The effects of exercise training on hypertensive older adults

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The effects of exercise training on hypertensive older adults: an umbrella meta-analysis.

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Abstract

Exercise training has been shown to blunt many of the physiological declines and common diseases of the aging process. One such beneficial effect is the reduction of BP in hypertensive older adults. However, there is no consensus agreement about which aerobic (AT) or resistance training (RT) benefits may be lost by the use of combined training (CT), or even what benefits could be acquired only by performing CT considering the extensive health needs of older adults with hypertension. Thus, we proposed an umbrella meta-analysis. The benefits conferred by CT are extensive and encompass cardiorespiratory fitness, muscular fitness, and blood lipid profile improvements. Thus, CT may be recommended to improve the extensive health needs of hypertensive older adults that go beyond blood pressure reduction.

Keywords: aging, blood pressure, resistance training, cardiorespiratory fitness, muscle strength.

Introduction

The prevalence of hypertension increases with aging, affecting 67.2% of US adults ≥ 60 years of age, 76.5% of US adults aged ≥ 80 years, and an increasing number of the overall population [1]. Hypertension is the most common risk factor for cardiovascular diseases [2] and higher risk of death from stroke, heart disease or other vascular diseases. Importantly, higher blood pressure (BP) values are increasingly evident in older ages [1,3]. It is clear that lifestyle interventions are needed to help address these BP-related negative health outcomes.

Exercise training has been shown to blunt many of the physiological declines and common diseases of the aging process [4,5], including the reduction of BP in hypertensive older adults [6]. A previous meta-analysis in this population showed aerobic training (AT) resulted in an almost twofold reduction in systolic BP (-12.32 [-16.39; -8.24]mmHg) compared to resistance training (RT: -6.76 [-8.36; -5.17]mmHg) while the few studies testing combined training (CT) did not yield significant summarized effects [6]. AT, RT and CT resulted in similar and significant reductions in diastolic BP [6].

Although BP control needs to be considered to prevent mortality in hypertensive older adults [7,8], this population also has broad health needs that have been shown to be positively impacted by exercise. Specifically, older people benefit from AT's effects on cardiorespiratory fitness and RT's effects on muscle mass preservation and strength, both of which decline naturally with age. The positive adaptations from both AT and RT are associated with lower risk of morbidity, mortality, disability and frailty compared with being inactive [4,9,10].

Recently, the European Society of Cardiology summarized the five major components of physical fitness: cardiorespiratory, motor, morphological, muscular and metabolic [10]. They highlighted the importance of AT, RT and also flexibility and balance exercise for specific benefits in older adults, who are at increased risk for cardiovascular disease. However, there is no consensus about which AT or RT benefits could be lost by the use of CT, or even what benefits could be acquired just by doing CT considering the extensive health needs of older adults with hypertension.

Thus, we proposed an umbrella meta-analysis for hypertensive older adults in order to investigate the effects of exercise on important health markers in this population. In the present study we meta-analyzed the effects of different exercise training programs (AT, RT and CT), on cardiorespiratory fitness, strength, body composition, lipid profile, blood glucose and resting heart rate of hypertensive older adults.

Methods

Search strategy

The systematic search was conducted on MEDLINE in August of 2019, combining the adequate descriptors for aging, exercise training, hypertension and controlled trials. We selected randomized control trials testing exercise training effects (AT, RT or CT) on different health markers in hypertensive older adults, aged > 50 years. We considered hypertensive, the older adults with SBP >130mmHg or DBP >80mmHg, according to American College of Cardiology/American Heart Association [11]. Details of the selection process are described in Figure 1.

Please, insert Figure 1 here.

Chan et al. [12] shared the data of both AT and tai chi groups by e-mail, however the tai chi group was excluded, because it did not meet our inclusion criteria. Tomeleri et al. [13] included pre-hypertensive and hypertensive subjects in their sample, but, considering the pre-hypertensive baseline systolic BP values were above 130mmHg, we did not exclude them as they met our criteria. Only data from the hypertensive group of Miura et al. [14] were included in the analyses. Moreau et. al. [15] presented their partial results for 12 weeks of intervention; however, we included only the results of 24 weeks to avoid sample overlapping.

Training interventions with other types of exercise besides AT, RT or CT were excluded. We selected the health outcomes that were prevalent among the studies (analyzed in at least 3 studies): cardiorespiratory fitness assessed as maximum oxygen consumption, muscle strength, body weight, fat mass, muscle mass, body mass index (BMI), waist circumference, high density lipoprotein (HDL), low density lipoprotein (LDL), triglycerides (TG), total cholesterol (TC), blood glucose, and resting heart rate (HR).

Data extraction

Mean, standard deviation (SD) and sample number (n) were used for analysis. Standard error (SE) was converted to SD by the equation $SD = SE \times (\sqrt{n})$, if SD was not provided in the original study. Median and interquartile range (IQR) were replaced by median and SD (SD=(IQR / 1.35)) [16]. The 95% confidence intervals were converted to SD considering the equation $(\sqrt{(n)} * (UL - LL)/(2 * T.INV\ (0.05;n - 1))$, where n is the sample size, UL is the upper limit, LL is the lower limit and T.INV is the function that calculates the left-tailed inverse of the Student`s T distribution [17].

Risk of bias

We assessed the quality of the studies by PEDro scale, and the two questions regarding blinded patient and care providers were excluded as it is not possible in exercise intervention trials [18]. Removing those 2 questions, scores on PEDro scale ranged from 0 (very low methodological quality) to 9 (high methodological quality). This assessment was not an exclusion criterion and the results of each study were presented for qualitative characterization. Egger's tests were performed to check the risk of publication bias in each of the meta-analyses [19].

Statistical analyses

The umbrella meta-analyses were performed using Comprehensive Meta-Analysis (CMA) software, version 3.3.070. The effect size was calculated using raw mean difference (RMD) for all variables excepting for muscle strength that was calculated using standard mean difference (SMD); always subtracting the changes in control from the training groups. For non-significant heterogeneity, fixed effect models were selected (weight, HR, waist and muscle mass) and for significant heterogeneity, random effects models were selected (cardiorespiratory fitness, HDL, LDL, TC, TG, glucose, muscle strength, BMI and fat mass). The independent training interventions within a study were treated as a separate trial for meta-analyses and both interventions were compared to the same control group. Conservative pre-post correlations of 0.5 were assumed [20].

For subgroups, Z tests were applied for comparison between two groups and Q tests for comparisons between groups [20]. Since only cardiorespiratory fitness, muscle strength, BMI and TC presented high inconsistency (I^2 >60), we showed the effects of each type of training (AT, RT and CT) for these variables. The sub-group analysis of muscle mass was not possible, considering there was only one study assessing muscle mass after AT and only one after RT.

Results

Population and exercise training characteristics are described in Table 1. The mean age of participants across all studies included was 63 years old (from 52.2 ± 3 to 76 ± 5), including men, women and mixed samples, normal weight, overweight or obese, from different countries, with treated blood pressure (TBP) and non- treated blood pressure (non-TBT). Exercise training protocols were composed by AT, RT or CT, from 2 to 7 days per week, including a variety of intensities, volumes and type of exercises (Table 1).

Please, insert Table 1 here.

The overall effects of exercise training (from any type) in hypertensive older adults (>50yr) are illustrated in figure 2 and these data suggest that most outcomes were improved compared to control groups. There were not enough studies and considerable inconsistency among studies to compare type of training subgroups for some outcomes (Table 3).

In summary, CT confirmed its comprehensive health benefits, being the only one to reduce BMI, fat mass, glucose, triglycerides, and total cholesterol significantly. As expected, while only AT and CT increased cardiorespiratory fitness, only RT and CT increased strength, reinforcing the need of CT also in the hypertensive older adults. Because upper and lower body strength of the included studies were tested in the same analysis, there was a sample overlapping. Thus, to avoid this limitation we isolated muscle groups and confirmed the significant increase of SMD strength of upper body (1.24 [0.46; 2.02], p=0.002, k=4) and lower body (0.78[0.48; 1.09], p<0.001, k=5). The only outcome that CT was not able to improve was the resting heart rate which was only reduced by AT. Details regarding the effects of individual studies were presented in the forest plots (Supplementary material: Figures S1-S13).

The quality of the studies ranged from 5 to 9 in PEDro scale, and details of their classification can be assessed in Table 2. Egger tests suggested there were no significant risk of publication bias for HR, cardiorespiratory fitness, TC, TG, LDL, glucose, BMI, weight, waist, fat mass and muscle mass (p > 0.05 for all); however, there was significant risk of publication bias for strength (p = 0.01) and HDL (p = 0.01).

