Comparative effectiveness of different types of exercise reducing arterial stiffness in children and adolescents

Supplementary material

Table S1. Characteristics of the included studies

			Sample			Intervention			Outcome	
Reference	Country	Study design	Sample size (%women)	Age (years)	Type of population	Type of exercise	Intervention characteristics	Type of PWV	Measuring device	Basal values (m/s)
Bharath et al. 2018	United States	RCT	IG = 20 (100%) CG = 20 (100%)	IG: 14.8±1 CG: 14.6±1	Obese adolescents	Combined exercise	IG: Resistance training + 30' treadmill walking • 60 min • 5 times/wk • 12 weeks	baPWV	Tonometry SphygmoCor	IG: 8.5±1.2 CG: 8.3±1
Bruyndonckx et al. 2015	Belgium	Quasi experimental study	IG = 33 (72.7%) CG = 28 (78.5%)	IG: 15.4±1.5 CG: 15.1±1.2	Obese adolescents	Combined exercise	IG: Resistance training + aerobic exercise (running, cycling or swimming) • 40 min • 3 times/wk • 40 weeks	aPWV	Oscillometric Arteriograph	IG: 5.9±0.4 CG: 6.1±0.5
Chuensiri et al. 2017	Thailand	RCT	IG = 16 (0%) CG = 16 (0%)	IG: 11.0±0.3 CG: 10.6±0.3	Obese children	HIIT	IG: Cycling at 90% of peak power output • 8 sets of 2' – 1' rest • 3 times/wk • 12 weeks	baPWV	Oscillometric VP-1000plus	IG: 10.0±0.3 CG: 10.0±0.4
Davis et al. 2019	United States	RCT	IG = 90 (67%) CG = 85 (55%)	IG: 9.6±0.2 CG: 9.7±0.2	Overweight children	Aerobic exercise	IG: Instructor-led aerobic exercise • 40 min • 5 times/wk • 32 weeks	cfPWV	Tonometry SphygmoCor	IG: 5.1±0.2 CG: 5.1±0.1
Hacke et al. 2017	Germany	RCT	IG = 92 (54.3%) CG = 43 (49.8%)	IG: 4.7±0.2 CG: 5.1±0.3	Healthy preschoolers	Sensorymotor training	IG: Psychomotor play and functional gymnastics • 60 min • 2 times/wk • 24 weeks	aPWV	Oscillometric Mobil-O-Graph	IG: 4.3±0.3 CG: 4.3±0.2

Horner et al. 2015	United States	RCT	IG1 = 30 (50) IG2 = 27 (51.8) CG = 24 (50)	IG1: 14.7±1.8 IG2: 14.6±1.9 CG: 14.9±1.8	Obese adolescents	IG1: Aerobic exercise IG2: Resistance training	IG1: Moderate intensity exercise on a treadmill, elliptical or stationary bike • 60 min • 3 times/wk • 24 weeks IG2: Series of 10 whole body exercises (2 sets of 8–12 repetitions) • 60 min • 2 times/wk • 24 weeks	aPWV	Piezoelectric Complior system	IG1: 6.5±1.4 IG2: 6.6±1.7 CG: 6.4±1.6
Ketelhut et al. 2020	Germany	RCT	IG = 22 (50%) CG = 24 (41.6%)	IG: 10.8±0.6 CG: 10.7±0.7	Healthy children	HIIT	IG: Instructor-led HIIT • 20 min • 3 times/wk • 12 weeks	aPWV	Oscillometric Mobil-O-Graph	IG: 4.8±0.3 CG: 4.4±0.3
Ketelhut et al. 2021	Germany	RCT	IG = 51 (64.7%) CG = 54 (46.3%)	IG: 8.1±0.6 CG: 8.3±0.6	Healthy children	HIIT	IG: Instructor-led HIIT • 45 min • 2 times/wk • 36 weeks	aPWV	Oscillometric Mobil-O-Graph	IG: 4.8±0.3 CG: 4.6±0.3
Lee et al. 2020	United States	RCT	IG1 = 38 (66.8) IG2 = 40 (62.5) IG3 = 40 (65)	IG1: 14.4±1.6 IG2: 14.4±1.6 IG3: 14.5±1.7	Obese adolescents	IG1: Aerobic exercise IG2: Resistance training IG3: Combined exercise	IG1: Progressive aerobic exercise (treadmills and/or ellipticals) IG2: whole-body resistance exercises IG3: 30’ aerobic exercise+ 30’whole-body resistance exercises • 60 min • 3 times/wk	cfPWV	Piezoelectric Complior system	IG1: 5.96±0.7 IG2: 5.84±0.9 IG3: 5.99±0.9

