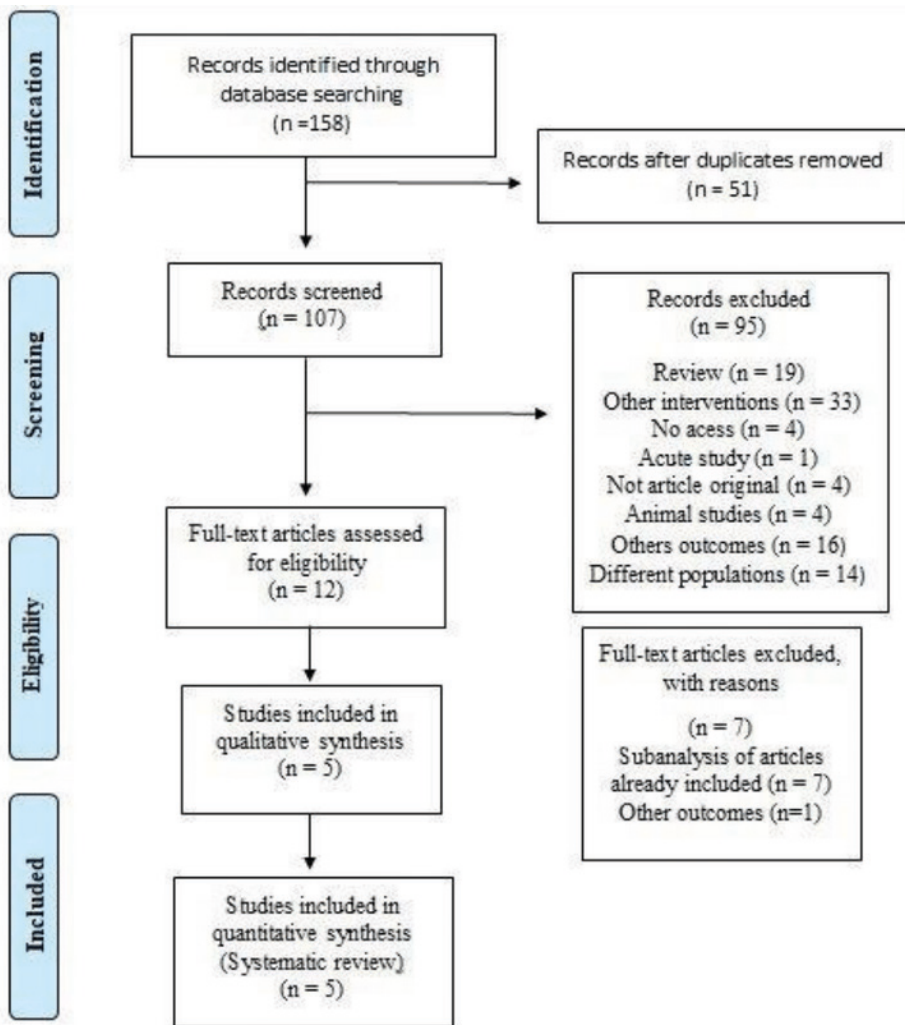


Figure 1. Article selection flowchart