

## REVIEW ARTICLE

# Effects of multicomponent training on lean and bone mass in postmenopausal and older women: a systematic review

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### Abstract

**Objective:** The purpose of this systematic review was to update and examine to what extent multicomponent training interventions could improve lean and bone mass at different anatomical regions of the body in postmenopausal and older women.

**Methods:** A computerized literature search was performed in the following online databases: PubMed MEDLINE, Cochrane, and Web of Knowledge. The search was performed to include articles up until February 2017. The methodological quality of selected studies was evaluated using the Cochrane risk of bias tool.

**Results:** Fifteen studies met the inclusion criteria. Studies examining the effects of combined training methods in postmenopausal and older women showed contrasting results, possibly due to the wide range of the participants' age, the evaluation of different regions, and the varying characteristics of the training methods between studies. Overall, it appears that exercise modes that combine resistance, weight-bearing training, and impact-aerobic activities can increase or prevent muscle and skeletal mass loss during the ageing process in women.

**Conclusions:** Further studies are needed to identify the optimal multicomponent training protocols, specifically the training loads that will improve lean and bone mass at different anatomical locations, in postmenopausal and older women.

**Key Words:** Aging – Bone density – Combined training – Exercise – Muscle mass.

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Accelerated muscle and bone loss is closely associated with the ageing process and could trigger the onset of chronic diseases, such as sarcopenia and osteoporosis.<sup>1-4</sup> These characteristic changes in body composition negatively affect the overall quality of life in older adults,<sup>5</sup> as it has been shown that declines in physical function and loss of independence leads to a higher risk of fractures and falls, and produces an increase in the percentage of mortality.<sup>6</sup>

Sarcopenia is defined as the age-related decrease in skeletal muscle mass (MM), neuromuscular function, and strength.<sup>7</sup> These decrements are mainly apparent in women largely due to the hormonal deficits associated with menopause.<sup>4</sup> Additionally, during menopause, there is an intensified loss of bone mass, which is the consequence of an imbalance in bone formation, where there is a higher rate in bone removal with

respect to its renewal.<sup>8,9</sup> This decrease in bone mass contributes to a higher prevalence of osteoporotic fractures in women.<sup>10</sup>

Some studies have shown that mechanical loading on the skeleton is necessary to prevent loss of bone mass.<sup>11,12</sup> In addition, nutritional status, physical activity, hormonal growth, and behavioral and environmental factors can affect bone development and its maintenance. However, it is clear that continuous adaptation to external loads on the bone is an important factor for bone development. Because skeletal muscle contractions provide the largest physiological loading on the bone, there is a close relationship between muscle strength and size with bone strength.<sup>13</sup> Thus, exercise not only plays an important role in promoting gains in MM<sup>14</sup> but also maximizes bone mass.<sup>15,16</sup> Although regular physical activity is proposed to elicit favorable muscle and bone health, not all exercise interventions have found positive findings in women. Previous studies suggest that training methods that include high-impact activities generate greater osteogenic potential,<sup>17</sup> but there is still some controversy with regards to the type of training that can produce higher increases in muscle and bone mass in postmenopausal and older women.

It has been previously shown that strength training provides a powerful stimulus to increase and maintain muscle and bone in the elderly.<sup>18-21</sup> Interestingly, many studies have utilized a

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combination of different types of exercises (ie, multicomponent training [MT]) as an efficient method to minimize the reductions in muscle strength<sup>22,23</sup> and bone loss.<sup>24,25</sup> Kwon et al<sup>26</sup> have shown that 24 weeks of MT with low-impact aerobic exercises, resistance, and balance training improved MM in older women, but no significant effects on bone mineral density (BMD) of the spine and femoral neck were observed. Nevertheless, a meta-analysis by Martyn-St James and Carroll<sup>27</sup> reported that combining jogging with low-impact exercise or combining impact activities with high-magnitude exercise (ie, resistance training) is beneficial in preserving BMD in postmenopausal women. Similarly, Gómez-Cabello et al<sup>24</sup> showed that MT consisting of strength, aerobic, high-impact, and weight-bearing training can improve or at least attenuate the biological decrease in bone mass during ageing. Thus, it is not clear which MT method achieves better results.

These controversial outcomes in muscle and bone mass following different MT protocols may be explained by differences in age and sex of the participants. Therefore, the purpose of this systematic review was to update and examine to what extent MT interventions can improve lean and bone mass at different anatomical regions of the body in postmenopausal and older women.

## METHODS

### Literature search and data sources

The current study followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>28</sup> A computerized literature search was performed in the following online databases: PubMed MEDLINE, Cochrane, and Web of Knowledge (WoS). The search included articles that were published up until February 2017. Keywords used for the database search were: “combined training”, “combined exercise”, “high-impact”, “multi-component”, “multicomponent”, “body composition”, “muscle mass”, “fat-free mass”, “lean mass”, “bone mass”, “bone mineral density”, “BMD”, “bone mineral content”, “BMC”, “women”, “older adults”, “elderly” or a combination of them. Reference lists of the evidence articles were also examined to find additional studies.