							• 24 weeks			
McNarry et al. 2020	United Kingdom	RCT	IG = 16 (40.7%) CG = 16 (39.4%)	13.6±0.9	Healthy adolescents	HIIT	IG: Instructor-led HIIT • 20 min • 3 times/wk • 12 weeks	cfPWV	Oscillometric Vicorder	IG: 5.7±0.7 CG: 5.4±0.5
Minghetti et al. 2022	Switzerland	RCT	IG = 46 (50%) CG = 22 (54.5%)	IG: 5.2±0.6 CG: 5.4±0.5	Healthy preschoolers	Sensorymotor training	IG: Gross motor skills and locomotor exercises • 45 min • 1 times/wk • 25 weeks	aPWV	Oscillometric Mobil-O-Graph	IG: 4.2±0.4 CG: 4.3±0.4
Son et al. 2017	South Korea	RCT	IG = 20 (100%) CG = 20 (100%)	IG: 15.0±1.0 CG: 15.0±1.0	Obese prehypertensive adolescents	Combined exercise	IG: Resistance exercise + badminton training • 60 min • 3 times/wk • 12 weeks	baPWV	Tonometry SphygmoCor	IG: 8.2±0.8 CG: 7.9±0.3
Sung et al. 2019	South Korea	RCT	IG = 20 (100%) CG = 20 (100%)	IG: 15.0±1.0 CG: 15.0±1.0	Prehypertensive adolescents	Aerobic exercise	IG: Aerobic exercise (jumping rope) • 50 min • 5 times/w • 12 weeks	baPWV	Tonometry SphygmoCor	IG: 8.2±1.0 CG: 8.2±0.5
Wong et al. 2018	United States	RCT	IG = 15 (100%) CG = 15 (100%)	IG: 15.2±1.2 CG: 15.3±1.1	Obese adolescents	Combined exercise	IG: 20’ resistance training + 30’ treadmill walking • 60 min • 3 times/w • 12 weeks	baPWV	Tonometry SphygmoCor	IG: 8.4±0.8 CG: 8.5±0.7

Table S2. Search strategy for MEDLINE

MEDLINE (via Pubmed)
((“cardiovascular disease” OR “cardiovascular risk” OR “arterial stiffness” OR “pulse wave velocity” OR “PWV”) AND (“physical activity” OR “physical exercise” OR “exercise” OR “training” OR “HIIT” OR “interval training” OR “intermittent exercise” OR “continuous exercise” OR “aerobic exercise” OR “endurance training” OR “resistance exercise” OR “strength” OR “stretching” OR “mind–body exercises” OR “Pilates” OR “yoga” OR “Tai Chi” OR sport) AND (child* OR pediatric OR infan* OR kids OR young OR adolescents OR teen*) AND (effectiveness OR “clinical trial” OR trials OR “controlled trial” OR random* OR “clinical trials”))
Results: 614

