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

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

2

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1 **Abstract**

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

11

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

1 **Introduction**

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

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

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

21 Recently, the European Society of Cardiology summarized the five major components of
22 physical fitness: cardiorespiratory, motor, morphological, muscular and metabolic ¹⁰. They
23 highlighted the importance of AT, RT and also flexibility and balance exercise for specific benefits

1 in older adults, who are at increased risk for cardiovascular disease. However, there is no consensus
2 about which AT or RT benefits could be lost by the use of CT, or even what benefits could be
3 acquired just by doing CT considering the extensive health needs of older adults with hypertension.

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

1 **Methods**

2 **Search strategy**

3 The systematic search was conducted on MEDLINE in August of 2019, combining the
4 adequate descriptors for aging, exercise training, hypertension and controlled trials. We selected
5 randomized control trials testing exercise training effects (AT, RT or CT) on different health
6 markers in hypertensive older adults, aged > 50 years. We considered hypertensive, the older adults
7 with SBP >130mmHg or DBP >80mmHg, according to American College of
8 Cardiology/American Heart Association¹¹. Details of the selection process are described in Figure
9 1.

10 **Please, insert Figure 1 here.**

11

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

19 Training interventions with other types of exercise besides AT, RT or CT were excluded.
20 We selected the health outcomes that were prevalent among the studies (analyzed in at least 3
21 studies): cardiorespiratory fitness assessed as maximum oxygen consumption, muscle strength,
22 body weight, fat mass, muscle mass, body mass index (BMI), waist circumference, high density

1 lipoprotein (HDL), low density lipoprotein (LDL), triglycerides (TG), total cholesterol (TC), blood
2 glucose, and resting heart rate (HR).

3

4 **Data extraction**

5 Mean, standard deviation (SD) and sample number (n) were used for analysis. Standard
6 error (SE) was converted to SD by the equation $SD = SE \times (\sqrt{n})$, if SD was not provided in the
7 original study. Median and interquartile range (IQR) were replaced by median and SD ($SD = (IQR$
8 $/ 1.35)$)¹⁶. The 95% confidence intervals were converted to SD considering the equation $(\sqrt{(n)$
9 $* (UL - LL) / (2 * T.INV (0.05; n - 1))$), where n is the sample size, UL is the upper limit, LL is
10 the lower limit and T.INV is the function that calculates the left-tailed inverse of the Student's T
11 distribution¹⁷.

12

13 **Risk of bias**

14 We assessed the quality of the studies by PEDro scale, and the two questions regarding
15 blinded patient and care providers were excluded as it is not possible in exercise intervention trials
16¹⁸. Removing those 2 questions, scores on PEDro scale ranged from 0 (very low methodological
17 quality) to 9 (high methodological quality). This assessment was not an exclusion criterion and the
18 results of each study were presented for qualitative characterization. Egger's tests were performed
19 to check the risk of publication bias in each of the meta-analyses¹⁹.

20

1 **Statistical analyses**

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

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

17 **Results**

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

1 **Please, insert Table 1 here.**

2

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

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

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

22

1 **Please, insert Table 2 here.**

2

3 **Please, insert Figure 2 here.**

4

5 **Please, insert Table 3 here.**

6

7 **Discussion**

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

16 Exercise capacity is associated with lower mortality risk even in hypertensive older adults
17 ^{21,22}. In the present study, cardiorespiratory fitness increased in hypertensive older adults following
18 AT and CT. The magnitude of this improvement is similar to what has previously been reported
19 in AT with young adults ²³. AT and CT led to an increase in cardiorespiratory fitness (5.85 [2.84;
20 8.86] and 3.72 [1.98; 5.45] ml/kg/min, respectively), which surpasses the level of improvement
21 (3.5 ml/kg/min) that has been previously demonstrated to confer a 10 to 12% reduction in mortality
22 rate independent of disease status in adult men ²⁴. Our findings suggest that at least part of the

1 physiological mechanisms associated with cardiorespiratory fitness adaptation (pulmonary
2 diffusion capacity, cardiac output, arterio-venous oxygen diff, cardiac output and capacity of blood
3 to transport oxygen) are still able to respond in this population.

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

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

19 We are not aware of any reason to expect a blunted increase in strength in hypertensive
20 older adults compared to healthy peers. In the present meta-analysis, CT did not increase muscle
21 strength as much as RT, as previous meta-analysis in healthy adults already showed ³⁴. Considering
22 the exercise protocols were not the same among studies, other confounding factors could be
23 causing such differences besides the type of training. Corroborating our findings, the higher

1 effectiveness of RT compared to CT has been shown in healthy older men ³⁵. Furthermore, the
2 same study showed the potential of AT to increase at least lower body muscle strength with
3 reduced magnitude compared to CT and RT ³⁵. However, controversial findings have been shown
4 regarding the effectiveness of these different types of training in muscle strength ^{36–38} and more
5 studies are needed for the overall older adult population.

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

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

22

23 **Limitations**

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

9 We were not able to analyze the following outcomes: mood ⁴⁷, inflammatory markers ⁴⁸,
10 oxidant and antioxidant blood markers ⁴⁹, blood flow and hemodynamics ^{49,50}, pulse wave velocity
11 ^{14,50,51}, nitric oxide ^{49,51,52}, other body composition markers ⁵²⁻⁵⁶, endothelin-1 ^{51,52}, apelin ⁵², uric
12 acid ⁵⁷, insulin ⁵⁴, cardiac function ^{50,54,56}, endothelial function ^{50,58,59}, arterial compliance ^{56,58},
13 baroreceptor sensitivity ⁵⁰, self-efficacy for exercise ⁶⁰, and specific older adults functional tests
14 such as flexibility, walking test, balance, stand to sit, hand and self-care working ^{14,51}. Thus, we
15 strongly recommend more studies investigating these health markers to consolidate the
16 effectiveness of different types of exercise training as a comprehensive therapy for hypertensive
17 older adults.

18

19 **Conclusion**

20 In conclusion, the umbrella meta-analysis confidently confirmed the effectiveness of
21 exercise training on the five major components of physical fitness (cardiorespiratory, motor,
22 morphological, muscular and metabolic) in hypertensive older adults. There is also strong evidence
23 for the highest potential to achieve comprehensive health benefits with combined training, instead

1 of either aerobic or resistance training alone. The superiority of combined training could not be
2 confirmed for a few outcomes and more studies are necessary to clarify all the important health
3 benefits in this population.

4 **Compliance with Ethical Standards**

5

6 **Founding**

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12 **Conflict of interest**

13 All authors declare that they have no competing interests.

14 **Ethical approval**

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

17 **Informed consent**

18 For this type of study informed consent is not required.

19

1 **References**

- 2 1 Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, Chiuve
3 SE, Cushman M, Delling FN, Deo R, de Ferranti SD, Ferguson JF, Fornage M, Gillespie
4 C, Isasi CR, Jiménez MC, Jordan LC, Judd SE, Lackland D, Lichtman JH, Lisabeth L, Liu
5 S, Longenecker CT, Lutsey PL, Mackey JS, Matchar DB, Matsushita K, Mussolino ME,
6 Nasir K, O’Flaherty M, Palaniappan LP, Pandey A, Pandey DK, Reeves MJ, Ritchey MD,
7 Rodriguez CJ, Roth GA, Rosamond WD, Sampson UKA, Satou GM, Shah SH, Spartano
8 NL, Tirschwell DL, Tsao CW, Voeks JH, Willey JZ, Wilkins JT, Wu JH, Alger HM,
9 Wong SS, Muntner P, American Heart Association Council on Epidemiology and
10 Prevention Statistics Committee and Stroke Statistics Subcommittee. Heart Disease and
11 Stroke Statistics—2018 Update: A Report From the American Heart Association.
12 *Circulation* 2018; **137**: e67–e492. doi:10.1161/CIR.0000000000000558
- 13 2 Perloff D, Grim C, Flack J, Frohlich ED, Hill M, McDonald M, Morgenstern BZ. Human
14 blood pressure determination by sphygmomanometry. *Circulation* 1993; **88**: 2460–
15 70. <http://www.ncbi.nlm.nih.gov/pubmed/8222141>. Accessed 6 April 2019
- 16 3 Lewington S, Clarke R, Qizilbash N, Peto R, Collins R, Prospective Studies
17 Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a
18 meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet*
19 (*London, England*) 2002; **360**: 1903–13. <http://www.ncbi.nlm.nih.gov/pubmed/12493255>.
20 Accessed 14 April 2019
- 21 4 Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ,
22 Skinner JS, Skinner JS. Exercise and Physical Activity for Older Adults. *Med Sci Sport*
23 *Exerc* 2009; **41**: 1510–1530. doi:10.1249/MSS.0b013e3181a0c95c