### Inclusion and exclusion criteria

Randomized and nonrandomized controlled trials that were published in English were considered for this systematic review. Studies were selected if the following criteria were met: participants were postmenopausal (defining the postmenopausal period as the years after the year when menstruation ceased) and/or older women (age mean  $\geq 65$  years); at least one group of the study performed a supervised MT program; and at least one outcome variable included BMD or bone mineral content (BMC) of different sites, or MM, lean mass (LM), or fat-free mass (FFM). The exclusion criteria were as follows: studies without a control group; and studies that included participants who were taking medical treatments or supplementations that may influence muscle or bone mass.

### Review selection

Three researchers (E.M.C., J.A.R.A., and D.J.R.C.) tabulated independently the selected indices in identical predetermined forms. After the removal of duplicates, the authors examined the titles and the abstracts. The full version of each article was obtained, and then, they were selected according to the previously established criteria. Disagreements were resolved by attaining a consensus among the reviewers.

### Risk of bias assessment (study quality)

The methodological quality of the selected studies was evaluated according to the Cochrane risk of bias tool.<sup>29</sup> This method assesses the following aspects: randomness of the allocation sequence (selection bias); concealment of the allocation sequence (selection bias); blinding of participants and personnel and blinding to outcome assessment (performance and detection bias, respectively); incomplete outcome data (attrition bias); selective outcome reporting (reporting bias); and any other biases. For each study, each item was described as having either a low, high, or unclear risk of bias. Two authors independently (E.M.C. and J.A.R.A.) assessed the risk of bias, and disagreements were resolved by a third party evaluator (D.J.R.C.), in accordance with the Cochrane Collaboration Guidelines.<sup>29</sup>

## RESULTS

### Study selection

A total of 1,484 studies were obtained from the database searches, and two additional records were identified after examination of the reference lists. Among them, 1,003 duplicates were removed, leaving 483 articles. Following the abstract and title screening, 453 articles were excluded. As a result, 30 studies were assessed for selection criteria. Of these articles, 15 met the inclusion criteria and were included for this systematic review (Fig. 1).

### Study characteristics

Tables 1 and 2 summarize the main MT characteristics of the 15 included studies using the populations, interventions, comparisons, and outcomes (PICO) format. To facilitate the comparison between studies, the results of the trials were classified by age: postmenopausal ( $n = 8$ ) and older women ( $n = 7$ ). The risk of bias assessment is shown in Figs. 2 and 3. Because of the lack of allocation concealment in all of the studies, the risk of bias of this criterion was high. With regards to the blinding of the participants, the personnel, and the outcome assessment, the risk of bias was unclear.

### Postmenopausal women

Among the studies with postmenopausal women that included a MT program (Table 1), a total of five studies<sup>22,30-33</sup> evaluated variables related to MM. Also, six studies<sup>22,30,31,34-36</sup> provided data on bone mass.

The effect of MT on MM has been studied by several authors. Marín-Cascales et al<sup>22</sup> showed improvement in whole body LM, but no changes were observed in the control