Table S3. CINeMA confidence rating

Comparison	Number of studies	Within-study bias	Reporting bias	Indirectness	Imprecision	Heterogeneity	Incoherence	Confidence rating
aer:comb	1	No concerns	Some concerns	Some concerns	No concerns	Some concerns	No concerns	**High**
aer:con	3	Some concerns	Some concerns	Some concerns	No concerns	Some concerns	No concerns	**High**
aer:res	2	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**Moderate**
comb:con	4	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**Moderate**
comb:res	1	No concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**High**
con:hit	4	Some concerns	Some concerns	No concerns	No concerns	Major concerns	No concerns	**Low**
con:res	1	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**Moderate**
con:sen	2	Some concerns	Some concerns	No concerns	Major concerns	No concerns	No concerns	**Low**
aer:hit	0	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**Moderate**
aer:sen	0	Some concerns	Some concerns	No concerns	No concerns	Some concerns	No concerns	**High**
comb:hit	0	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**Moderate**
comb:sen	0	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**Moderate**
hit:res	0	Some concerns	Some concerns	Some concerns	Major concerns	No concerns	No concerns	**Low**
hit:sen	0	Some concerns	Some concerns	No concerns	Some concerns	Some concerns	No concerns	**High**
res:sen	0	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	No concerns	**Moderate**

Table S4. Pooled SMD on types of PE. Upper right triangle gives the pooled mean differences from pairwise comparisons, lower left triangle pooled mean differences from the network meta-analysis (row intervention relative to column).

Aerobic exercise	-1.36 (-3.08; 0.36)	NA	-0.94 (-2.16; 0.29)	NA	-1.92 (-2.95; -0.89)
-1.34 (-2.41; -0.28)	Combined	NA	1.00 (-0.71; 2.71)	NA	-0.68 (-1.58; 0.21)
-0.82 (-2.10; 0.46)	0.52 (-0.69; 1.73)	HIIT	NA	NA	-1.11 (-2.01; -0.21)
-0.85 (-2.00; 0.30)	0.49 (-0.76; 1.74)	-0.03 (-1.53; 1.46)	Resistance training	NA	-0.73 (-2.50; 1.04)
-2.04 (-3.55; -0.53)	-0.70 (-2.15; 0.75)	-1.22 (-2.73; 0.29)	-1.19 (-2.88; 0.51)	Sensorymotor training	0.11 (-1.10; 1.32)
-1.93 (-2.84; -1.02)	-0.59 (-1.39; 0.22)	-1.11 (-2.01; -0.21)	-1.08 (-2.27; 0.11)	0.11 (-1.10; 1.32)	Control

Table S5. Analysis of the distribution of outcomes according to mean, standard deviation (SD) and Mean/SD ratio

Reference	Type of exercise (a)	Type of exercise (b)	Sample size (n)	Mean (a)	SD (a)	Mean/SD ratio (a)	Mean (b)	SD (b)	Mean/SD ratio (b)
Bharath et al. 2018	Combined	Control	20	8.5	1.2	7.1	8.3	1.0	8.3
Bruyndonckx et al. 2015	Combined	Control	48	5.9	1.87	3.2	6.1	2.1	2.9
Chuensiri et al. 2017	HIIT	Control	22	997.9	28.16	35.4	1004.0	40.1	25.0
Davis et al. 2019	Aerobic	Control	175	5.1	1.0	5.3	5.1	0.7	7.2
Hacke et al. 2017	Sensorymotor	Control	135	4.3	0.3	14.3	4.3	0.2	21.5
Horner et al. 2015	Aerobic	Control	43	646.8	138.1	4.7	644.4	154.8	4.2
Horner et al. 2015 (2)	Resistance	Control	39	659.8	170.8	3.9	644.4	154.8	4.2
Ketelhut et al. 2020	HIIT	Control	105	4.8	0.3	16.0	4.6	0.3	15.3
Ketelhut et al. 2021	HIIT	Control	46	4.8	0.3	16.0	4.4	0.3	14.7
Lee et al. 2020	Aerobic	Combined	74	596.8	75.3	7.9	599.3	94.1	6.4
Lee et al. 2020 (2)	Resistance	Combined	78	584.2	93	6.3	599.3	94.1	6.4
McNarry et al. 2020	HIIT	Control	32	5.6	0.6	9.3	5.5	0.5	11.0
Minghetti et al. 2022	Sensorymotor	Control	68	4.2	0.4	10.5	43	0.4	107.5
Son et al. 2017	Combined	Control	40	8.2	1.6	5.3	8.0	1.3	6.1
Sung et al. 2019	Aerobic	Control	40	8.2	1	8.2	8.2	0.5	16.4
Wong et al. 208	Combined	Control	30	8.4	3.1	2.7	8.5	2.7	3.1