- 1 5 Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases.
2 *Compr Physiol* 2012; **2**: 1143–1211. doi:10.1002/cphy.c110025
- 3 6 Sardeli AV, Griffith GJ, Dos Santos MVMA, Ito MSR, Nadruz W, Chacon-Mikahil MPT.
4 Do baseline blood pressure and type of exercise influence level of reduction induced by
5 training in hypertensive older adults? A meta-analysis of controlled trials. *Exp Gerontol*
6 2020; **140**: 111052. doi:10.1016/j.exger.2020.111052
- 7 7 Ferri C, Ferri L, Desideri G. Management of Hypertension in the Elderly and Frail
8 Elderly. *High Blood Press Cardiovasc Prev* 2017; **24**: 1–11. doi:10.1007/s40292-017-
9 0185-4
- 10 8 Williamson JD, Supiano MA, Applegate WB, Berlowitz DR, Campbell RC, Chertow GM,
11 Fine LJ, Haley WE, Hawfield AT, Ix JH, Kitzman DW, Kostis JB, Krousel-Wood MA,
12 Launer LJ, Oparil S, Rodriguez CJ, Roumie CL, Shorr RI, Sink KM, Wadley VG,
13 Whelton PK, Whittle J, Woolard NF, Wright JT, Pajewski NM, SPRINT Research Group.
14 Intensive vs Standard Blood Pressure Control and Cardiovascular Disease Outcomes in
15 Adults Aged ≥ 75 Years. *JAMA* 2016; **315**: 2673. doi:10.1001/jama.2016.7050
- 16 9 Reid KF, Naumova EN, Carabello RJ, Phillips EM, Fielding RA. Lower extremity muscle
17 mass predicts functional performance in mobility-limited elders. *J Nutr Health Aging*
18 2008; **12**: 493–8. <http://www.ncbi.nlm.nih.gov/pubmed/18615232>. Accessed 14 April 2019
- 19 10 Pelliccia A, Sharma S, Gati S, Bäck M, Börjesson M, Caselli S, Collet JP, Corrado D,
20 Drezner JA, Halle M, Hansen D, Heidbuchel H, Myers J, Niebauer J, Papadakis M,
21 Piepoli MF, Prescott E, Roos-Hesselink JW, Graham Stuart A, Taylor RS, Thompson PD,
22 Tiberi M, Vanhees L, Wilhelm M. 2020 ESC Guidelines on sports cardiology and exercise

- 1 in patients with cardiovascular disease. *Eur Heart J* 2020; **00**: 1–80.
2 doi:10.1093/eurheartj/ehaa605
- 3 11 Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C,
4 DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P,
5 Ovbiagele B, Smith SC, Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams KA,
6 Williamson JD, Wright JT. 2017
7 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the
8 Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults:
9 Executive Summary: A Report of the American College of Cardiology/American Heart
10 Association Task F. *Hypertension* 2018; **71**: 1269–1324.
11 doi:10.1161/HYP.0000000000000066
- 12 12 Chan AWK, Chair SY, Lee DTF, Leung DYP, Sit JWH, Cheng HY, Taylor-Piliae RE. Tai
13 Chi exercise is more effective than brisk walking in reducing cardiovascular disease risk
14 factors among adults with hypertension: A randomised controlled trial. *Int J Nurs Stud*
15 2018; **88**: 44–52. doi:10.1016/j.ijnurstu.2018.08.009
- 16 13 Tomeleri CM, Marcori AJ, Ribeiro AS, Gerage AM, Padilha C de S, Schiavoni D, Souza
17 MF, Mayhew JL, do Nascimento MA, Venturini D, Barbosa DS, Cyrino ES. Chronic
18 Blood Pressure Reductions and Increments in Plasma Nitric Oxide Bioavailability. *Int J*
19 *Sports Med* 2017; **38**: 290–299. doi:10.1055/s-0042-121896
- 20 14 Miura H, Takahashi Y, Maki Y, Sugino M. Effects of exercise training on arterial stiffness
21 in older hypertensive females. *Eur J Appl Physiol* 2015; **115**: 1847–1854.
22 doi:10.1007/s00421-015-3168-y

- 1 15 Moreau KL, Degarmo R, Langley J, McMahon C, Howley ET, Bassett DRJ, Thompson
2 DL. Increasing daily walking lowers blood pressure in postmenopausal women. *Med Sci*
3 *Sports Exerc* 2001; **33**: 1825–1831.
- 4 16 Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median,
5 range, and the size of a sample. *BMC Med Res Methodol* 2005; **5**: 13. doi:10.1186/1471-
6 2288-5-13
- 7 17 Higgins J, Thomas J, Chandler J, Cumpston M, Li T, Page M, Welch V. Chapter 6:
8 Choosing effect measures and computing estimates of effect. In Higgins J, Li T, Deeks J
9 (eds), *Cochrane Handbook for Systematic Reviews of Interventions version, 2nd ed.*
10 Chichester (UK): John Wiley & Sons, 2020www.training.cochrane.org/handbook.
- 11 18 Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro
12 scale for rating quality of randomized controlled trials. *Phys Ther* 2003; **83**: 713–21.
13 doi:https://doi.org/10.1093/ptj/83.8.713
- 14 19 Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple ,
15 graphical test measures of funnel plot asymmetry. *BMJ* 1997; **315**: 629–34.
16 doi:10.1136/bmj.315.7109.629
- 17 20 Borenstein M, Hedges L, Higgins J, Rothstein H. *Introduction to Meta-analysis*. Wiley
- 18 21 Faselis C, Doumas M, Pittaras A, Narayan P, Myers J, Tsimploulis A, Kokkinos P.
19 Exercise Capacity and All-Cause Mortality in Male Veterans With Hypertension Aged
20 ≥ 70 Years. *Hypertension* 2014; **64**: 30–35.
21 doi:10.1161/HYPERTENSIONAHA.114.03510

- 1 22 Blair SN, Kohl HW, Paffenbarger RS, Clark DG, Cooper KH, Gibbons LW. Physical
2 fitness and all-cause mortality. A prospective study of healthy men and women. *JAMA*
3 1989; **262**: 2395–401. <http://www.ncbi.nlm.nih.gov/pubmed/2795824>. Accessed 14 April
4 2019
- 5 23 Milanović Z, Sporiš G, Weston M. Effectiveness of High-Intensity Interval Training
6 (HIT) and Continuous Endurance Training for VO₂max Improvements: A Systematic
7 Review and Meta-Analysis of Controlled Trials. *Sport Med* 2015; **45**: 1469–1481.
8 doi:10.1007/s40279-015-0365-0
- 9 24 Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE. Exercise Capacity and
10 Mortality among Men Referred for Exercise Testing. *N Engl J Med* 2002; **346**: 793–801.
11 doi:10.1056/NEJMoa011858
- 12 25 Christou DD, Seals DR. Decreased maximal heart rate with aging is related to reduced
13 {beta}-adrenergic responsiveness but is largely explained by a reduction in intrinsic heart
14 rate. *J Appl Physiol* 2008; **105**: 24–9. doi:10.1152/jappphysiol.90401.2008
- 15 26 Gourine A V., Ackland GL. Cardiac Vagus and Exercise. *Physiology* 2019; **34**: 71–80.
16 doi:10.1152/physiol.00041.2018
- 17 27 Heath GW, Hagberg JM, Ehsani AA, Holloszy JO. A physiological comparison of young
18 and older endurance athletes. *J Appl Physiol* 1981; **51**: 634–640.
19 doi:10.1152/jappl.1981.51.3.634
- 20 28 Pauletto P, Scannapieco G, Pessina AC. Sympathetic drive and vascular damage in
21 hypertension and atherosclerosis. *Hypertens (Dallas, Tex 1979)* 1991; **17**: III75-
22 81. <http://www.ncbi.nlm.nih.gov/pubmed/2013498>. Accessed 7 April 2019