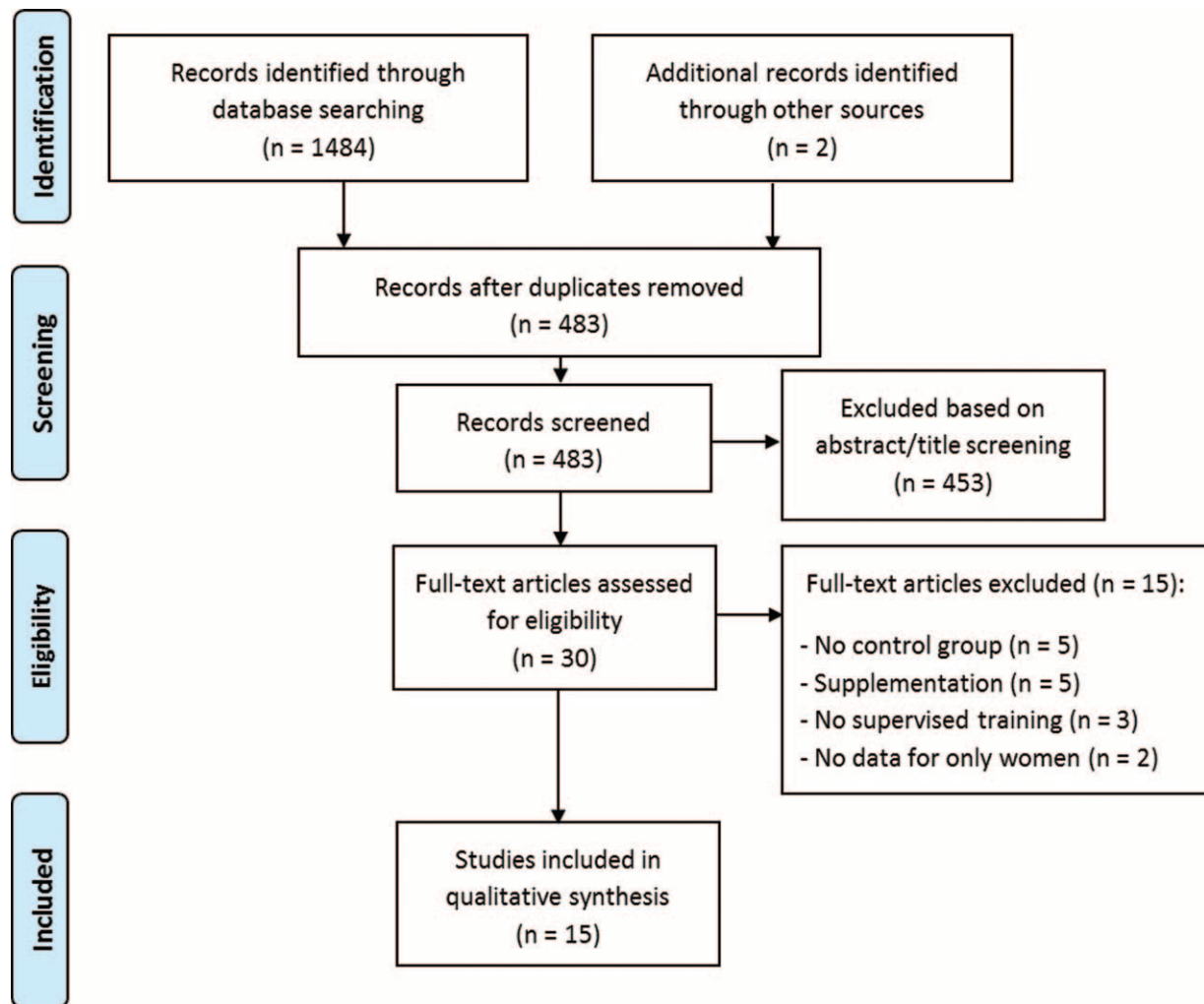


FIG. 1. Flow diagram of the study selection process.

group, following a 12-week program (three days per week of frequency) that consisted of combining 30 to 45 minutes of walking with four to six sets of 10 drop jumps. Rossi et al<sup>33</sup> demonstrated a significant improvement (+2.6%) in FFM after 16 weeks of combined aerobic and strength training (three days per week). Also, it was observed that the intervention group significantly increased lean body mass compared with the control women. However, some authors did not find increases in MM after MT.<sup>30-32</sup> Chien et al<sup>30</sup> examined the efficacy of combining 30 minutes of walking with 10 minutes of stepping exercise in postmenopausal women with osteopenia. They reported no changes in total FFM after 24 weeks of training, three days per week. Similarly, the 12-week MT program proposed by Park et al<sup>32</sup> (running and resistance training, three times per week) did not produce any improvements in LM in postmenopausal women.

Bravo et al<sup>34</sup> analyzed the effect of MT on bone mass in osteopenic postmenopausal women. The program consisted of 25 minutes of aerobic activity (walking or dancing) combined with 15 minutes of stepping and isometric exercises. In

this study, no changes were observed in the BMD measured in the femoral neck and lumbar spine after one year of training, whereas there was a significant decrease of 1.3% in BMD of the lumbar spine in the control group. Similar results were found by Marín-Cascales et al,<sup>31</sup> who showed nonsignificant differences in total BMD after 24 weeks of MT using drop jumps and aerobic activity in postmenopausal women.

However, the positive effects of MT on bone mass have been observed in postmenopausal women. In the study by Chien et al,<sup>30</sup> an increase of 6.8% was found in BMD measured at the femoral neck. Moreover, Tolomio et al<sup>36</sup> found that 11 months of a specific multicomponent exercise program, three times per week, improved the femoral neck T-score in a group of women with low bone mass. Furthermore, there were significant between-group differences in the femoral neck T score, and also all of the bone quality parameters evaluated by osteosonography. The exercise program used consisted of 20 minutes of walking, stretching, and jumping and 30 minutes of resistance training, balance, and mobility exercises. Multanen et al<sup>35</sup> examined the effect

TABLE 1. Characteristics of multicomponent training programs on bone and muscle mass in postmenopausal women