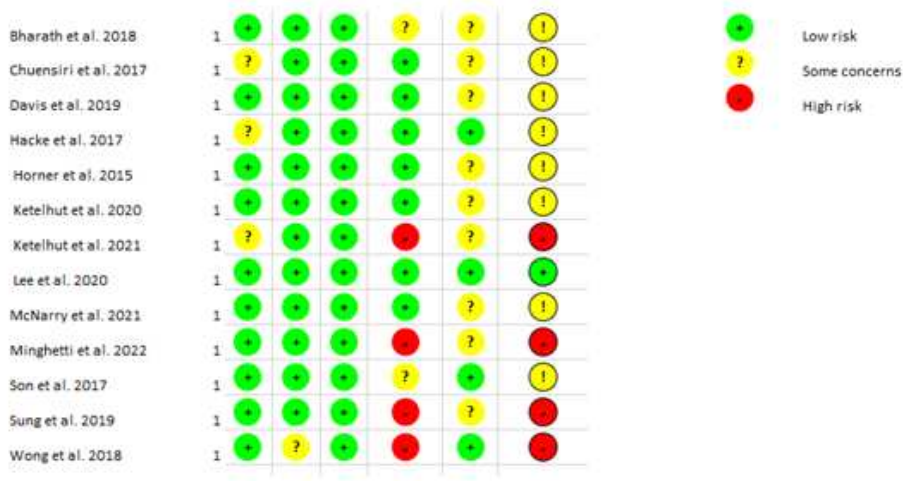


Figure S1. Quality assessment

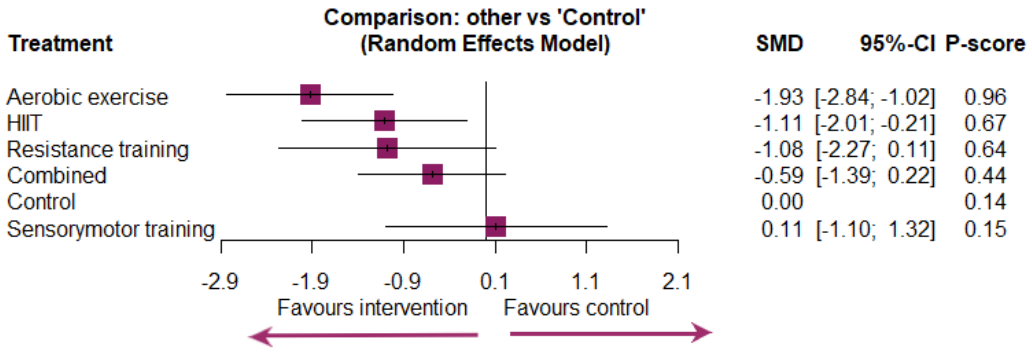


Figure S2. Forest plot of the pooled effect of each modality of exercise compared to the control group