Please, insert Table 2 here.

Please, insert Figure 2 here.

Please, insert Table 3 here.

Discussion

These analyses demonstrate the extensive health benefits of exercise training for the health profiles of hypertensive older adults (Figure 2). Although the effectiveness of CT for systolic BP reduction was not confirmed in a previous meta-analysis [6], which is important for this population, CT was the most effective intervention at improving a wide spectrum of health needs in the present study (Table 3). As expected for the general population [10], RT did not improve cardiorespiratory fitness or reduce resting HR in hypertensive older adults, while AT did not result in an increase in strength. In addition to improving cardiorespiratory fitness and muscle strength, CT also reduced BMI, fat mass, glucose, TC and TG, which did not improve by either RT or AT alone.

Exercise capacity is associated with lower mortality risk even in hypertensive older adults [21,22]. In the present study, cardiorespiratory fitness increased in hypertensive older adults following AT and CT. The magnitude of this improvement is similar to what has previously been reported in AT with young adults [23]. AT and CT led to an increase in cardiorespiratory fitness (5.85 [2.84; 8.86] and 3.72 [1.98; 5.45] ml/kg/min, respectively), which surpasses the level of improvement (3.5 ml/kg/min) that has been previously demonstrated to confer a 10 to 12% reduction in mortality rate independent of disease status in adult men [24]. Our findings suggest that at least part of the physiological mechanisms associated with cardiorespiratory fitness adaptation (pulmonary diffusion capacity, cardiac output, arterio-venous oxygen diff, cardiac output and capacity of blood to transport oxygen) are still able to respond in this population.

It is noteworthy that the maximum HR achieved during exercise is limited by the impaired beta adrenergic sensitivity in older adults [25]. Despite this not being a traditionally recognized limiting factor for cardiorespiratory fitness [26], it could play a key role in reducing cardiorespiratory fitness specifically in this population [27]. Since hypertensive individuals already have impaired autonomic control (including impaired beta-adrenergic sensitivity) [28,29] and this may be improved by exercise training, this topic deserves further investigation.

Despite the lower responsiveness of older adults to improvements in autonomic control with exercise training [30], a meta-analysis showed a significant reduction in resting HR (-6 [-2;-12]bpm) after AT in older adults [31]. We also found a significant reduction of resting HR following AT in hypertensive older adults, albeit a slightly lower magnitude (-3.98 [-5.76; -2.19] bpm). As expected, the RT was not able to reduce resting HR [32], and the only studying testing CT effects did not reach significant reduction in our meta-analysis (-1.70 [-4.76; 1.36]bpm). Although this may suggest an important effect of AT on autonomic control, there is evidence that training-induced bradycardia is not a consequence of changes in the activity of the autonomic nervous system, but rather a result of intrinsic electrophysiological changes in the sinus node [33].

We are not aware of any reason to expect a blunted increase in strength in hypertensive older adults compared to healthy peers. In the present meta-analysis, CT did not increase muscle strength as much as RT, as previous meta-analysis in healthy adults already showed [34]. Considering the exercise protocols were not the same among studies, other confounding factors could be causing such differences besides the type of training. Corroborating our findings, the higher effectiveness of RT compared to CT has been shown in healthy older men [35]. Furthermore, the same study showed the potential of AT to increase at least lower body muscle strength with reduced magnitude compared to CT and RT [35]. However, controversial findings have been shown regarding the effectiveness of these different types of training in muscle strength [36–38] and more studies are needed for the overall older adult population.

CT was the only intervention that resulted in reductions in both BMI and fat mass. Importantly, reduction in weight and waist circumference, and increase in muscle mass, did not reach sufficiently high heterogeneity to be compared among types of training. Since the studies included in the present analyses were not designed to compare types of training, the higher effectiveness of CT on body composition may be due to higher exercise volume in these protocols resulting in higher caloric expenditure [39,40].

Hypertensive individuals more frequently exhibit overweight or obesity, glucose intolerance, and dyslipidemias, which make hypertension an extremely frequent component of the metabolic syndrome [41]. The complementary effects of RT and AT could explain the significant benefit of CT reducing glucose, TG and TC [42,43]. A meta-analysis showed only AT was able to reduce glucose, TG and LDL, while RT increased HDL; importantly, CT was not analyzed [43]. The increase in LDL and TC by RT subgroup in the current study was counterintuitive; however, in these analyses the RT subgroup consisted of just two studies and only one of them resulted in such negative results. Adverse metabolic responses to exercise training occur in around 10% of the general population [44] and another explanation of these negative effects of RT could be a higher caloric intake triggered by the hunger and desire to eat following each RT session [45,46].

Limitations

The low number of studies for subgroup analysis (type of training comparisons) is a limitation of our analyses. Although we clustered the type of training intervention among AT, RT and CT, there were different types of AT, RT and CT protocols such as: traditional, low intensity and concentric and eccentric RT; free weight, machines and resistance band circuit RT; walking, running, cycling and swimming AT; continuous, high intensity interval AT; and a variety of AT and RT intensities. Thus, despite our confidence in affirming the effectiveness of exercise training in the overall health marker analyses, further comparison among exercise protocols still needs to be confirmed by a meta-analysis with a larger number of studies in the future.

We were not able to analyze the following outcomes: mood [47], inflammatory markers [48], oxidant and antioxidant blood markers [49], blood flow and hemodynamics [49,50], pulse wave velocity [14,50,51], nitric oxide [49,51,52], other body composition markers [52–56], endothelin-1 [51,52], apelin [52], uric acid [57], insulin [54], cardiac function [50,54,56], endothelial function [50,58,59], arterial compliance [56,58], baroreceptor sensitivity [50], self-efficacy for exercise [60], and specific older adults functional tests such as flexibility, walking test, balance, stand to sit, hand and self-care working [14,51]. Thus, we strongly recommend more studies investigating these health markers to consolidate the effectiveness of different types of exercise training as a comprehensive therapy for hypertensive older adults.

Conclusion

In conclusion, the umbrella meta-analysis confidently confirmed the effectiveness of exercise training on the five major components of physical fitness (cardiorespiratory, motor, morphological, muscular and metabolic) in hypertensive older adults. There is also strong evidence for the highest potential to achieve comprehensive health benefits with combined training, instead of either aerobic or resistance training alone. The superiority of combined training could not be confirmed for a few outcomes and more studies are necessary to clarify all the important health benefits in this population.

Compliance with Ethical Standards

Founding

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Conflict of interest

All authors declare that they have no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

For this type of study inform consent is not required.

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Figures legends

Figure 1. Flowchart of study selection.

Legend: AT: aerobic training; CT: combined training; RT: resistance training; HR: heart rate; HDL: high density lipoprotein; LDL: low density lipoprotein; TG: triglycerides; BMI: body mass index; TC: total cholesterol; n: number of articles; k: number of subgroups.

Figure 2. Overall exercise training effects on health markers of hypertensive older adults (>50yr).

Legend: The results are based on AT, CT and RT (overall) effects available for each analysis.

red cross means there was not a significant effect of exercise training in that variable and green arrows mean there was a significant effect of exercise training in the direction of the arrow (increase: pointing up and decrease: pointing down). LDL: Low density lipoprotein; HDL: high density lipoprotein; BP: blood pressure; BMI: body mass index.

Table legends

Table 1. Characteristics of the 23 studies included.

Legend: AT: aerobic training ; CT: combined training; CWT: circuit weight training; RT: resistance training; W: women: M: men; TBP: treated blood pressure ; non-TBP: non-treated blood pressure: NR: not reported; w: week; RM: repetition maximum; MVC: maximum voluntary capacity; mmol/l: millimoles per liter; HRR: heart rate recovery; OMNI-RES scale: perceived exertion scale adapted; VO_2Max: maximal oxygen uptake; HRmax: maximum heart rate; kgm/min-1: kilogram-force meter/minute; SBP: systolic blood pressure; THR: target heart rate.

Table 2. Quality of studies included.

Legend: 1: Eligibility criteria specified; 2: Random allocation; 3: Concealed allocation; 4: Groups similar at baseline; 7: Assessor blinding; 8: Less than 15% dropouts; 9: Intention-to-treat analysis; 10: Between-group statistical comparisons; 11: Point measures and variability data; Questions 5 and 6, regarding blinded patient and care providers, were nulled as it is not possible in exercise interventions RCTs.

Table 3. Summarized effects of exercise training (AT. RT and CT) on health adaptations of hypertensive older adults (>50yr).

Legend: significant effects are highlighted in bold. AT: Aerobic training; CT: Combined training; RT: Resistance training. LL: lower limit; UL: upper limit; BMI: body mass index; HDL: high density lipoprotein; LDL: low density lipoprotein; SMD: standardized mean difference; UM: unit measurement.