Study, y	No. of participants <sup>a</sup>	Age (y) and time since menopause <sup>a,b</sup>	Training protocol	Protocol time and exercise frequency	Training intensity	Pathology	Measurements	Results
Bravo et al, <sup>34</sup> 1996	MT: 61 C: 63	50-70 MT: 59.6 ± 5.8 C: 59.9 ± 6.4 > 1 y	MT: AT (25 min, walking/dancing), SE up and down from benches (15 min) and isometric exercises (UE, scapular waist, abdomen and back)	12 mos 3/wk	60%-70% HRR 12-15 RM	Osteopenic	FN and LS BMD	MT: NC FN and LS BMD C: NC FN BMD and ↓ LS BMD (-1.3%)
Chien et al, <sup>30</sup> 2000	MT: 22 C: 21	48-65 MT: 57.1 ± 8.6 C: 57.0 ± 5.4 ≥ 6 mos	MT: treadmill walking (30 min) and SE using a 20-cm high bench (10 min)	24 wks 3/wk	AT: 70%-85% of VO <sub>2</sub> max SE: speed of 96 bpm	Osteopenic	FN and LS BMD WB FFM	MT: ↑ FN BMD (+6.8%), NC LS BMD and WB FFM C: ↓ LS BMD (-2.3%), NC FN BMD and WB FFM
Marín-Cascales et al, <sup>22</sup> 2015	MT: 14 WBVT: 14 C: 10	MT: 57.7 ± 7.1 WBVT: 60.1 ± 5.8 C: 62.4 ± 5.1 > 3 y	MT: 4-6 × 10 drop jumps (height of 5-10 cm) + AT (30-45 min walking) WBVT: 5-8 sets of vibration, holding half-squat and performing ankle plantar and dorsal flex (60 s working time, 60 s RP).	12 wks 3/wk	AT: 50%-60% HRR WBVT: 35 Hz, amplitude 4 mm	Overweight	WB BMD WB LM	MT: NC WB BMD and ↑ WB LM WBVT: NC WB BMD and ↑ WB LM C: NC WB BMD and LM
Marín-Cascales et al, <sup>31</sup> 2017	MT: 13 WBVT: 15 C: 10	MT: 58.4 ± 7.4 WBVT: 59.6 ± 5.9 C: 62.4 ± 5.1 > 3 y	MT: 4-6 × 10 drop jumps (height of 5-25 cm) + AT (30-60 min walking) WBVT: 5-11 sets of vibration, holding half-squat and performing ankle plantar and dorsal flex (60 s working time, 60 s RP).	24 wk 3/wk	AT: 50-75% HRR WBVT: 35-40 Hz, amplitude 4 mm	Overweight	WB BMD WB LM	MT: NC WB BMD and LM C: NC WB BMD and LM
Multanen et al, <sup>35</sup> 2014	MT: 36 C: 40	50-66 MT: 58 ± 4 C: 59 ± 4	MT (55 min): AT (height of the foam fences from 5 to 20 cm) and SE (height of 10-20 cm in jumping exercises).	12 mos 3/wk	Low accelerations peaks (impacts)	Osteoporotic	FN, LS and TR BMC	MT: FN BMC (+0.6%), NC LS and TR BMC C: FN BMC (-1.2%) and ↑ FN BMC (1.6%), NC LS and TR BMC
Park et al, <sup>32</sup> 2015	MT: 10 C: 10	MT: 57.2 ± 2.57 C: 57.2 ± 1.69	MT: AT (40 min, running) and RT (40 min, 3 × 8-12 rep, UE and LE exercises)	12 wks 3/wk	AT: 40%-75% HRR RT: 60%-70% 1RM	Abdominal obesity	WB LM	MT: NC WB LM C: NC WB LM

(Continued on next page)

TABLE 1. Continued

Study, y	No. of participants <sup>a</sup>	Age (y) and time since menopause <sup>a,b</sup>	Training protocol	Protocol time and exercise frequency	Training intensity	Pathology	Measurements	Results
Rossi et al, <sup>33</sup> 2016	AT: 15 MT: 32 C: 18	61.0 ± 6.3 1-3 y	AT: 3 distances (400, 800, and 1,200 m) in the shortest possible time MT (57 min): AT (30 min) + RT (27 min, 3-4 × 8-15 rep of leg press, leg ext, leg curl, bench press, seated row, arm curl, triceps ext, side elevation with dumbbells, and abdominal exercises).	16 wks	RT: 65%-80% 1RM	Obesity	WB FFM	AT: † WB FFM (+1.7%) MT: † WB FFM (+2.6%) C: NC WB FFM and † WB FFM
Tolomio et al, <sup>36</sup> 2010	MT: 58 C: 67	MT: 62 ± 5.0 C: 64 ± 5.3 > 10 y	MT: WU (20-25 min, walking, stretching, small jumps) and 30 min of RT, endurance, BT, and joint mobility (exercises with dumbbells, therabands, steps and balls).	11 mos 3/wk	—	Osteopenic/ osteoporotic	FN and H BMD FN and H T-score Ad-Sos, UBPI and T-score (osteosonography)	MT: † FN T-Score, NC FN and H BMD, H T-score, Ad-Sos, UBPS and T-score C: † FN T-score, NC FN and H BMD, FN and H T-score, † † † † † Ad-Sos, † † † † † UBPI and † † † † † T-score (osteosonography)

† indicates significant increase ( $P \leq 0.05$ ); † indicates significant decrease ( $P \leq 0.05$ ); † † indicates significant increase ( $P \leq 0.01$ ); † † † indicates significant decrease ( $P \leq 0.001$ ); † indicates significant difference from MT ( $P \leq 0.05$ ); † † † indicates significant difference from MT ( $P \leq 0.001$ ); — indicates no reported/no data.