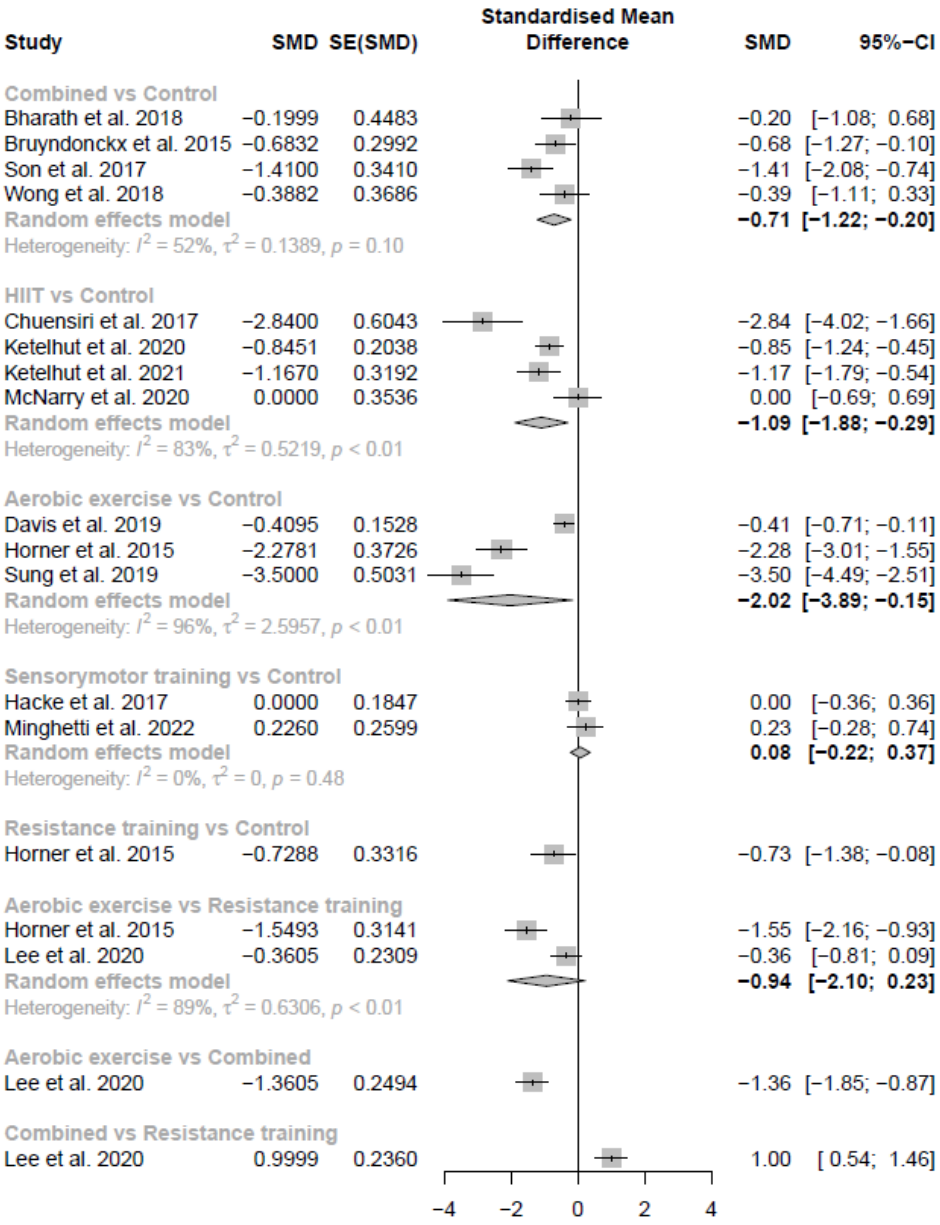


Figure S3. Pairwise comparations (only comparisons with direct evidence are shown).