- 1 29 Izzo JL, Taylor AA. The sympathetic nervous system and baroreflexes in hypertension
2 and hypotension. *Curr Hypertens Rep* 1999; **1**: 254–
3 63.<http://www.ncbi.nlm.nih.gov/pubmed/10981075>. Accessed 7 April 2019
- 4 30 Sandercock GRH, Bromley PD, Brodie DA. Effects of exercise on heart rate variability:
5 inferences from meta-analysis. *Med Sci Sports Exerc* 2005; **37**: 433–
6 9.<http://www.ncbi.nlm.nih.gov/pubmed/15741842>. Accessed 14 April 2019
- 7 31 Huang G, Shi X, Davis-Brezette JA, Osness WH. Resting heart rate changes after
8 endurance training in older adults: a meta-analysis. *Med Sci Sports Exerc* 2005; **37**: 1381–
9 6.<http://www.ncbi.nlm.nih.gov/pubmed/16118586>. Accessed 14 April 2019
- 10 32 Sardeli AV, Heeren M V., Magalhães LS, Rodrigues B, Cavaglieri CR, Chacon-Mikahil
11 MPT. Resistance training and cardiovascular autonomic modulation in humans: a
12 systematic review and meta-analysis. *Manual, Ther Posturology Rehabil J* 2017; **15**: 541.
- 13 33 D'Souza A, Bucchi A, Johnsen AB, Logantha SJRJ, Monfredi O, Yanni J, Prehar S, Hart
14 G, Cartwright E, Wisloff U, Dobryznski H, DiFrancesco D, Morris GM, Boyett MR.
15 Exercise training reduces resting heart rate via downregulation of the funny channel
16 HCN4. *Nat Commun* 2014; **5**: 3775. doi:10.1038/ncomms4775
- 17 34 Sabag A, Najafi A, Michael S, Esgin T, Halaki M, Hackett D. The compatibility of
18 concurrent high intensity interval training and resistance training for muscular strength
19 and hypertrophy: a systematic review and meta-analysis. *J Sports Sci* 2018; **36**: 2472–
20 2483. doi:10.1080/02640414.2018.1464636
- 21 35 Cadore EL, Pinto RS, Lhullier FLR, Correa CS, Alberton CL, Pinto SS, Almeida APV,
22 Tartaruga MP, Silva EM, Krueel LFM. Physiological effects of concurrent training in

- 1 elderly men. *Int J Sports Med* 2010; **31**: 689–697. doi:10.1055/s-0030-1261895
- 2 36 Izquierdo M, Ibañez J, Häkkinen K, Kraemer WJ, Larrión JL, Gorostiaga EM. Once
3 Weekly Combined Resistance and Cardiovascular Training in Healthy Older Men. *Med*
4 *Sci Sports Exerc* 2004; **36**: 435–443. doi:10.1249/01.MSS.0000117897.55226.9A
- 5 37 Karavirta L, Häkkinen K, Kauhanen A, Arijä-Blázquez A, Sillanpää E, Rinkinen N,
6 Häkkinen A. Individual responses to combined endurance and strength training in older
7 adults. *Med Sci Sports Exerc* 2011; **43**: 484–490. doi:10.1249/MSS.0b013e3181f1bf0d
- 8 38 Sillanpää E, Häkkinen A, Nyman K, Mattila M, Cheng S, Karavirta L, Laaksonen DE,
9 Huuhka N, Kraemer WJ, Häkkinen K. Body composition and fitness during strength
10 and/or endurance training in older men. *Med Sci Sports Exerc* 2008; **40**: 950–958.
11 doi:10.1249/MSS.0b013e318165c854
- 12 39 Swift DL, Johannsen NM, Earnest CP, Church TS. The Role of Exercise and Physical
13 Activity in Weight Loss and Maintenance. *Prog Cardiovasc Dis* 2014; **56**: 441–447.
14 doi:10.1016/J.PCAD.2013.09.012
- 15 40 Ho SS, Dhaliwal SS, Hills AP, Pal S. The effect of 12 weeks of aerobic, resistance or
16 combination exercise training on cardiovascular risk factors in the overweight and obese
17 in a randomized trial. *BMC Public Health* 2012; **12**: 704. doi:10.1186/1471-2458-12-704
- 18 41 Zimlichman R, Julius S, Mancia G (eds). *Prehypertension and Cardiometabolic*
19 *Syndrome*. <https://www.springer.com/series/15049>
- 20 42 Stefani L, Galanti G. Physical Exercise Prescription in Metabolic Chronic Disease. In
21 Shen B (ed), *Translational Informatics in Smart Healthcare*. Singapore: Springer

- 1 Singapore, 2017, 123–141.
- 2 43 Ostman C, Smart NA, Morcos D, Duller A, Ridley W, Jewiss D. The effect of exercise
3 training on clinical outcomes in patients with the metabolic syndrome: a systematic review
4 and meta-analysis. *Cardiovasc Diabetol* 2017; **16**: 110. doi:10.1186/s12933-017-0590-y
- 5 44 Bouchard C, Blair SN, Church TS, Earnest CP, Hagberg JM, Häkkinen K, Jenkins NT,
6 Karavirta L, Kraus WE, Leon AS, Rao DC, Sarzynski MA, Skinner JS, Slentz CA,
7 Rankinen T. Adverse metabolic response to regular exercise: Is it a rare or common
8 occurrence? *PLoS One* 2012; **7**. doi:10.1371/journal.pone.0037887
- 9 45 Larsen PS, Donges CE, Guelfi KJ, Smith GC, Adams DR, Duffield R. Effects of aerobic,
10 strength or combined exercise on perceived appetite and appetite-related hormones in
11 inactive middle-aged men. *Int J Sport Nutr Exerc Metab* 2017; **27**: 389–398.
12 doi:10.1123/ijsnem.2017-0144
- 13 46 Freitas MC, Panissa VLG, Lenquiste SA, Serra F de M, Figueiredo C, Lira FS, Rossi FE.
14 Hunger is suppressed after resistance exercise with moderate-load compared to high-load
15 resistance exercise: The potential influence of metabolic and autonomic parameters. *Appl*
16 *Physiol Nutr Metab* 2020; **45**: 180–186. doi:10.1139/apnm-2019-0086
- 17 47 Stanton JM, Arroll B. The effect of moderate exercise on mood in mildly hypertensive
18 volunteers: a randomized controlled trial. *J Psychosom Res* 1996; **40**: 637–642.
- 19 48 Lima LG, Bonardi JMT, Campos GO, Bertani RF, Scher LML, Louzada-Junior P,
20 Moriguti JC, Ferriolli E, Lima NKC. Effect of aerobic training and aerobic and resistance
21 training on the inflammatory status of hypertensive older adults. *Aging Clin Exp Res* 2015;
22 **27**: 483–489. doi:10.1007/s40520-014-0307-y

- 1 49 Dantas FFO, Brasileiro-Santos M do S, Batista RMF, do Nascimento LS, Castellano LRC,
2 Ritti-Dias RM, Lima KC, Santos A da C. Effect of Strength Training on Oxidative Stress
3 and the Correlation of the Same with Forearm Vasodilatation and Blood Pressure of
4 Hypertensive Elderly Women: A Randomized Clinical Trial. *PLoS One* 2016; **11**:
5 e0161178. doi:10.1371/journal.pone.0161178
- 6 50 Nualnim N, Parkhurst K, Dhindsa M, Tarumi T, Vavrek J, Tanaka H. Effects of
7 swimming training on blood pressure and vascular function in adults >50 years of age.
8 *Am J Cardiol* 2012; **109**: 1005–10. doi:10.1016/j.amjcard.2011.11.029
- 9 51 Son W-M, Sung K-D, Cho J-M, Park S-Y. Combined exercise reduces arterial stiffness,
10 blood pressure, and blood markers for cardiovascular risk in postmenopausal women with
11 hypertension. *Menopause* 2017; **24**: 262–268. doi:10.1097/GME.0000000000000765
- 12 52 Izadi MR, Ghardashi Afousi A, Asvadi Fard M, Babae Bigi MA. High-intensity interval
13 training lowers blood pressure and improves apelin and NOx plasma levels in older
14 treated hypertensive individuals. *J Physiol Biochem* 2018; **74**: 47–55. doi:10.1007/s13105-
15 017-0602-0
- 16 53 Barone BB, Wang N-Y, Bacher AC, Stewart KJ. Decreased exercise blood pressure in
17 older adults after exercise training: contributions of increased fitness and decreased
18 fatness. *Br J Sports Med* 2009; **43**: 52–56. doi:10.1136/bjism.2008.050906
- 19 54 Stewart KJ, Ouyang P, Bacher AC, Lima S, Shapiro EP. Exercise effects on cardiac size
20 and left ventricular diastolic function: relationships to changes in fitness, fatness, blood
21 pressure and insulin resistance. *Heart* 2006; **92**: 893–898. doi:10.1136/hrt.2005.079962
- 22 55 Church TS, Earnest CP, Skinner JS, Blair SN. Effects of different doses of physical