Supplementary material

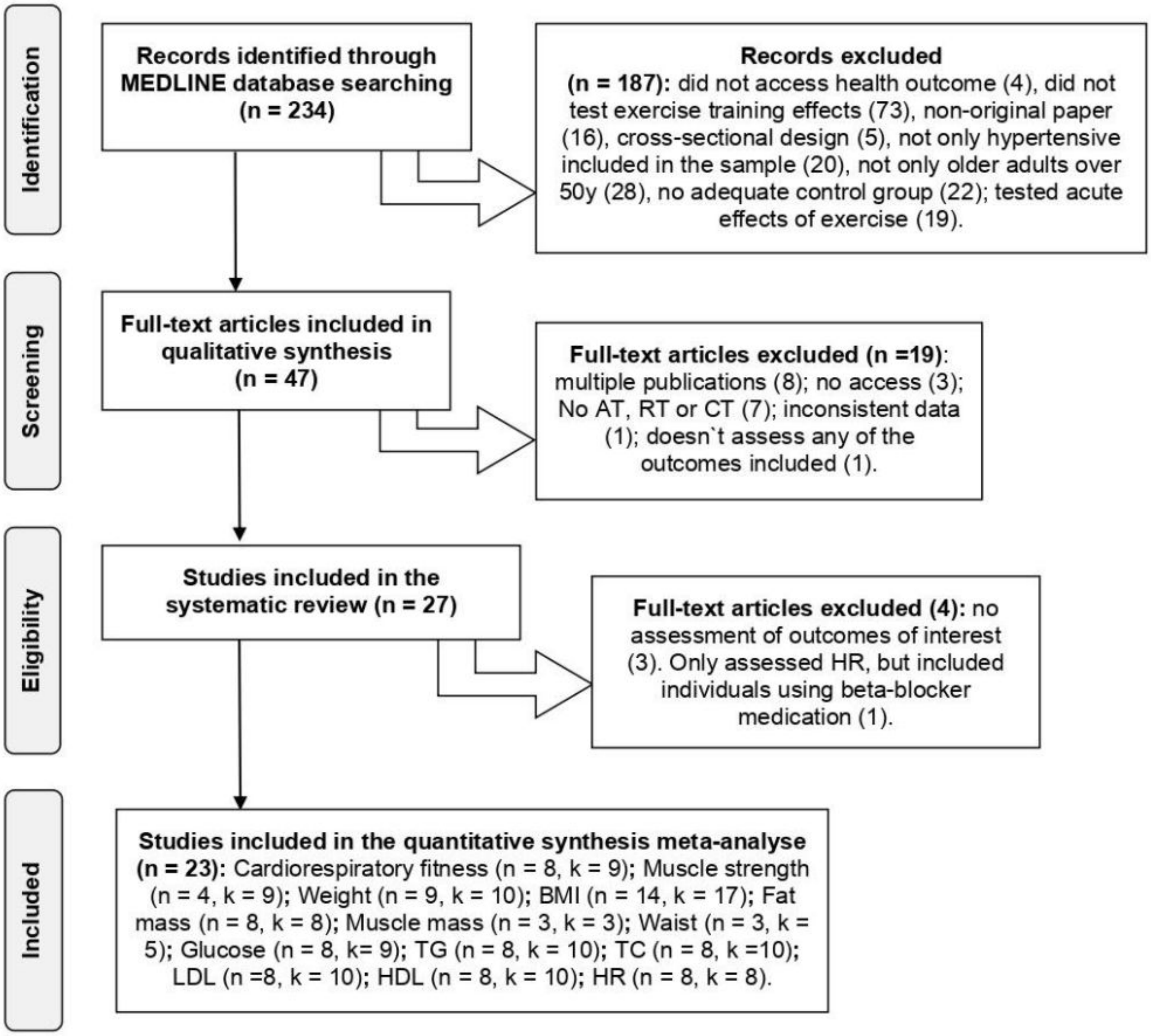

Figure 1. Flowchart of study selection.

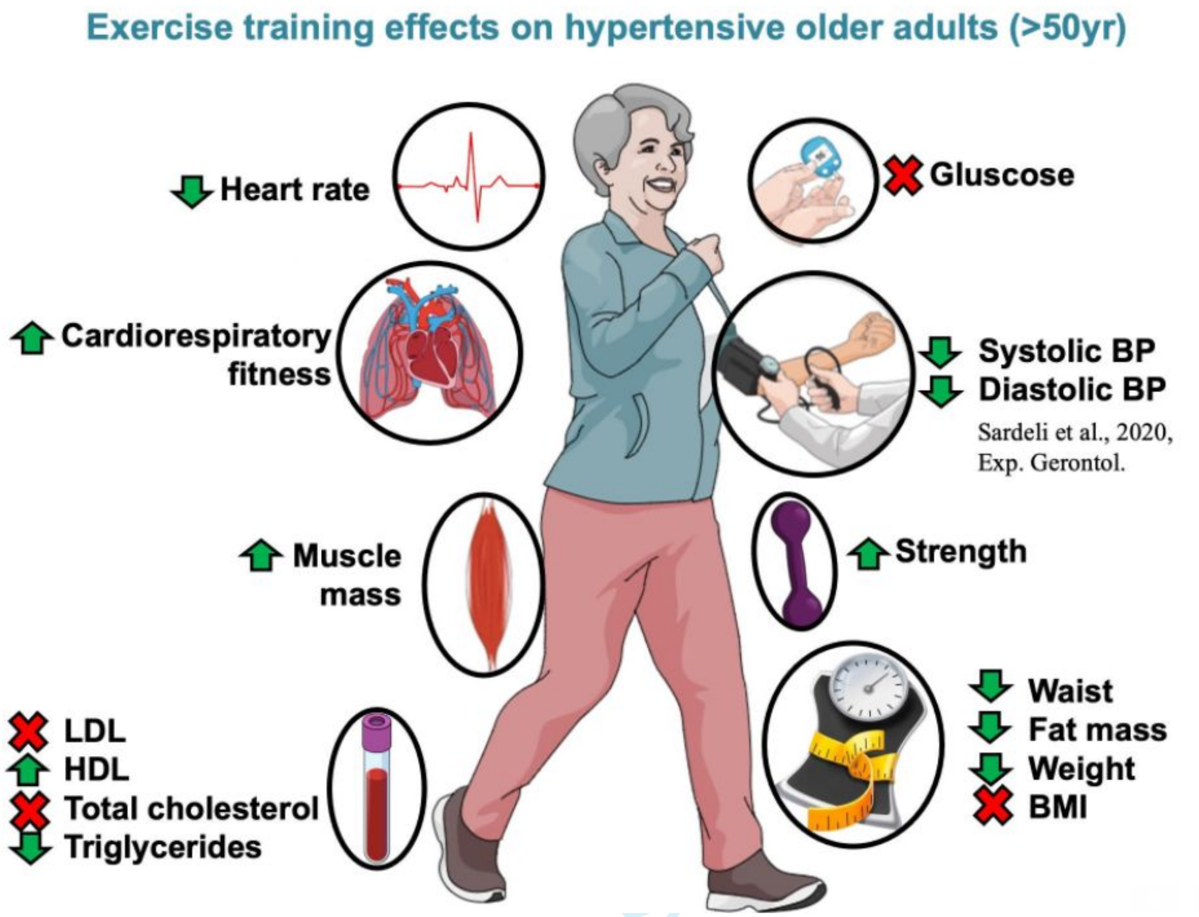

Figure 2. Overall exercise training effects on health markers of hypertensive older adults (>50yr).