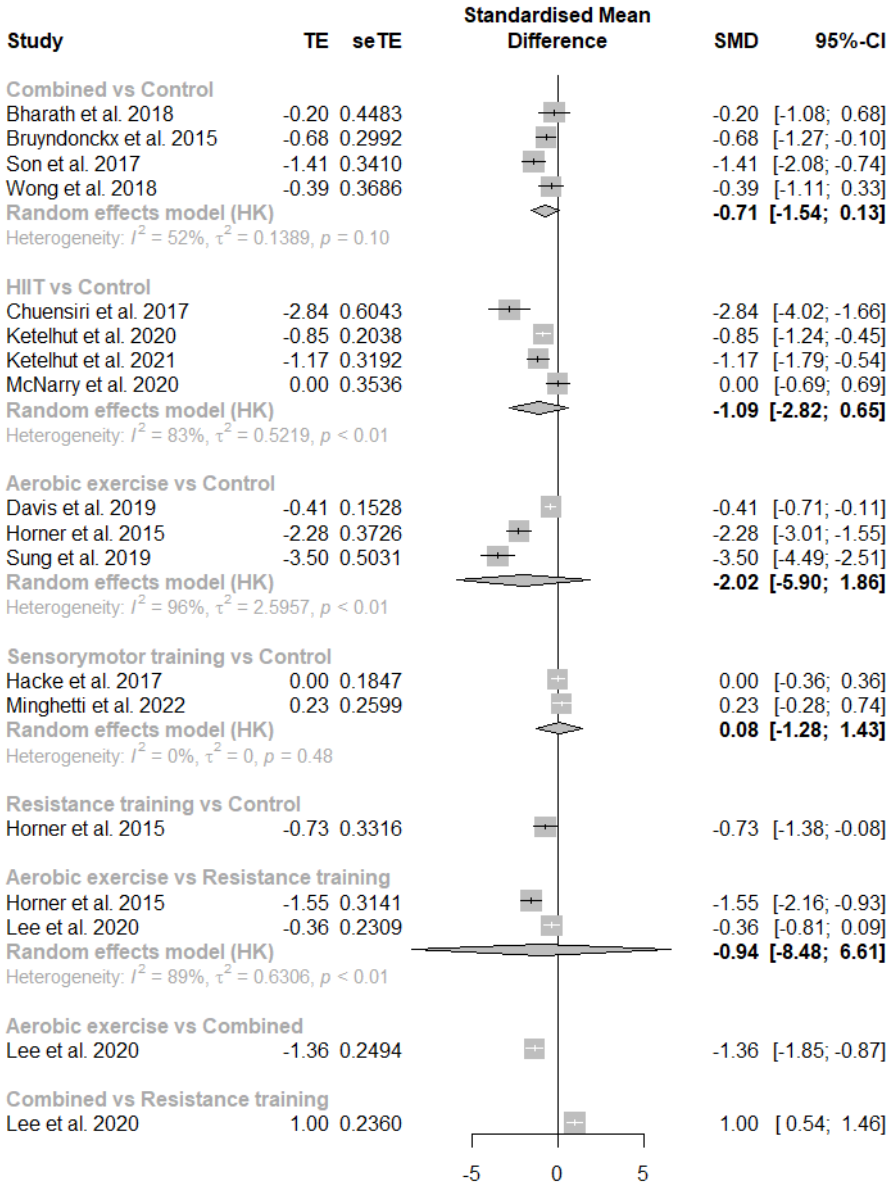


Figure S4. Pairwise comparations using Hartung-Knapp-Sidik-Jonkman random effects method (only comparisons with direct evidence are shown).