- 1 activity on cardiorespiratory fitness among sedentary, overweight or obese
2 postmenopausal women with elevated blood pressure: a randomized controlled trial.
3 *JAMA* 2007; **297**: 2081–2091. doi:10.1001/jama.297.19.2081
- 4 56 Dimeo F, Pagonas N, Seibert F, Arndt R, Zidek W, Westhoff TH. Aerobic exercise
5 reduces blood pressure in resistant hypertension. *Hypertens (Dallas, Tex 1979)* 2012; **60**:
6 653–658. doi:10.1161/HYPERTENSIONAHA.112.197780
- 7 57 Lamina S. Comparative effect of interval and continuous training programs on serum uric
8 acid in management of hypertension: a randomized controlled trial. *J strength Cond Res*
9 2011; **25**: 719–726. doi:10.1519/JSC.0b013e3181d09edf
- 10 58 Westhoff TH, Franke N, Schmidt S, Vallbracht-Israng K, Meissner R, Yildirim H,
11 Schlattmann P, Zidek W, Dimeo F, van der Giet M. Too old to benefit from sports? The
12 cardiovascular effects of exercise training in elderly subjects treated for isolated systolic
13 hypertension. *Kidney Blood Press Res* 2007; **30**: 240–247. doi:10.1159/000104093
- 14 59 Westhoff TH, Franke N, Schmidt S, Vallbracht-Israng K, Zidek W, Dimeo F, van der Giet
15 M. Beta-blockers do not impair the cardiovascular benefits of endurance training in
16 hypertensives. *J Hum Hypertens* 2007; **21**: 486–493. doi:10.1038/sj.jhh.1002173
- 17 60 Lee L-L, Arthur A, Avis M. Evaluating a community-based walking intervention for
18 hypertensive older people in Taiwan: a randomized controlled trial. *Prev Med (Baltim)*
19 2007; **44**: 160–166. doi:10.1016/j.jpmed.2006.09.001
- 20
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1 **Figures legends**

2

3 **Figure 1. Flowchart of study selection.**

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

7 **Figure 2. Overall exercise training effects on health markers of hypertensive older adults**
8 **(>50yr).**

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

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

14 **Table legends**

15 **Table 1. Characteristics of the 23 studies included.**

16 **Legend:** AT: aerobic training ; CT: combined training; CWT: circuit weight training; RT:
17 resistance training; W: women; M: men; TBP: treated blood pressure ; non-TBP: non-treated blood
18 pressure; NR: not reported; w: week; RM: repetition maximum; MVC: maximum voluntary
19 capacity; mmol/l: millimoles per liter; HRR: heart rate recovery; OMNI-RES scale: perceived
20 exertion scale adapted; VO₂Max: maximal oxygen uptake; HRmax: maximum heart rate;
21 kgm/min-1: kilogram-force meter/minute; SBP: systolic blood pressure; THR: target heart rate.

22 **Table 2. Quality of studies included.**

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

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

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

Supplementary material

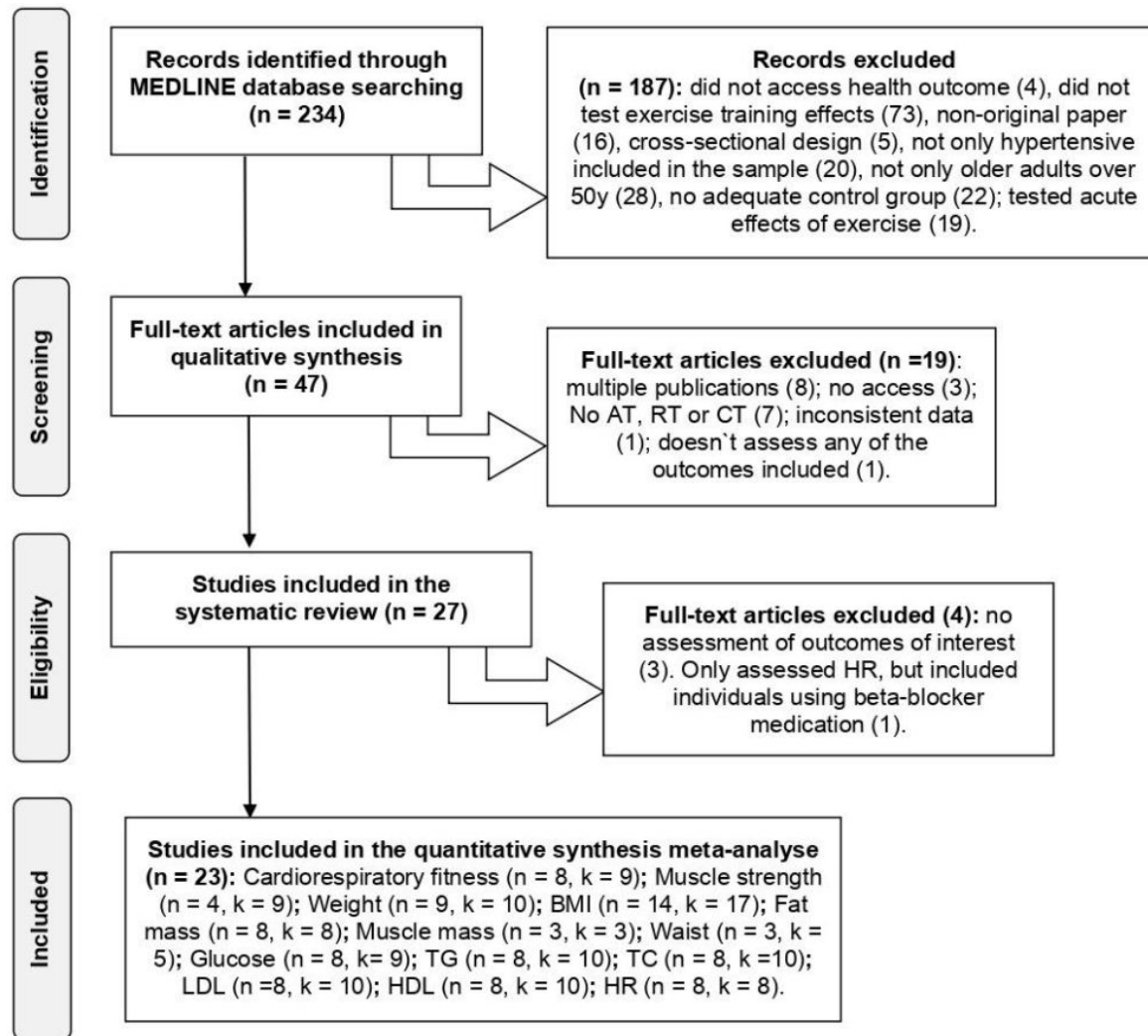


Figure 1. Flowchart of study selection.