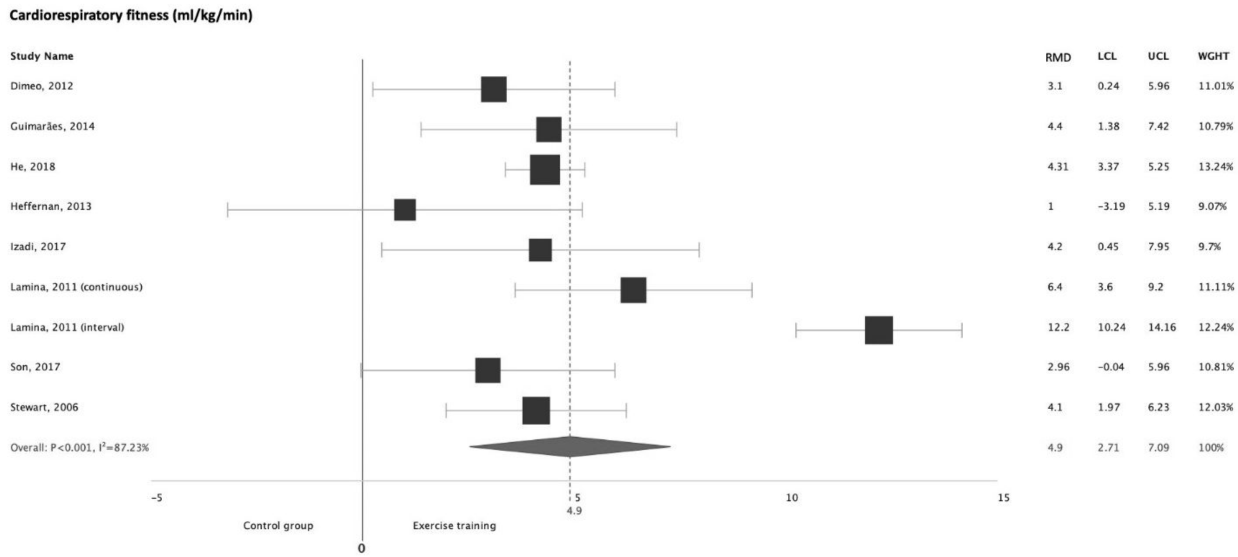

Figure S1. Forest plot of exercise training effects on Cardiorespiratory fitness. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

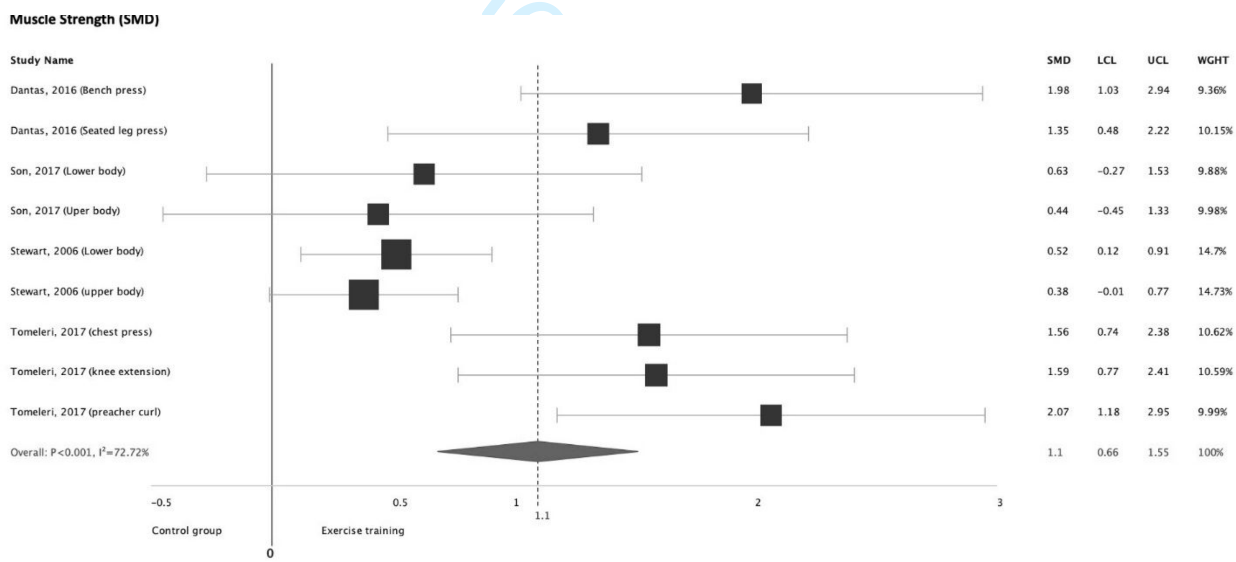

Figure S2. Forest plot of exercise training effects on Muscle strength. SMD: Standardized mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

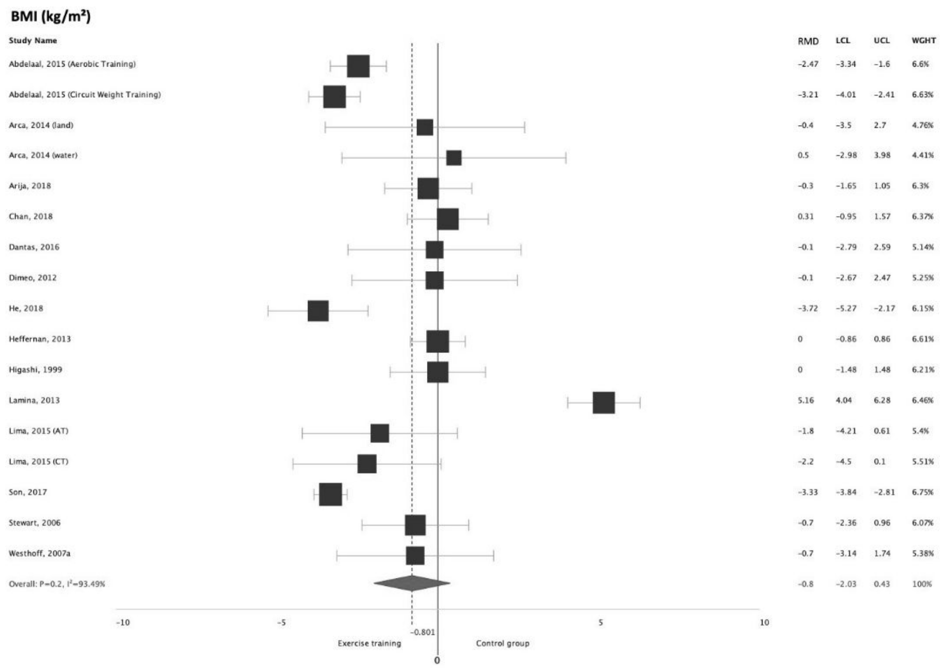

Figure S3. Forest plot of exercise training effects on Body mass index. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

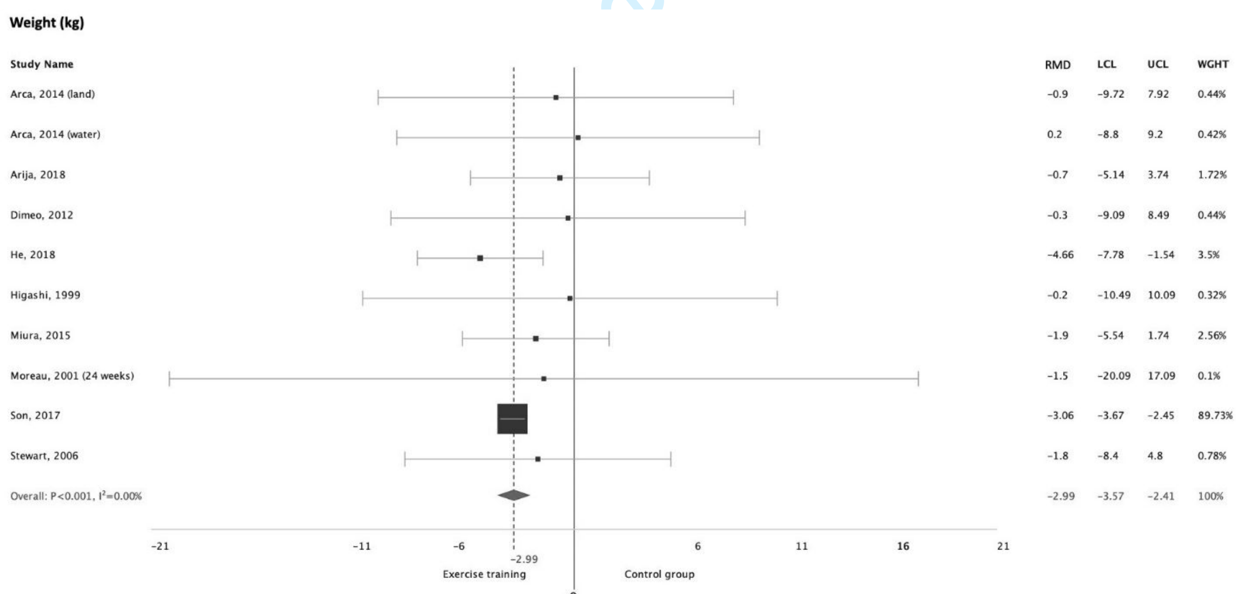

Figure S4. Forest plot of exercise training effects on Weight. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