Ad-Sos, amplitude-dependent speed of sound; AT, aerobic training participants; BT, balance training participants; BMC, bone mineral content; BMD, bone mineral density; C, control participants group; ext, extension; FFM, fat-free mass; Fle, flexion; FN, femoral neck; H, hip; HRR, heart rate reserve; LE, lower extremities; LM, lean mass; LS, lumbar spine; MT, multicomponent training participants; MM, muscle mass; NC, no changes within group; rep, repetition; RM, repetition maximum; RP, resting period; RT, resistance training participants; SE, stepping exercise; TR, trochanter; UBPI, Ultrasound Bone Profile Index; UBPS, ultrasound bone profile score; UE, upper extremities; VO<sub>2</sub>max, maximum oxygen uptake; WB, whole body; WBVT, whole body vibration training participants; WU, warm-up.

<sup>a</sup>Exercise group are indicated where applicable.

<sup>b</sup>Data are presented as means, ranges or mean ± standard deviations.

**TABLE 2. Characteristics of multicomponent training programs on bone and muscle mass in older women**

Study, y	No. of participants <sup>a</sup>	Age (y) and time since menopause <sup>a,b</sup>	Training protocol	Protocol time and exercise frequency	Training intensity	Pathology	Measurements	Results
Chuin et al, <sup>40</sup> 2009	MT: 8 C: 7	61-73 MT: 65.4 ± 3.5 C: 67.4 ± 3.8	MT: treadmill or cycle ergometer followed by static stretching (15min) and RT (45 min, 3 × 8 rep, abdominals, leg press, bench press, leg ext, shoulder press, sit up, seated row, triceps ext and biceps curl). 90-120s RP between each set.	6 mos 3/wk	RT: 80% 1RM	Overweight	FN and LS BMD	MT: NC FN and LS BMD C: NC FN BMD and ↓ LS BMD
Englund et al, <sup>37</sup> 2005	MT: 21 C: 19	66-87 MT: 72.8 ± 3.6 C: 73.2 ± 4.9	MT: RT (2 × 8-12rep for each muscle group), AT (walking and jogging), BT (static and dynamic), coordination, stretching and relaxation exercises.	12 mos 2/wk	-	Overweight	Arms, FN, LS, TR, WB and WT BMD WB BMC WB LM	MT: ↑ Arms, ↑ LS, ↑↑ TR, ↑↑ WB BMD, ↑↑ WB BMC and ↓↓ WB LM. NC FN and WT BMD. C: ↑ Arms, ↑ TR, ↑ WB BMD, ↑ WB BMC, ↓↓ WB LM and ↓ WT BMD (8.4%). NC FN, LS and WT BMD
Korpelainen et al, <sup>41</sup> 2006	MT: 84 C: 76	MT: 72.8 ± 3.6 C: 73.2 ± 4.9	MT (45 min): jumping and BT (walking, knee bends, leg lifts, heel rises and drops, dancing, stamping, stair climbing and SE) 20 min daily exercises at home	30 mos 3/wk 6 mos/y	-	Osteopenic/ osteoporotic	FN BMC and BMD TR BMC and BMD Radius BMD Calcaneal BUA and SOS	MT: ↓↓ TR BMC (-2.9%), ↓↓ distal radius (-3.8%) and ↓ ultradistal radius (-3.1%) BMD and ↓ Calcaneal BUA and ↓ SOS. NC FN BMC and BMD, and TR C: ↓ FN (-1.1%) and ↓ TR (-1.6%), ↓↓ distal radius (-3.1%) and ↓ ultradistal radius (-3.4%) BMD, ↓↓ TR BMC (-7.7%) and ↓ Calcaneal BUA and ↓ SOS. NC FN BMC
Karinkanta et al, <sup>42</sup> 2007	RT: 37 BT: 35 MT: 36 C: 36	70-78 RT: 72.7 ± 2.5 BT: 72.9 ± 2.3 MT: 72.9 ± 2.2 C: 72.0 ± 2.1	RT: raising for a chair (using weight vest), squatting, leg presses, H abduction, H ext, calf rise and rowing using RT machines. BT: static and dynamic balance, agility training, jumps and other impacts, changes of direction exercises. MT: RT + BT	12 mos 3/wk	RT: from 50-60% to 75%-80% 1RM	Overweight	FN BMD and BMC Radius and tibia	MT: NC FN BMD and BMC, radius and tibia C: NC FN BMD and BMC, radius and ↑ Tibial shaft BSI (2%)