Exercise training effects on hypertensive older adults (>50yr)

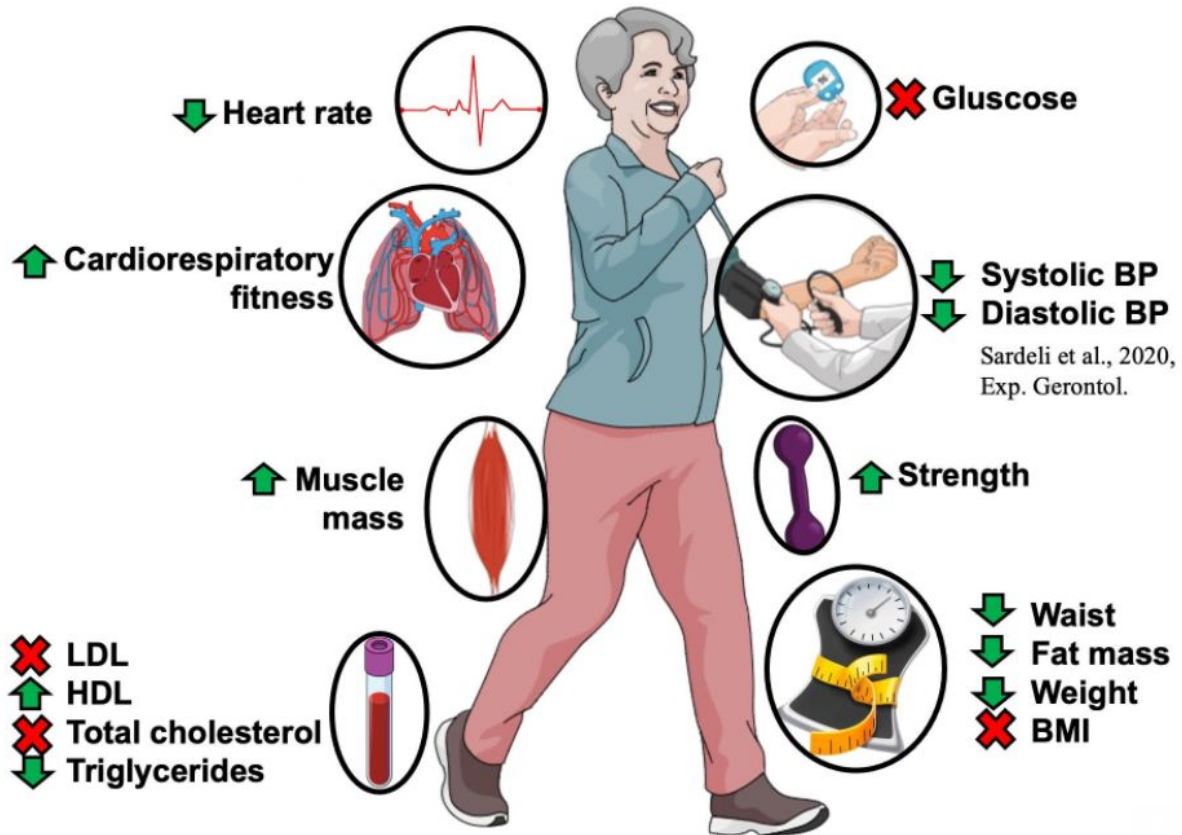


Figure 2. Overall exercise training effects on health markers of hypertensive older adults (>50yr).

Cardiorespiratory fitness (ml/kg/min)

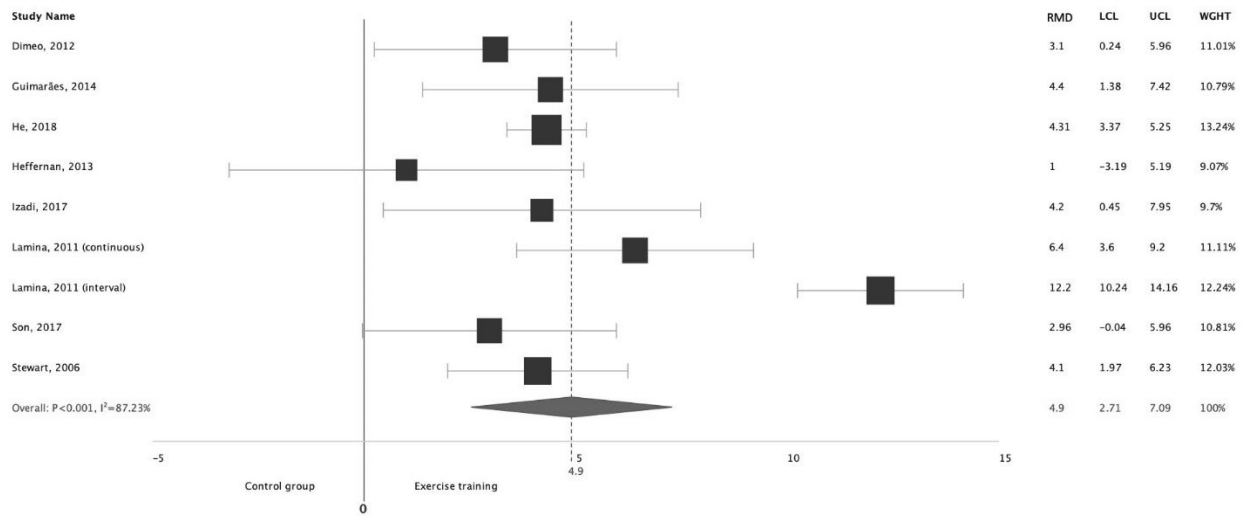


Figure S1. Forest plot of exercise training effects on Cardiorespiratory fitness. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

Muscle Strength (SMD)

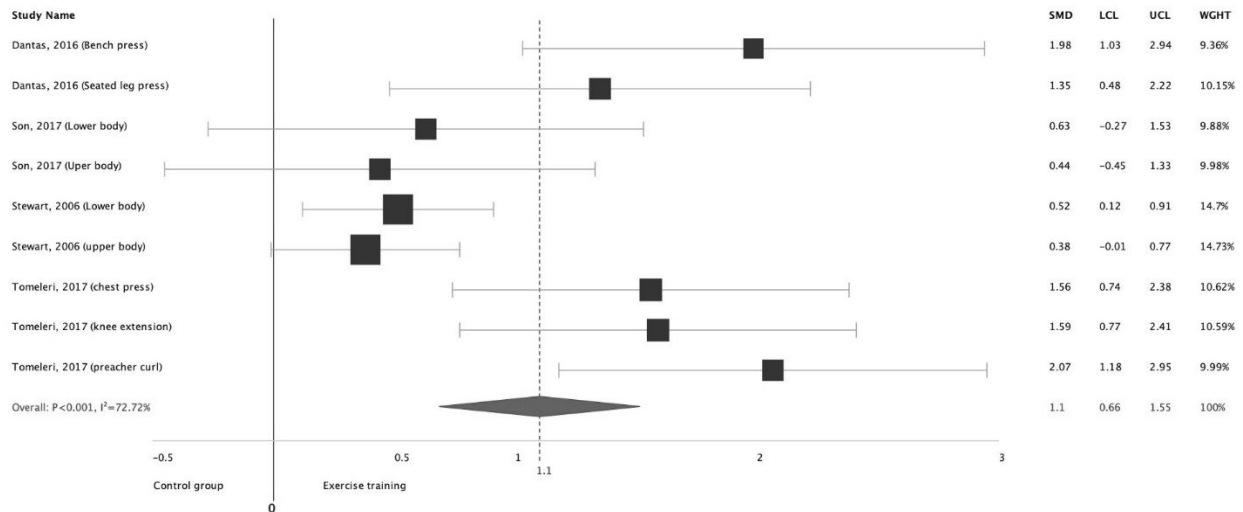


Figure S2. Forest plot of exercise training effects on Muscle strength. SMD: Standardized mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