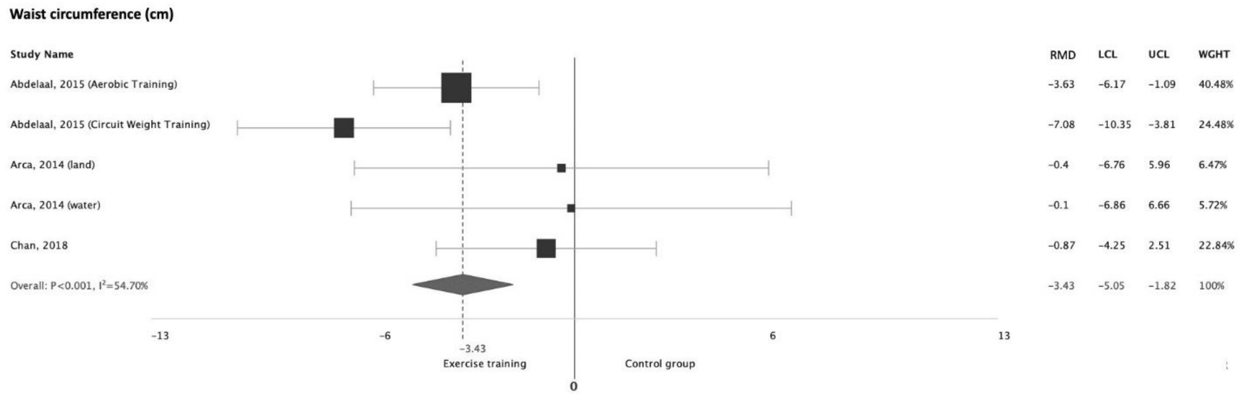

Figure S5. Forest plot of exercise training effects on Waist circumference. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

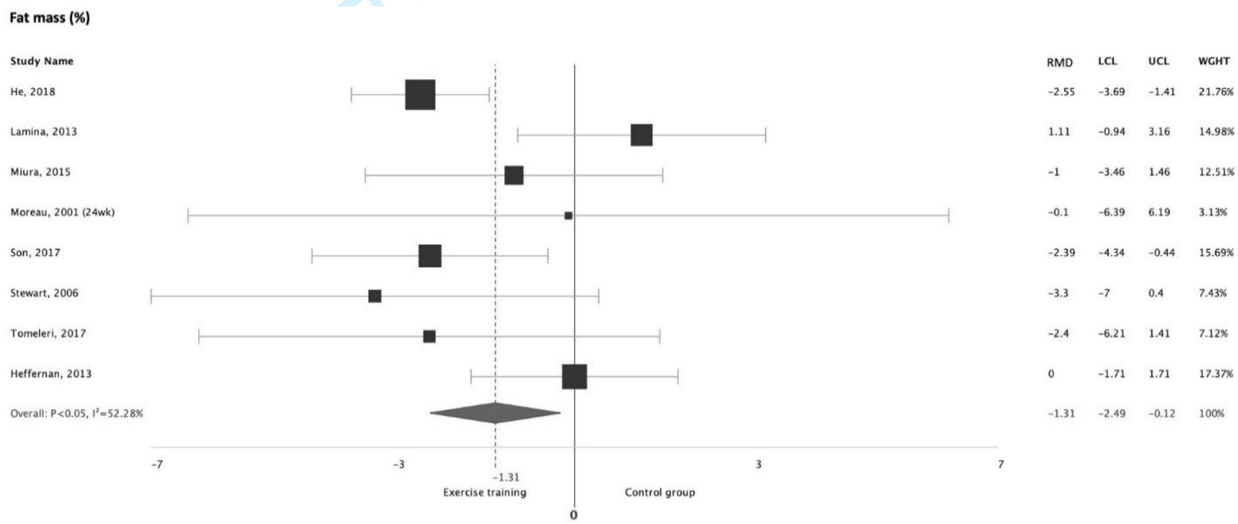

Figure S6. Forest plot of exercise training effects on Fat mass. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

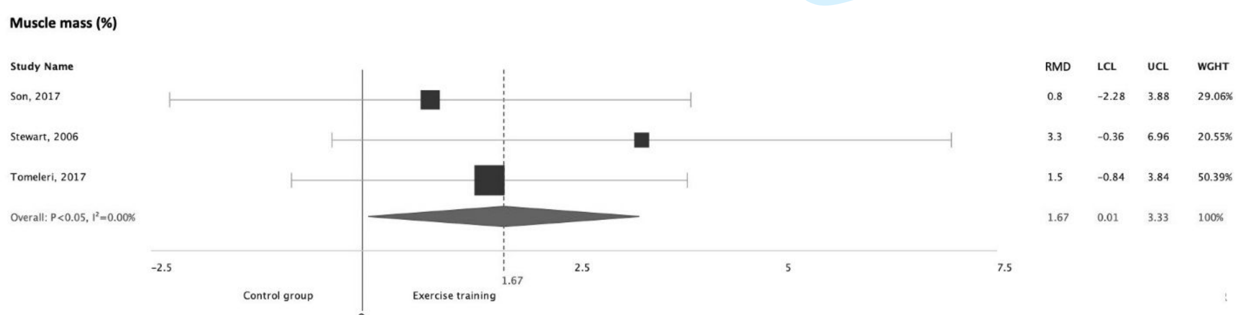

Figure S7. Forest plot of exercise training effects on Muscle mass. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

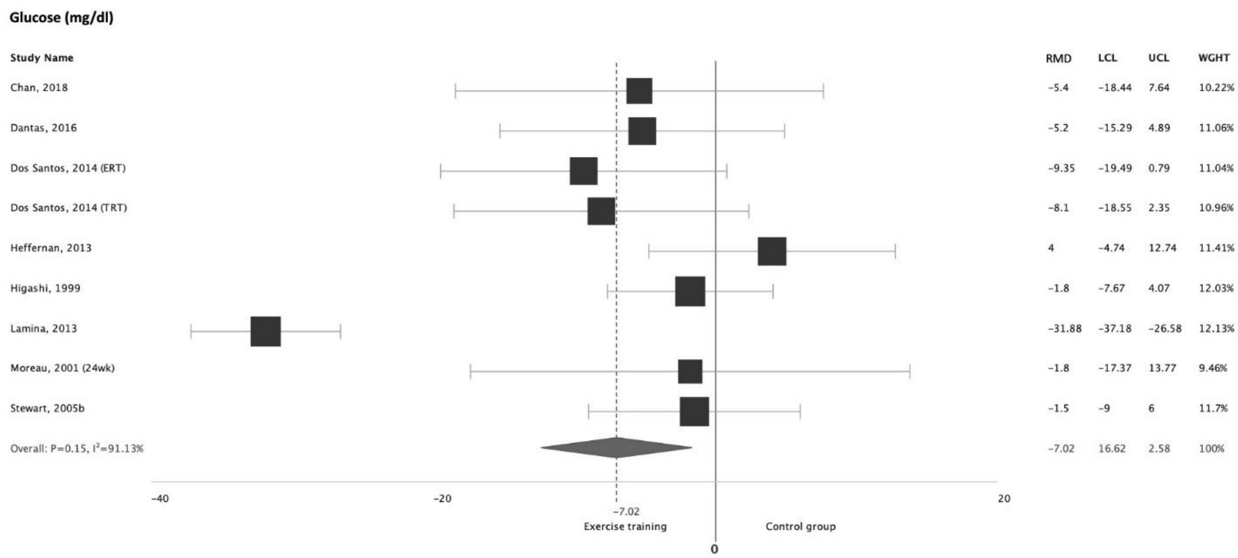

Figure S8. Forest plot of exercise training effects on Glucose. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