(Continued on next page)

TABLE 2. Continued

Study, y	No. of participants <sup>a</sup>	Age (y) and time since menopause <sup>a,b</sup>	Training protocol	Protocol time and exercise frequency	Training intensity	Pathology	Measurements	Results
Kwon et al, <sup>26</sup> 2008	MT: 20 C: 20	70-80 MT: 77.4 ± 2.6 C: 77.0 ± 3.3	MT: stretching (20 min), low-impact AT (30 min), RT (3-10 rep, free weights) and BT	24 wks 3/wk	40%-75% HRR	-	FN, LS, TR, WB and WT BMD WB, UE and LE MM	MT: ↑ TR BMD, ↑↑ WB, ↑↑ UE and ↑ LE MM. NC FN, LS, WB and WT BMD C: ↓↑ WB, ↓↑ UE, ↑ LE MM and ↑ TR BMD. NC LE MM, FN, LS, TR, WB and WT BMD
Marques et al, <sup>38</sup> 2011	MT: 30 C: 30	60-95 MT: 70.1 ± 5.4 C: 68.2 ± 5.7 > 10 y	MT: 10 min light stretching and WU, 15 min of weight-bearing activities (marching in place, SE using a 15-cm-high bench, and heel-drops), 10 min muscular endurance exercises (UE and LE), 10 min BT and 10 min agility training	32 wks 2/wk	SE: speed of 120-125 bpm	Overweight	FN, LS and TR BMD WB LM and FFM	MT: ↑↑ FN BMD (+2.8%), NC LS and TR BMD, WB LM and FFM C: ↑ FN BMD. NC FN, LS and TR BMD, WB LM and FFM
Park et al, <sup>39</sup> 2008	MT: 25 C: 25	65-70 MT: 68.3 ± 3.6 C: 68.4 ± 3.4 > 5 y	MT: stretching (9 min), RT exercise (23 min), BT (18 min) and posture correction training.	48 wks 3/wk	Weight-bearing exercise: 65%-75% of the MHR	-	FN, LS, TR and WT BMD WB LM	MT: ↑ FN and ↑ TR BMD. NC LS and WT BMD, and WB LM C: ↑ FN and ↑ TR BMD. NC FN, LS, TR and WT BMD, and WB LM

↑ indicates significant increase ( $P \leq 0.05$ ); ↓ indicates significant decrease ( $P \leq 0.05$ ); ↑↑ indicates significant increase ( $P \leq 0.01$ ); ↓↓ indicates significant decrease ( $P \leq 0.01$ ); ↑↑↑ indicates significant increase ( $P \leq 0.001$ ); ↓↓↓ indicates significant decrease from MT ( $P \leq 0.01$ ); — indicates not reported/no data.

AT, aerobic training participants; BT, balance training participants; BMC, bone mineral content; BMD, bone mineral density; BSI, bone strength index; BUA, broadband ultrasound attenuation; C, control participants group; Ext, extension; FFM, fat-free mass; FN, femoral neck; H, hip; HRR, heart rate reserve; LE, lower extremities; LM, lean mass; LS, lumbar spine; MHR, maximal heart rate; MM, muscle mass; MT, multicomponent training participants; NC, no changes within group; rep, repetition; RM, repetition maximum; RP, resting period; RT, resistance training participants; SE, stepping exercise; SOS, speed of sound; TR, trochanter; UE, upper extremities; WB, whole body; WT, Ward's triangle; WU, warm-up.

<sup>a</sup>Exercise group are indicated where applicable.

<sup>b</sup>Data are presented as means, ranges or mean ± standard deviations.

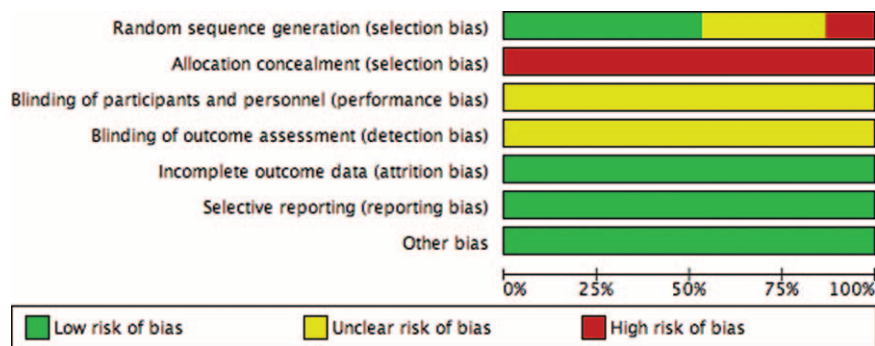


FIG. 2. Risk of bias graph.

of high-impact training on bone in osteoporotic postmenopausal women. The exercise group that completed a program of aerobic training plus step-aerobic jumping exercises found a mean gain of 0.6% in BMC at the femoral neck, whereas the control group lost 1.2%. After 12 months, BMC at the femoral neck was significantly higher (1.6%) in the MT group than in the control group.