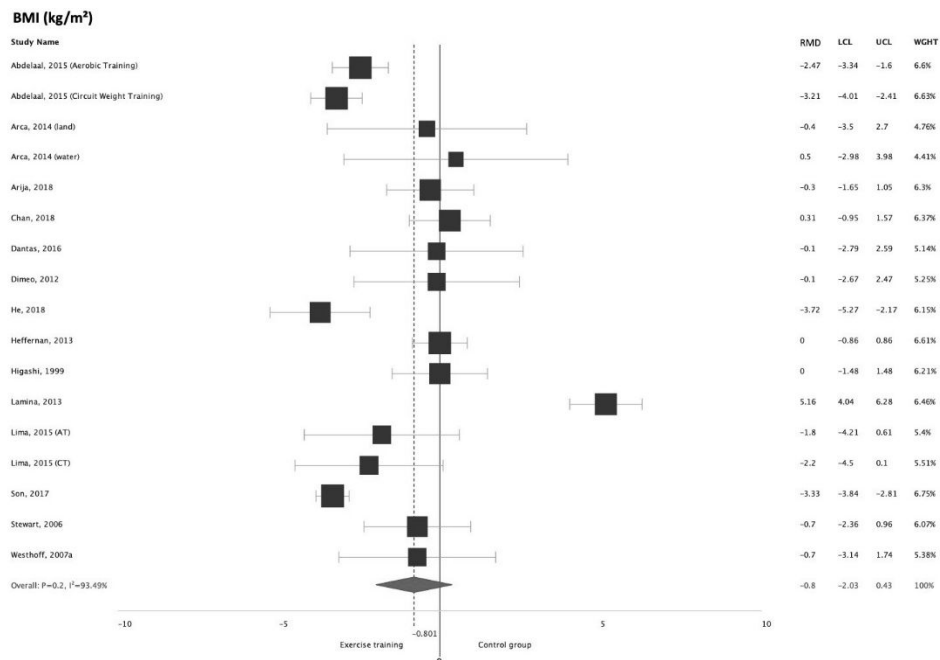


Figure S3. Forest plot of exercise training effects on Body mass index. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

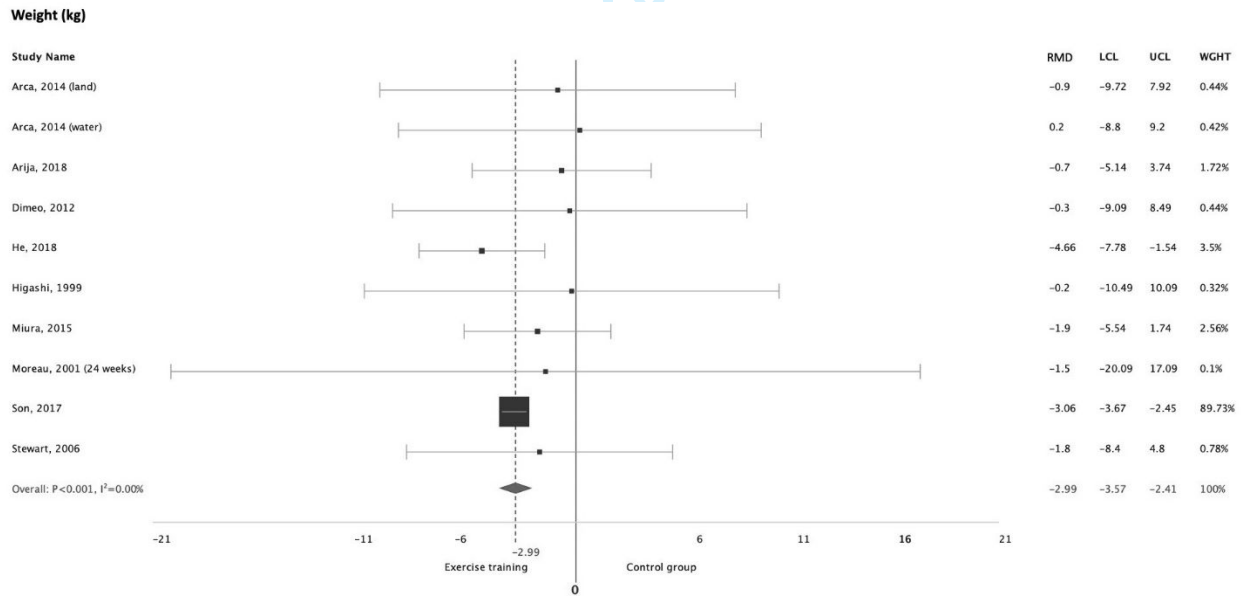


Figure S4. Forest plot of exercise training effects on Weight. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

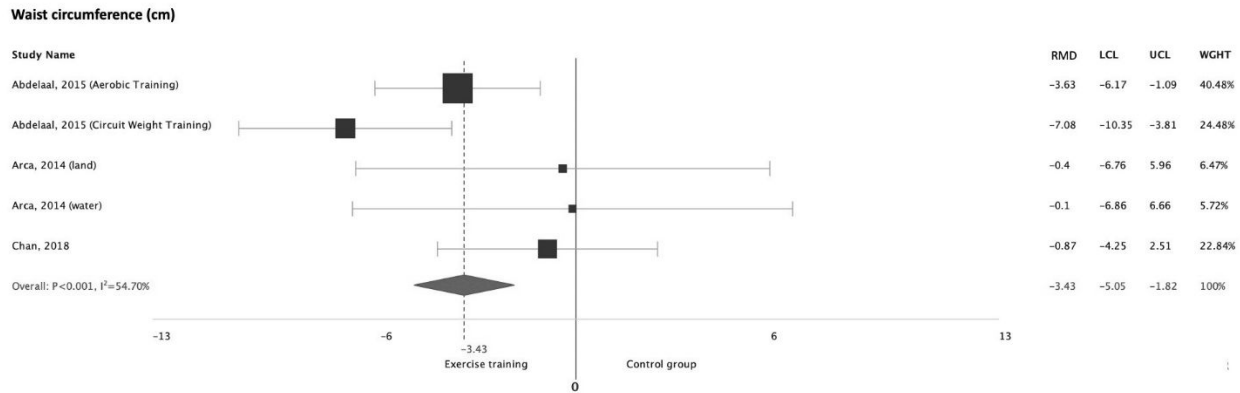


Figure S5. Forest plot of exercise training effects on Waist circumference. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

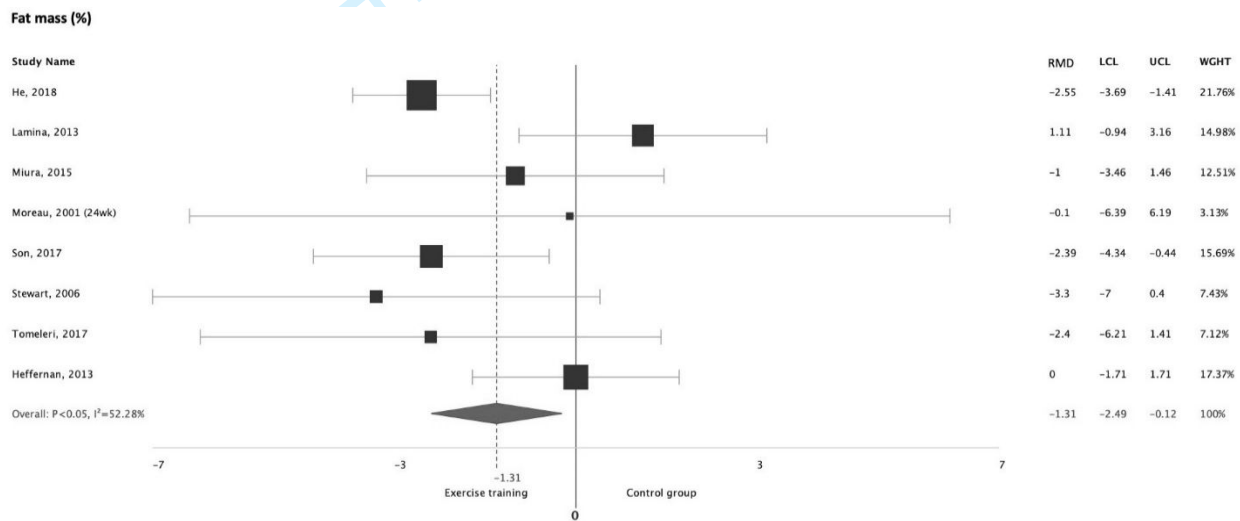


Figure S6. Forest plot of exercise training effects on Fat mass. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