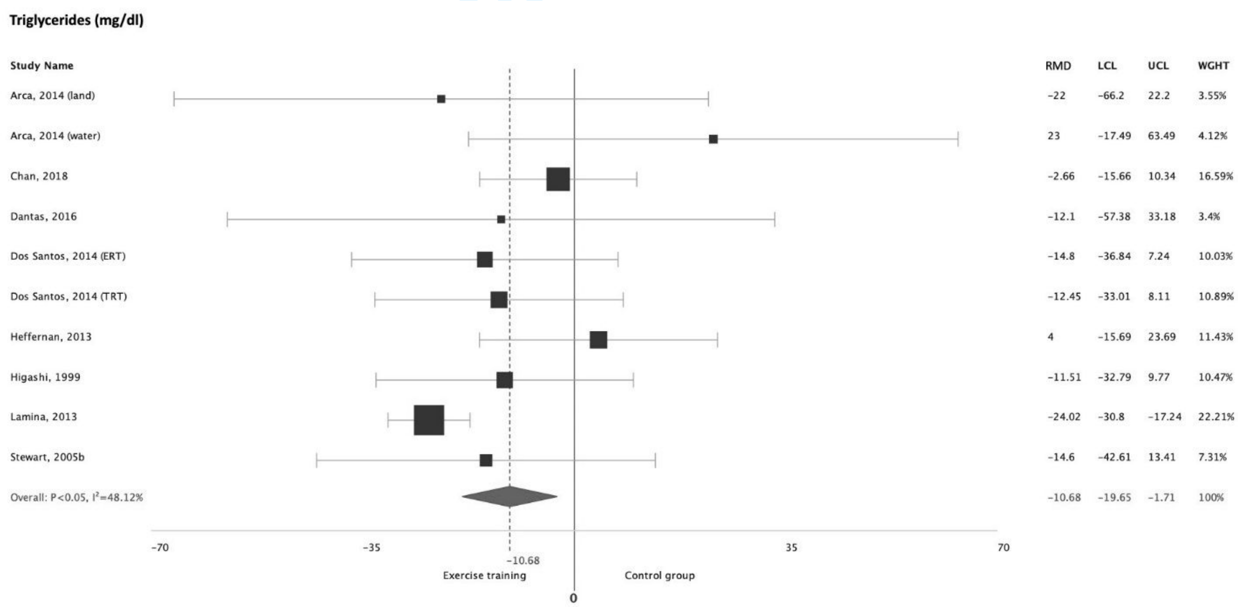

Figure S9. Forest plot of exercise training effects on Triglycerides. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

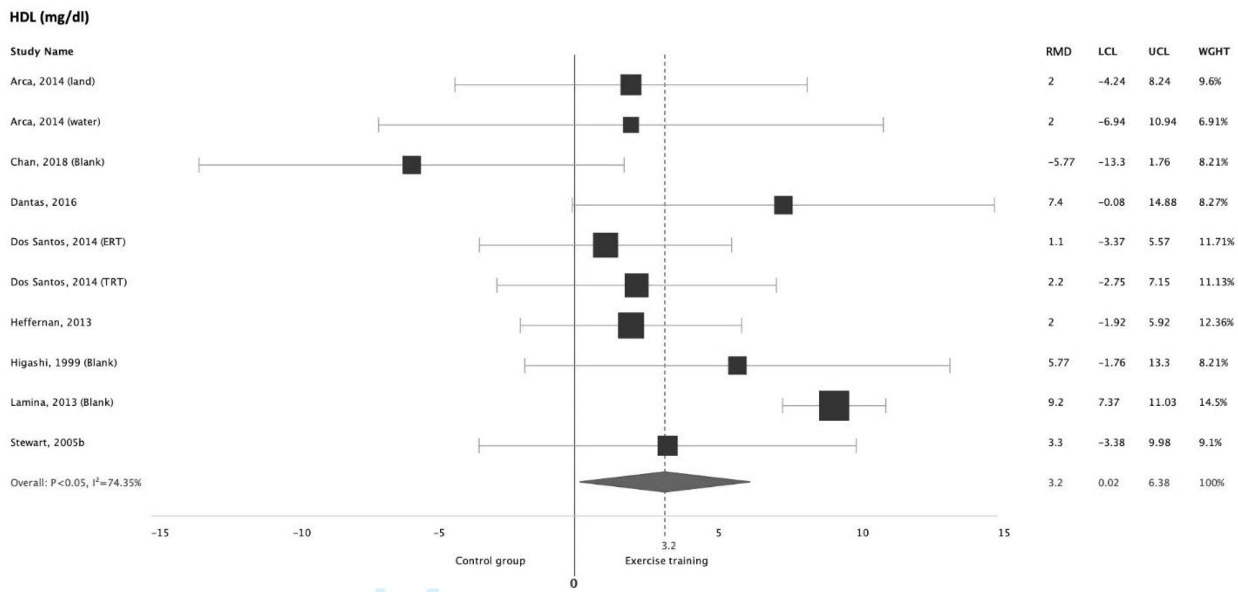

Figure S10. Forest plot of exercise training effects on HDL. HDL: High density lipoprotein; RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

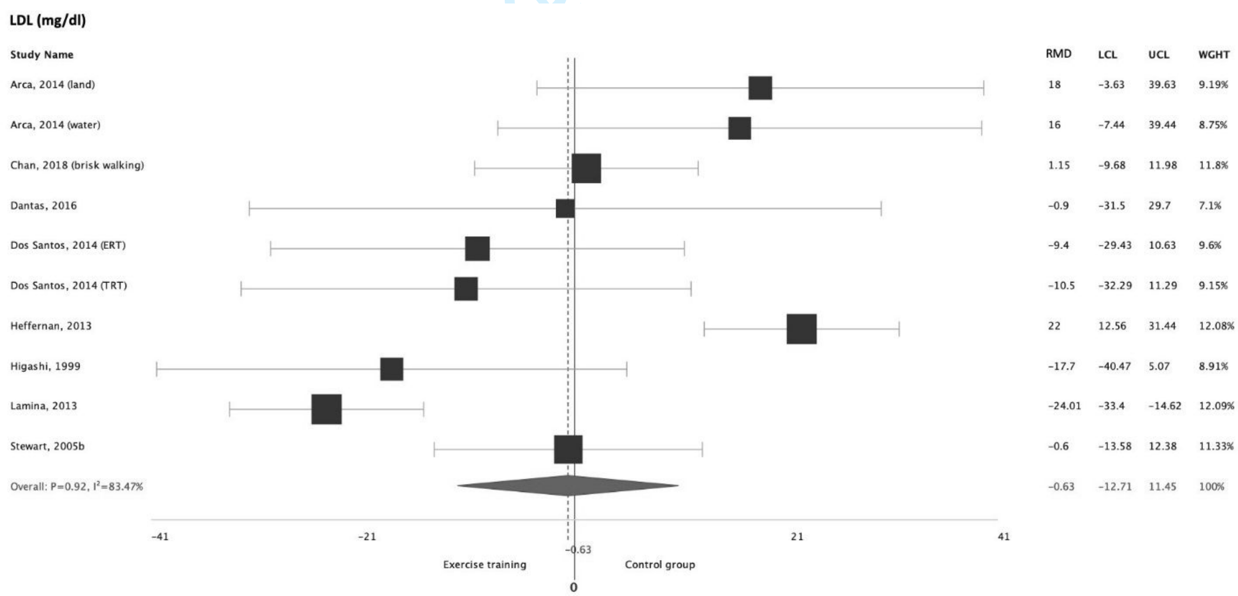

Figure S11. Forest plot of exercise training effects on LDL. LDL: Low density lipoprotein; RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

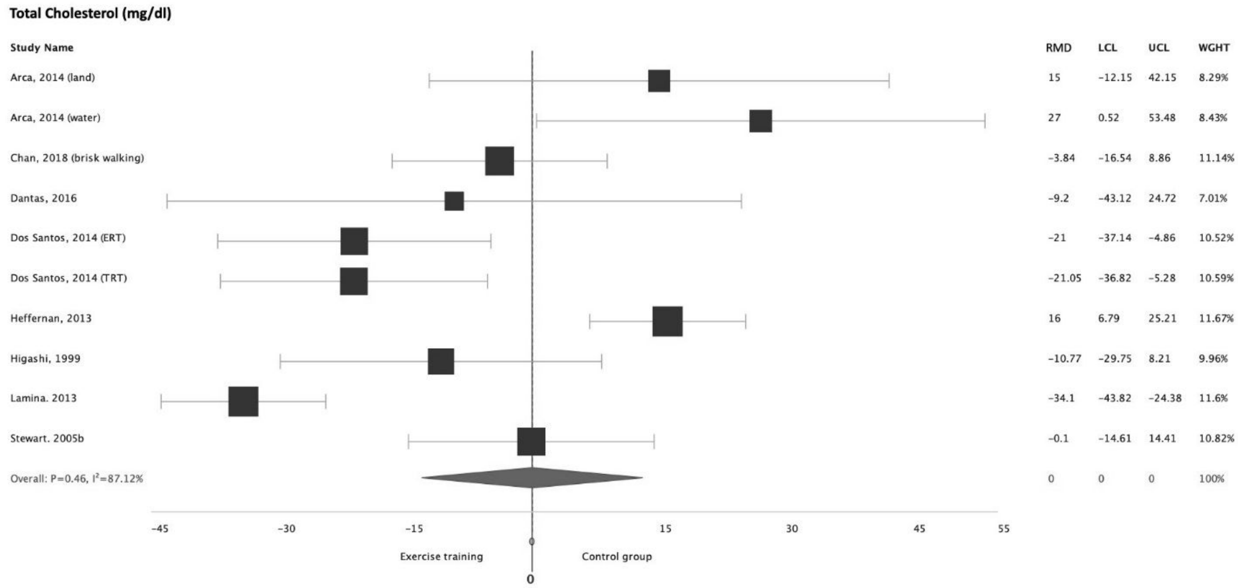

Figure S12. Forest plot of exercise training effects on Total cholesterol. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