**Older women**

A combination of various types of exercise has been utilized in training programs by several authors to analyze the effects of these training protocols on body composition. In this systematic review, four studies<sup>26,37-39</sup> assessed the effect of MT on muscle tissue, and seven studies<sup>26,37-42</sup> reported outcomes in bone mass in older women (Table 2).

There was only one study that found positive adaptations in muscle after an MT program.<sup>26</sup> Kwon et al<sup>26</sup> showed improvements in MM of the whole body, and upper and lower limbs after 24 weeks of MT of stretching, low-impact aerobic, resistance training, and balance exercise. In the control group, MM of the whole body and upper limbs decreased significantly, and there were significant differences between groups in all MM variables. However, when Englund et al<sup>37</sup> evaluated the effects of MT on LM after one year of walking and jogging, resistance training, balance, coordination, stretching, and relaxation exercises, there was a significant decrease in LM between pre and post-testing in training and control groups. Marques et al<sup>38</sup> examined the effect of a MT program that was composed of stretching, weight-bearing activities, muscular endurance exercise, balance, and agility training in MM. After 32 weeks (two days per week of training frequency) of MT, no changes were observed in LM and FFM in the exercise group. These results agree with Park et al<sup>39</sup> that showed no adaptations in LM in the MT group (stretching, resistance training, weight-bearing exercise, balance, and posture correction training, three times per week for 48 weeks). Also, there were no changes between pre and post-testing in the muscle parameters in the control group.

Some studies have shown that MT can prevent bone demineralization in older women.<sup>26,37-39,41,42</sup> Englund et al<sup>37</sup> observed increases in total BMC and BMD of the

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bravo et al. (1996)	+	-	?	?	+	+	+
Chien et al. (2000)	-	-	?	?	+	+	+
Chuin et al. (2009)	?	-	?	?	+	+	+
Englung et al. (2005)	?	-	?	?	+	+	+
Karinkanta et al. (2007)	+	-	?	?	+	+	+
Korpelainen et al. (2006)	+	-	?	?	+	+	+
Kwon et al. (2008)	-	-	?	?	+	+	+
Marín-Cascales et al. (2015)	+	-	?	?	+	+	+
Marín Cascales et al. (2017)	+	-	?	?	+	+	+
Marques et al. (2011)	+	-	?	?	+	+	+
Multanen et al. (2014)	+	-	?	?	+	+	+
Park et al. (2008)	+	-	?	?	+	+	+
Park et al. (2015)	?	-	?	?	+	+	+
Rossi et al. (2016)	?	-	?	?	+	+	+
Tolomio et al. (2010)	?	-	?	?	+	+	+

FIG. 3. Risk of bias summary.



arms, lumbar spine, trochanter, and whole body in both MT-trained and untrained groups. In addition, there was a significant increment in BMD of the Ward's triangle (8.4%,  $P < 0.01$ ) in the MT-trained compared with the control participants. Karinkanta et al<sup>42</sup> reported that one year of MT with a frequency of three days per week, which consisted of resistance (raising for a chair, squatting, leg presses, etc) and balance training (static and dynamic balance, agility, jumps, etc), was not sufficient enough to increase bone mass in older women. However, the trained group showed a better tibial shaft bone strength index by 2% compared with the control group. Similarly, Kwon et al<sup>26</sup> observed an increase in trochanter BMD, and Park et al<sup>39</sup> confirmed an improvement in femoral neck and trochanter BMD in trained women. Moreover, Marques et al<sup>38</sup> showed significant group differences in femoral neck BMD, where the MT-trained group increased femoral neck BMD by +2.8%, the control group reported no changes in BMD. Korpelainen et al<sup>41</sup> conducted a 30-month study with osteopenic and osteoporotic older women, using a program of six months of MT training (jumping and balance exercises, three times per week) per year, and demonstrated no positive results in the exercise group in BMD at the femoral neck or trochanter. In addition, the participants in the trained and control groups presented a decrease in BMC at the trochanter, but the loss was higher in the control group. The training program was not able to enhance bone mass at the calcaneus, and both groups showed a decrease in distal and ultradistal radius. Likewise, Chuin et al<sup>40</sup> observed no change in bone mass after a MT program, which consisted of aerobic activity, stretching, and resistance training for six months, three days per week. However, there was a significant decrease in lumbar spine BMD in the control group, and also a statistically significant difference between control and exercise groups.

## DISCUSSION

### Summary of findings

The main aim of this systematic review was to determine the effectiveness of MT programs on lean and bone mass at different body sites in postmenopausal and older women. The results show contradicting findings with combined training in postmenopausal and older women, as some studies observed increments in muscle and bone mass, whereas others reported no significant improvements in these parameters.