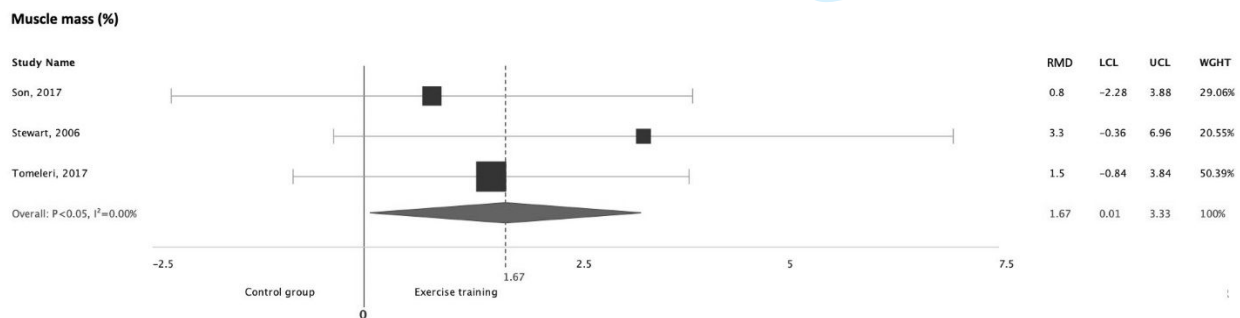


Figure S7. Forest plot of exercise training effects on Muscle mass. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

Glucose (mg/dl)

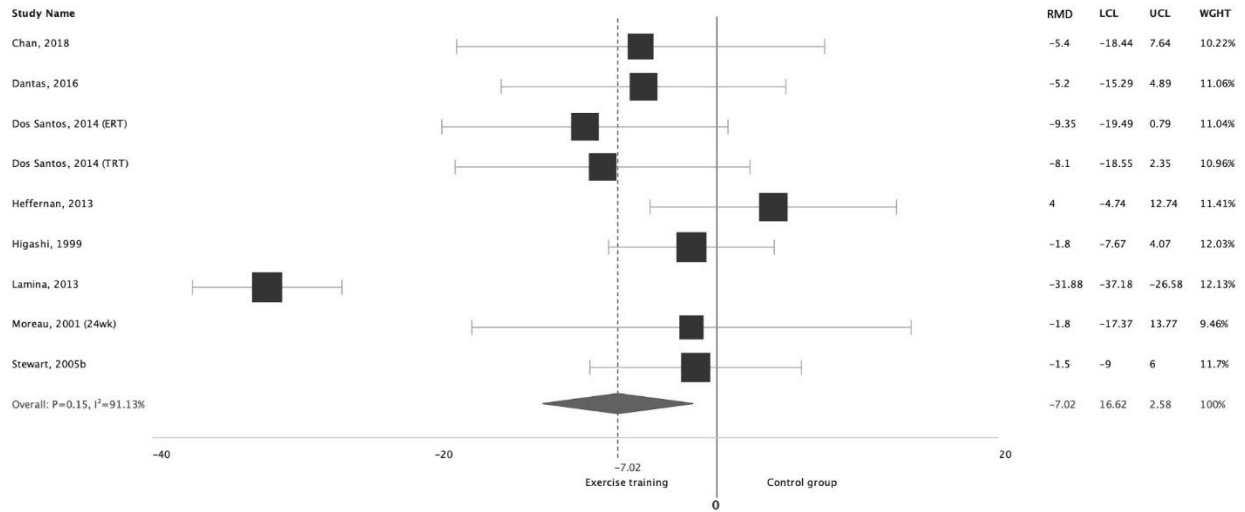


Figure S8. Forest plot of exercise training effects on Glucose. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

Triglycerides (mg/dl)

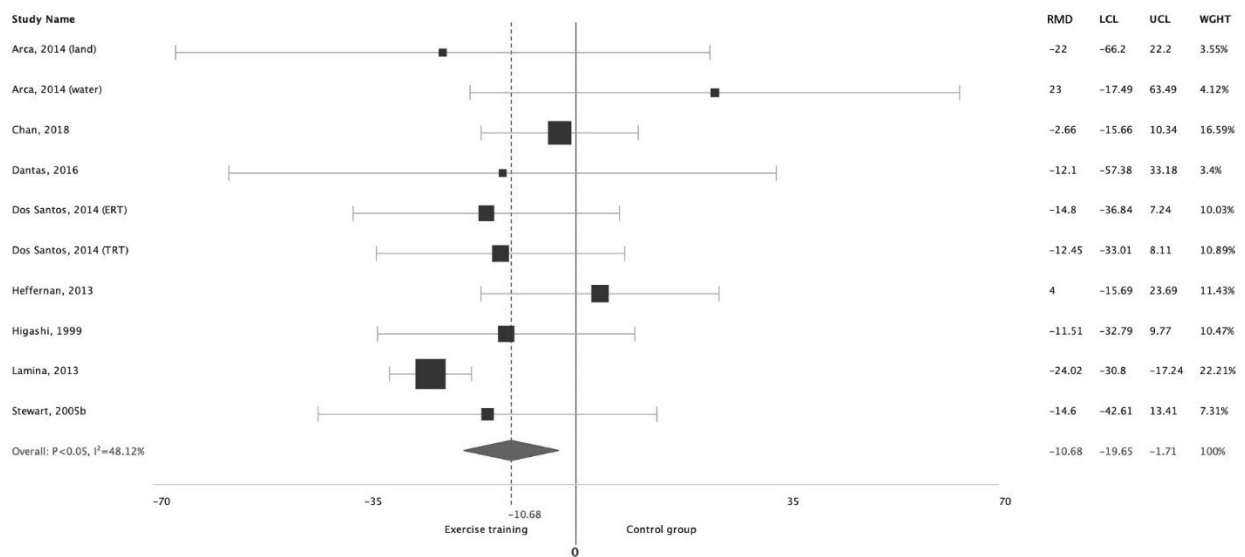


Figure S9. Forest plot of exercise training effects on Triglycerides. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

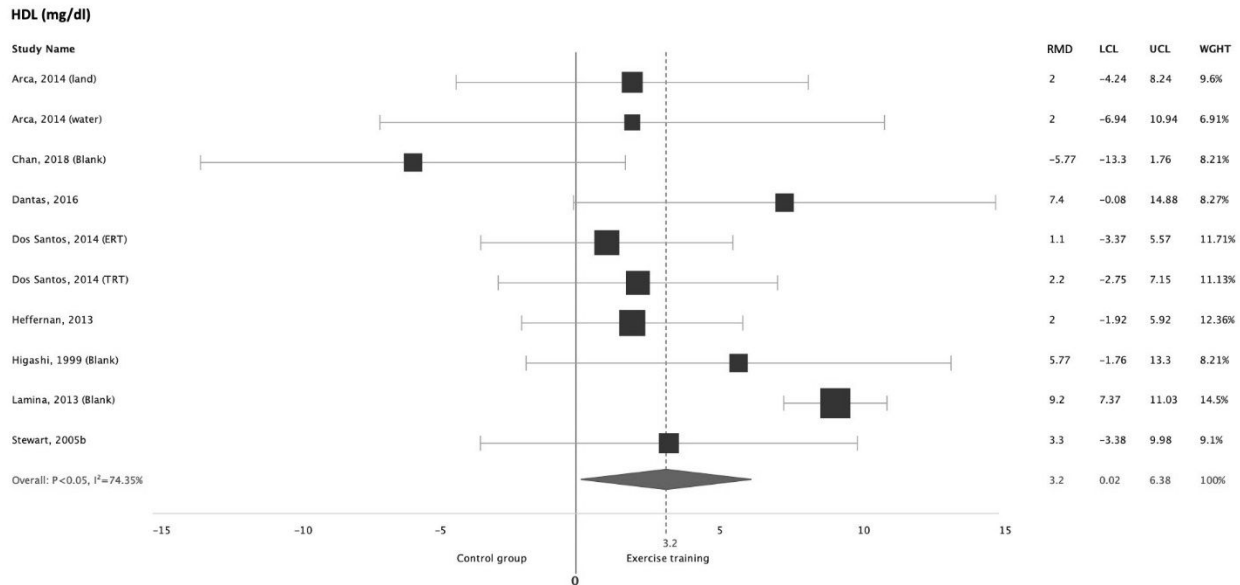


Figure S10. Forest plot of exercise training effects on HDL. HDL: High density lipoprotein; RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