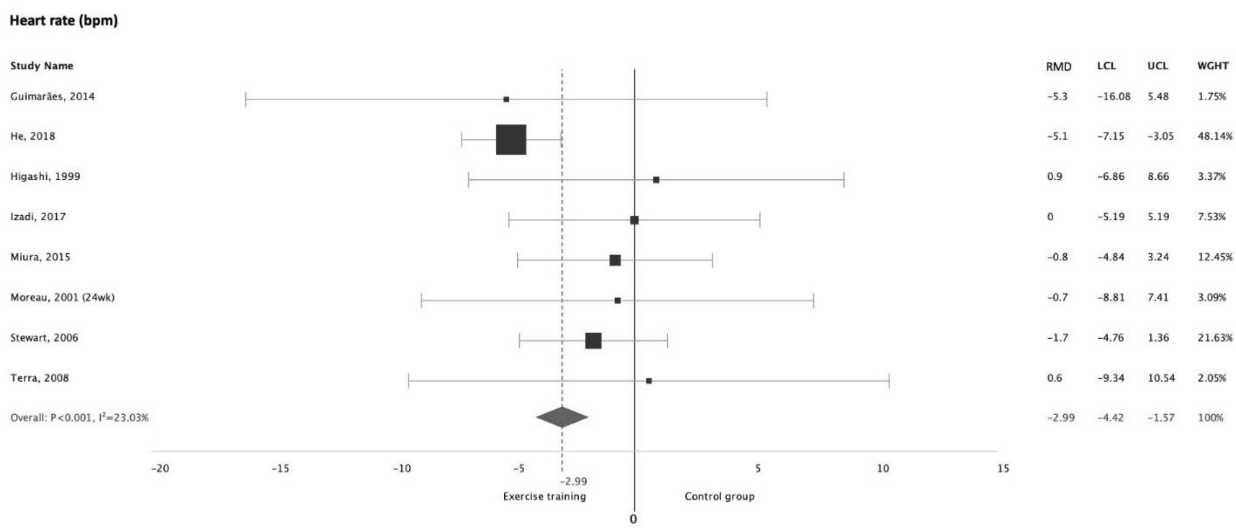

Figure S13. Forest plot of exercise training effects on heart rate. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

Table 1. Characteristics of the 23 studies included.

First author, publication year (Subgroup)	Location	Mean age (SD); sex; mean BMI (SD); Anti-hypertensive medication.	Type of exercise; volume; intensity; weekly frequency; intervention duration; adherence.
Abdelaal, 2015 (21) (AT)	Egypt	53 (3.5); 8M and 12W; 34.55 (1.1); NR.	**AT.** Treadmill walking; 20-50 min; 60-75% VO_2max; 3/w; 12w; NR.
Abdelaal, 2015 (21) (CWT)	Egypt	52.2 (3.0); 9M and 11W; 34.8 (1.14); NR.	**RT.** Exercises for upper/lower limbs; 2-3x10 rep; 60-75% 1RM; 3/w; 12w; NR.
Arca, 2014 (22) (Water)	Brazil	64.0 (7.0); 19W; 27.0 (5.1); TBP and non-TBP.	**AT.** Underwater walking, stretching, isotonic movements, relaxation; 150 min/w; 50-60% HRR; 3/w; 12w; NR.
Arca, 2014 (22) (Land)	Brazil	64.0 (7.0); 19W; 28.3 (4.2); TBP and non-TBP.	**AT.** Walking, stretching, stationary bike, relaxation; 150 min/w; 50-60% HRR; 3/w; 12w; NR.
Arija, 2018 (23)	Spain	67.4 (6.6); 64M and 116W; 30.5 (4.3); TBP and non-TBP.	**AT.** Walking; 120 min/w; 396 METs/min/w; 2/w; 36w; NR.
Chan, 2018 (12)	China	64.4 (9.8); 42M and 40W; 25.90 (4.4); TBP and non-TBP.	**AT.** Walking; 150 min; 5-6 km/h; 5/w; 12w; 80%.
Dantas, 2016 (24)	Brazil	64.7 (4.7); 13W; 28.6 (3.2); TBP.	**RT.** Exercises for upper/lower limbs and trunk; 9-15 reps; 9 exercises per session; 5-7 OMNI-RES scale; 2/3/w; 10w; NR.
Dimeo, 2012 (25)	Germany	62.8 (8.1); 11M and 13W; 28.9 (4.4); TBP.	**AT.** Treadmill walking; Lactate concentration 2.0 (0.5) mmol/L; 3/w; 8-12w; NR.
Dos Santos, 2014 (26) (ERT)	Brazil	64.2 (3.1); 20W; 27.8 (4.7); TBP and non-TBP.	**CT. RT:** Exercises for upper/lower limbs and trunk; 3x10 reps; 70-120% of 10 RM; **AT:** Treadmill; 20min; 65–75% THR; 3/w; 16w; 95%.
Dos Santos, 2014 (26) (TRT)	Brazil	62.2 (2.5); 20W; 28.5 (4.4); TBP and non-TBP.	**CT. RT:** Exercises for upper/lower limbs and trunk; 3x10 reps; 100-120 of 10 RM; **AT:** Treadmill; 20min; 65–75% THR; 3/w; 16w; 95%.
Guimarães, 2014 (27) (HEx)	Brazil	55 (5.9); 8M and 8W; 29.2 (4.9); TBP.	**CT. RT:** Exercises for upper/lower limbs, **AT:** Walking inside the pool; 180 min/w; 11-13 Borg Scale; 3/w; 12/w; 100%.
He, 2018 (28)	China	58.0 (2.); 23W; 24.15 (3.03); TBP and non-TBP.	**AT.** Walking; 180 min; 45% to 50% of VO_2max; 3/w; 12w; 91%.
Heffernan, 2013 (29)	USA	60 (2); 6M and 15W; 24 (1); non-TBP.	**RT.** Exercises for upper/lower limbs and trunk; 2x12-15; 40-60%1RM; 3/w; 12w; NR.
Higashi, 1999 (30)	Japan	62.7 (11.8); 14M and 6W; 24.1 (1.8); NR.	**AT.** Walking; 150-210min; 52 (6) % VO_2max; 5-7/w; 12w; NR.
Izadi, 2018 (31)	Iran	M 60.9 (5.71); W 64.6 (4.7); 8M and 7W; 25.2 (0.55); 25.7 (0.72); TBP.	**AT.** Cycle ergometer; 85-90% HRR; 3/w; 6w; 68%.