Five studies<sup>22,30-33</sup> assessed the effect of MT interventions on MM, FFM, and LM in postmenopausal women. Among them, two articles<sup>22,33</sup> found significant increases in the experimental groups that performed a multicomponent exercise program. However, the other three studies<sup>30-32</sup> did not obtain any adaptations in the MT groups. When comparing the studies that found positive changes, the combined-impact aerobic exercises and strength training appears to be an efficient MT method for enhancing MM in postmenopausal women. This is probably due to increases in protein synthesis from aerobic training<sup>43</sup> and promoting muscle fiber hypertrophy using high loads in resistance training.<sup>44</sup> Concerning

older women, four studies<sup>26,37-39</sup> presented MM as an outcome variable. Of these studies, only one<sup>26</sup> reported pre-to-post improvements in body, upper, and lower limbs MM. Therefore, the effects of MT on MM in older women remain unclear. The absence of gains in MM may be related to the large methodological differences between programs. Hence, additional randomized controlled trials using specific MT programs are needed and may help clarify its benefits on MM in postmenopausal and older women.

With respect to bone mass in postmenopausal women, only three studies showed enhanced femoral neck BMD<sup>30,36</sup> and BMC.<sup>35</sup> One study<sup>34</sup> showed that MT maintained femoral neck and lumbar spine BMD compared with controls that observed bone loss at the spine. However, no changes in BMD were observed in the other two articles.<sup>22,31</sup> The lack of significant improvements in these studies may be explained by the fact that the exercise program was focused on the lower extremities, but whole-body BMD was measured. As osteogenic responses occur at loaded regions,<sup>17</sup> the training protocol should be specific to areas (eg, the lumbar spine, femoral neck, and trochanter) that are most predisposed to fractures in women.

In this review, all of the included studies<sup>26,37-42</sup> with older women analyzed the effect of MT on bone tissue. There were five records<sup>26,37-39,42</sup> that showed BMD gains. In contrast, Chuin et al<sup>40</sup> did not show any significant effect on the bone, but did find a decrease in lumbar spine BMD in the control group. Korpelainen et al<sup>41</sup> did not observe significant increases in the femoral neck and trochanter BMD in older women, but a decrement was shown at these regions in the control group after 30 months of intervention. Moreover, there were decreases in bone parameters in the calcaneus, distal, and ultradistal radius in both groups. This is the only long-term study in the present systematic review that found no significant impact on bone mass in the above mentioned sites in older women after MT. The lack of improvements may be explained by the noncontinuous nature of the training program. Women in the exercise group attended supervised training sessions for a 6-month period each year and trained unsupervised at home for 20 minutes for the remaining six months (ie, alternating supervised and unsupervised periods during the intervention study).

Although there are different MT protocols used to elicit changes in muscle and bone mass, walking is one of the most frequent types of aerobic activity employed for MT. Other activities such as isometric, strength, and resistance exercises, stretching or coordination, and relaxation movements are also typically included in the MT programs. Although the best training protocol for improving muscle and bone tissues remains to be clarified, studies that combine resistance, weight-bearing, aerobic, and high-impact (jogging, jumping, and stepping) training appear to be effective in increasing or preventing muscle and skeletal mass loss during the ageing process in women. It is worth noting that studies that showed enhancements in body parameters after MT included resistance training with high-intensity loads (between 70% and 80% of 1RM), with two to three sets per exercise and session.

Most of the aerobic training programs in the MT interventions showed positive effects on muscle and bone mass using an approximate volume of 30 minutes. The most utilized exercise frequency for MT was three times per week.

Even though positive effects on bone mass can be achieved after six months in some body sites, the success of the MT interventions is higher when lengthened to one year. However, not all MT programs have shown benefits for muscle and bone mass because of the high heterogeneity of the MT modes, the intensities and durations used, the ages and characteristics (baseline muscle and bone mass values) of the participants, and/or the anatomical sites examined. As there are disparities within the results of this systematic review regarding multicomponent exercise programs, further trials are needed to establish the most optimal MT for postmenopausal and older women.

### Limitations

The main limitations of this systematic review were: the low number of studies included (eight focused on postmenopausal women and seven with older women) due to the few existing publications on MT intervention in women that examine muscle or bone mass as an outcome variable; and that some studies included participants with pathologies (overweight, obesity, osteopenia, or osteoporosis) that might have affected the results of muscle or bone mass.

### CONCLUSIONS

There remains conflicting evidence regarding the effects of combined training methods in postmenopausal and older women in this systematic review, likely due to the different ages of the participants, various regions assessed, and diverse characteristics of the training methods between studies. Although it is not clear if multicomponent exercise protocols are able to improve muscle and bone mass in postmenopausal and older women, combining resistance training using high-intensity loads and impact-aerobic activities may be the most optimal strategy to enhance muscle and bone mass. However, further studies are needed to examine specific MT protocols and its effects on muscle and bone health at different anatomical locations in these women.

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