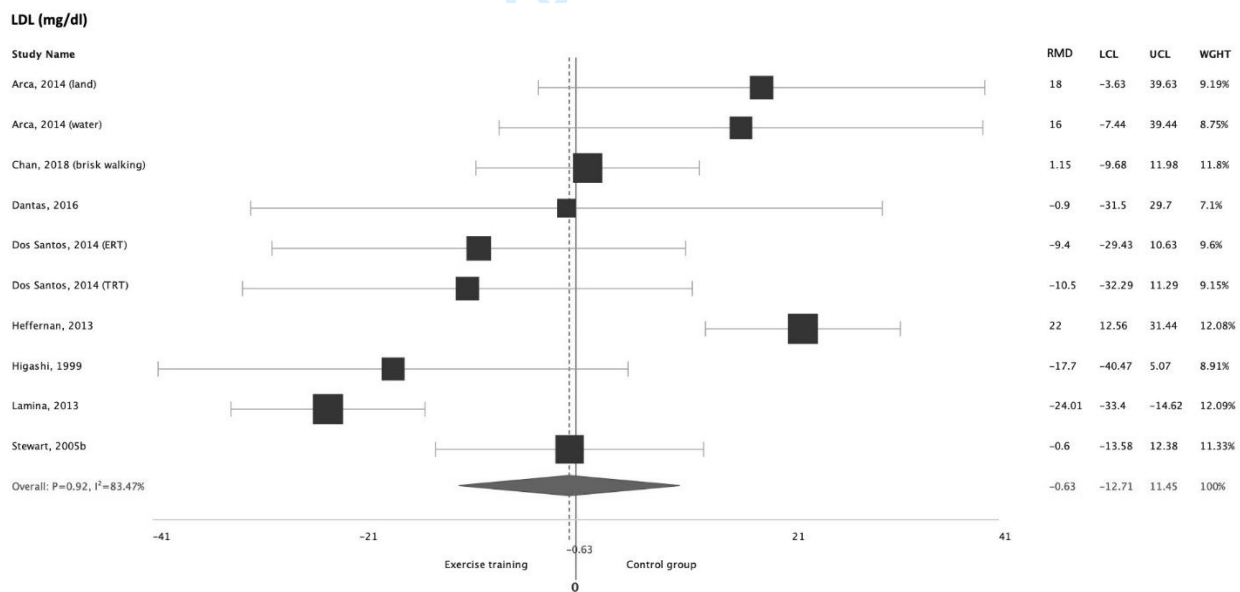


Figure S11. Forest plot of exercise training effects on LDL. LDL: Low density lipoprotein; RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

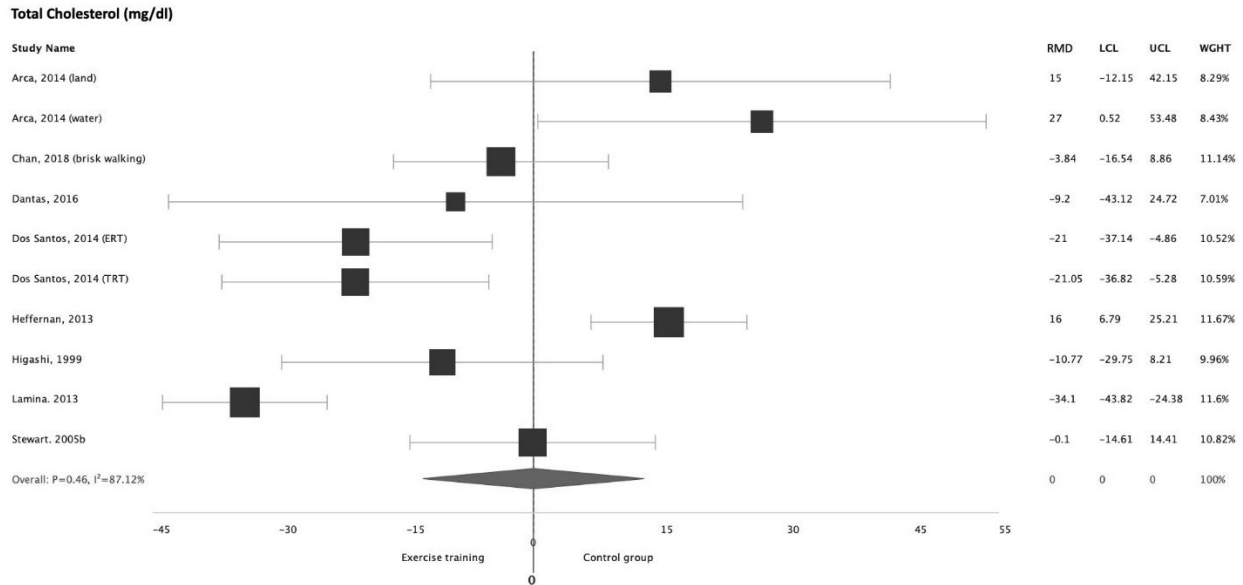


Figure S12. Forest plot of exercise training effects on Total cholesterol. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

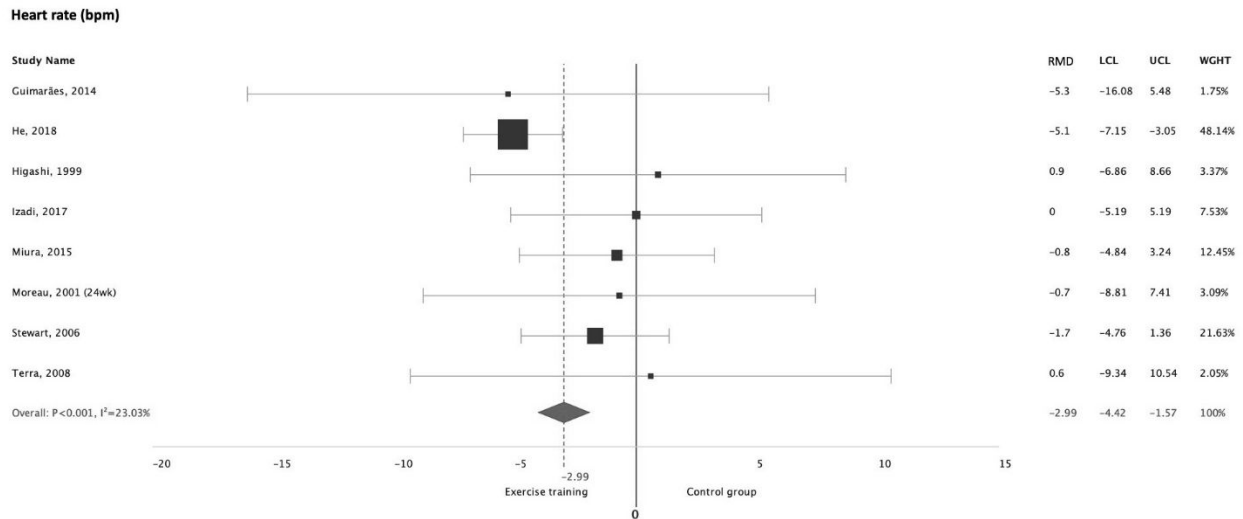


Figure S13. Forest plot of exercise training effects on heart rate. RMD: Raw mean difference; LCL: lower confidence limit; UCL: Upper confidence limit; WGHT: Weight.

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 ₂ max; 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%. 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.
Dantas, 2016 (24)	Brazil	64.7 (4.7); 13W; 28.6 (3.2); TBP.	AT. Treadmill walking; Lactate concentration 2.0 (0.5) mmol/L; 3/w; 8-12w; NR.
Dimeo, 2012 (25)	Germany	62.8 (8.1); 11M and 13W; 28.9 (4.4); 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) (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; 100-120 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, AT: Walking inside the pool; 180 min/w; 11-13 Borg Scale; 3/w; 12/w; 100%.
Guimarães, 2014 (27) (HEX)	Brazil	55 (5.9); 8M and 8W; 29.2 (4.9); TBP.	AT. Walking; 180 min; 45% to 50% of VO ₂ max; 3/w; 12w; 91%.
He, 2018 (28)	China	58.0 (2.); 23W; 24.15 (3.03); TBP and non-TBP.	RT. Exercises for upper/lower limbs and trunk; 2x12-15; 40-60%1RM; 3/w; 12w; NR.
Heffernan, 2013 (29)	USA	60 (2); 6M and 15W; 24 (1); non-TBP.	AT. Walking; 150-210min; 52 (6) % VO ₂ max; 5-7/w; 12w; NR.
Higashi, 1999 (30)	Japan	62.7 (11.8); 14M and 6W; 24.1 (1.8); NR.	AT. Cycle ergometer; 85-90% HRR; 3/w; 6w; 68%.
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.	

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; VO₂Max: 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.