Lamina, 2011 (32) (Interval)	Nigeria	58.6 (7.2); 140M; 22.5 (2.9); TBP and non-TBP.	**AT.** Cycle ergometer; 135-180min (6 bouts: 6min cycling with load and 6min cycling with no load); 100 kgm/min-1 (17 Watts); 60-79% HRmax; 3/w; 8w; 73.6%.
Lamina, 2011 (32) (Continuous)	Nigeria	58.4 (6.9); 112M; 25 (3.9); TBP and non-TBP.	**AT.** Cycle ergometer; 135-180min; 100 kgm/min-1 (17 Watts); 60-79% HRmax; 3/w; 8w; 73.6%.
Lamina, 2013 (33)	Nigeria	58.9 (7.35); 140M; 24.9 (4.9); TBP and non-TBP.	**AT.** Cycle ergometer; 135-180 min; 100 kgm (17 wats); 60-79% Hrmax; 3/w; 8w; 84.6%.
Lima, 2015 (34) (AG)	Brazil	67.8 (4.3); 1M and 14W; 28.9 (3.5); TBP.	**AT.** Treadmill walking; 30 min; 3/w; 16w; NR.
Lima, 2015 (34) (RAG)	Brazil	67.8 (5.2); 2M and 13W; 28 (3.2); TBP.	**CT. RT:** 2 circuit laps of 9 Exercises for upper/lower limbs and trunk; 15 rep upper limbs and 20 rep lower limbs and trunk; 50-60% 1RM; **AT:** Continuous walking; 30 min; 3/w; 16w; NR.
Miura, 2015 (14)	Japan	72.9 (5.7); 92W; NR; non-TBP.	**CT. RT:** Resistance circuit; 3-5x15-20 reps; 15-20 RM; **AT:** Recreational activities; 180 min/w; 2/w; 12w; NR.
Moreau, 2001 (35)	USA	53 (2); 81.1 (5.9); 15W; TBP and non-TBP.	**AT.** Walking; progressively increasing to 3km increase in daily walking; self-selected comfortable pace; 7/w; 24w; NR.
Son, 2017 (36)	Korea	76.0 (5); 10W; 22.8 (0.7); non-TBP.	**CT. RT:** Resistance band exercises, **AT:** walking; 210 min/w; 40-70% HRR; 3/w; 12w; NR.
Stewart, 2005(37)	USA	63.0 (95% CI: 61.5–64.5); 25M and 26W; 29.4 (95% CI: 28.3 - 30.4); non-TBP.	**CT. RT:** Full body; 2x10-15reps; 50% 1RM; **AT:** Treadmill, cycle ergometer, or stair stepper; 50% 1RM, 60-90% HRmax; 3/w; 26w; 88%.
Stewart, 2006 (38)	USA	63 (5.3); 25M and 26W; 29.4 (95% CI: 28.3 - 30.4); non-TBP.	**CT. RT:** Full body; 2x10-15reps; 50% 1RM; **AT:** Treadmill, cycle ergometer, or stair stepper; 60-90% HRmax; 3/w; 26w; 88%.
Terra, 2008 (39)	Brazil	66.8 (5.6); 20W; 28.3 (5.8); TBP.	**RT.** Exercises for upper/lower limbs; 10 exercises per session; 3x8-12; 60-80%1RM; 3/w; 12w; 96%.
Tomeleri, 2017 (13) (SBP >140mmHg)	Brazil	71.3 (2.6); 9W; 69.8 (9.2); TBP and non-TBP.	**RT.** Exercises for upper/lower limbs; 1x10-15; 15RM; 2/w; 12w; >85%.
Tomeleri, 2017 (13) (SBP <140mmHg)	Brazil	65.5 (1.8); 6W; 28.9 (6.3); TBP and non-TBP.	**RT.** Exercises for upper/lower limbs; 1x10-15; 15RM; 2/w; 12w; >85%.
Westhoff, 2007	Germany	67.2 (4.8); 13M and 14W; 27.7 (4.4); TBP.	**AT.** Treadmill walking; 108 min/w; Lactate concentration of 2.5 (0.5) mmol/L above the aerobic threshold; 3/w; 12w; NR.

Legend: AT: aerobic training ; CT: combined training; CWT: circuit weight training; RT: resistance training; W: women: M: men; TBP: treated blood pressure ; non-TBP: non-treated blood pressure: NR: not reported; w: week; RM: repetition maximum; MVC: maximum voluntary capacity; mmol/l: millimoles per liter; HRR: heart rate recovery; OMNI-RES scale: perceived exertion scale adapted; VO_2Max: maximal oxygen uptake; HRmax: maximum heart rate; kgm/min-1: kilogram-force meter/minute; SBP: systolic blood pressure; THR: target heart rate.

Table 2. Quality of studies included.

First author, publication year	**1**	**2**	**3**	**4**	**7**	**8**	**9**	**10**	**11**	Sum
Abdelaal, 2015	yes	yes	yes	yes	yes	yes	yes	yes	yes	9
Arca, 2014	yes	yes	no	yes	no	yes	yes	yes	yes	7
Arija, 2018	yes	yes	no	yes	no	yes	yes	yes	yes	7
Chan, 2018	yes	yes	no	yes	yes	yes	yes	yes	yes	8
Dantas, 2016	yes	yes	no	yes	yes	yes	yes	yes	yes	8
Dimeo, 2012	yes	yes	no	yes	no	yes	yes	yes	yes	7
Dos Santos, 2014	yes	yes	no	yes	no	yes	yes	yes	yes	7
Guimarães, 2014	yes	yes	yes	yes	yes	yes	yes	yes	yes	9
He, 2018	yes	yes	no	no	no	yes	yes	yes	yes	6
Heffernan, 2013	yes	yes	no	yes	no	yes	yes	yes	yes	7
Higashi, 1999	yes	yes	no	yes	no	yes	yes	yes	yes	7
Izadi, 2017	yes	yes	no	yes	no	no	no	yes	yes	5
Lamina, 2011	yes	yes	no	yes	yes	no	no	yes	yes	6
Lamina, 2013	yes	yes	no	yes	no	no	no	yes	yes	5
Lima, 2015	yes	yes	no	yes	no	yes	yes	yes	yes	7
Miura 2015	yes	yes	no	yes	no	yes	yes	yes	yes	7
Moreau, 2001	yes	yes	no	yes	no	yes	yes	yes	yes	7
Son, 2017	yes	yes	no	yes	yes	yes	yes	yes	yes	8
Stewart, 2005	yes	yes	no	yes	no	yes	yes	yes	yes	7
Stewart 2006	yes	yes	no	yes	no	yes	yes	yes	yes	7
Terra, 2008	yes	no	no	yes	no	yes	yes	yes	yes	6
Tomeleri, 2017	yes	yes	no	yes	yes	yes	yes	yes	yes	8
Westhoff, 2007	yes	yes	no	yes	yes	yes	yes	yes	yes	8

1: Eligibility criteria specified; 2: Random allocation; 3: Concealed allocation; 4: Groups similar at baseline; 7: Assessor blinding; 8: Less than 15% dropouts; 9: Intention-to-treat analysis; 10: Between-group statistical comparisons; 11: Point measures and variability data; Questions 5 and 6, regarding blinded patient and care providers, were nulled as it is not possible in exercise interventions RCTs.

Table 3. Summarized effects of exercise training (AT. RT and CT) on health adaptations of hypertensive older adults (>50yr).

Training adaptation (UM)		**Overall**		**AT**		**CT**		**RT**	**p-value difference**
	k	MD [LL; UL]	k	MD [LL; UL]	k	MD [LL; UL]	k	MD [LL; UL]	**p-value difference**
Cardiorespiratory fitness (ml/kg/min)	9	**4.90 [2.71; 7.09]**	6	**5.85 [2.84; 8.86]**	2	**3.72 [1.98; 5.45]**	1	1.00 [-3.19; 5.19]	0.17
Muscle strength (SMD)	9	**1.10 [0.66;1.55]**			4	**0.46 [0.21;0.71]**	5	**1.69 [1.30; 2.08]**	**<0.001**
BMI (kg/m^2)	17	0.43 [-2.03; 0.80]	9	0.11 [-1.89; 2.12]	3	**-2.71 [-3.78; -1.64]**	5	-1.32 [-2.72; 0.08]	**0.03**
Weight (kg)	10	**-2.99 [-3.57; -2.42]**							
Waist (cm)	5	**-3.43 [-5.05; 1.82]**							
Fat mass (%)	8	**-1.31 [-2.49; -0.12]**	3	-0.73 [-3.74; 2.28]	2	**-2.59 [-4.31; 0.86]**	3	-0.57 [-1.89; 0.75]	0.18
Muscle mass (%)	3	**1.67 [0.01; 3.33]**							
Glucose (mg/dl)	9	-7.02 [-16.62; 2.58]	4	-10.86 [-29.50; 8.17]	3	**-5.23 [-10.45; -0.01]**	2	0.06 [-6.55; 6.66]	0.051
Triglycerides (mg/dl)	10	**-10.68 [-19.65; -1.71]**	5	-10.76 [-25.47; 3.96]	3	**-13.78 [-27.03; -0.53]**	2	1.44 [-16.62; 19.50]	0.12
HDL (mg/dl)	10	**3.20 [0.02; 6.38]**	5	3.15 [-2.62; 8.92]	3	1.93 [-1.04; 4.90]	2	3.72 [-1.21; 8.66]	0.81
LDL (mg/dl)	10	-0.63 [-12.71; 11.45]	5	-2.51 [-19.65; 14.63]	3	-4.66 [-14.41; 5.08]	2	**20.01 [10.99; 29.03]**	0.22
Total Cholesterol (mg/dl)	10	-5.16 [-18.83; 8.51]	5	-3.52 [-24.75; 17.71]	3	**-13.15 [-22.05; -4.24]**	2	**14.27 [5.38; 23.16]**	0.23
Heart rate (bpm)	8	**-2.95 [-4.36; -1.54]**	5	**-3.98 [-5.76; -2.19]**	1	-1.70 [-4.76; 1.36]	2	-0.63[-4.14; 2.89]	0.61

Note: significant effects are highlighted in bold. AT: Aerobic training; CT: Combined training; RT: Resistance training. LL: lower limit; UL: upper limit; BMI: body mass index; HDL: high density lipoprotein; LDL: low density lipoprotein; MD: mean difference; SMD: standardized mean difference; UM: unit measurement.