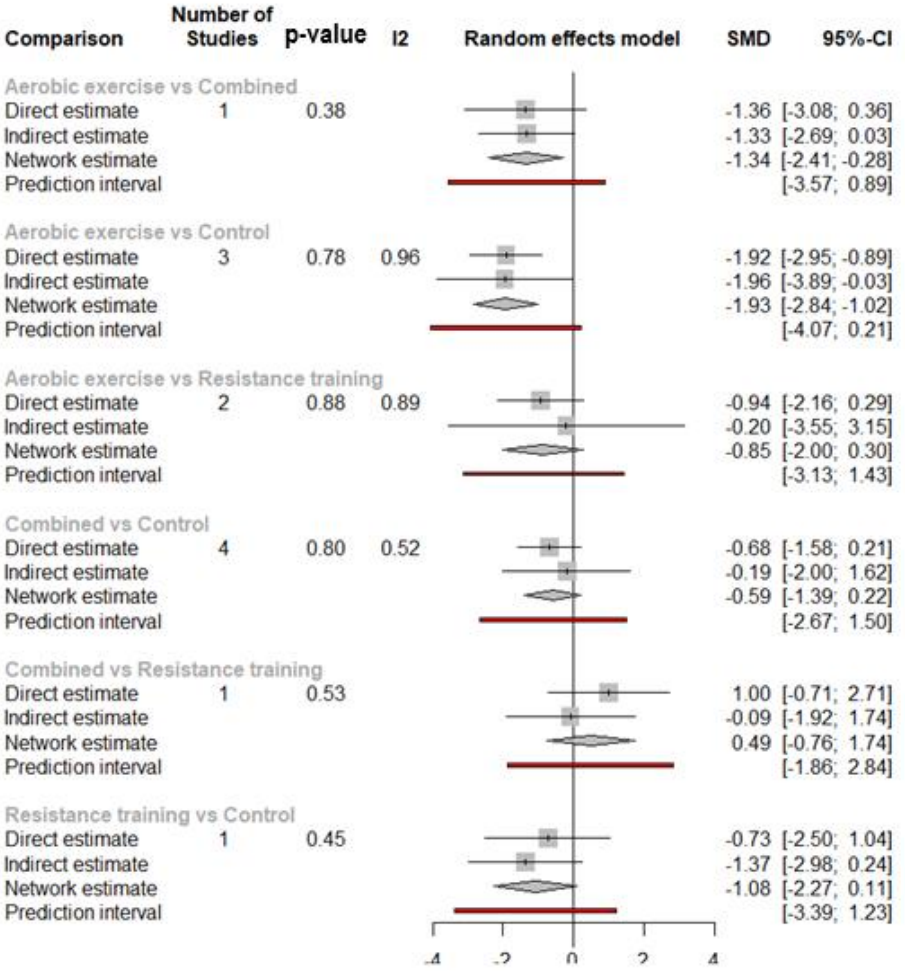


Figure S5. Node-splitting

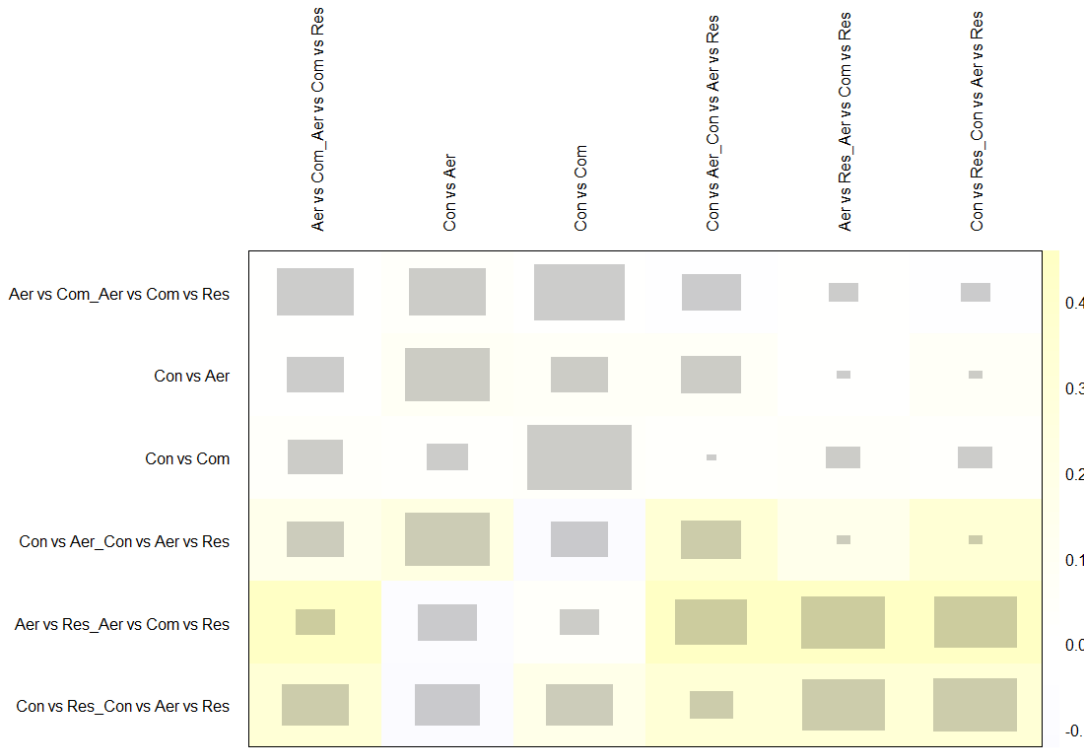
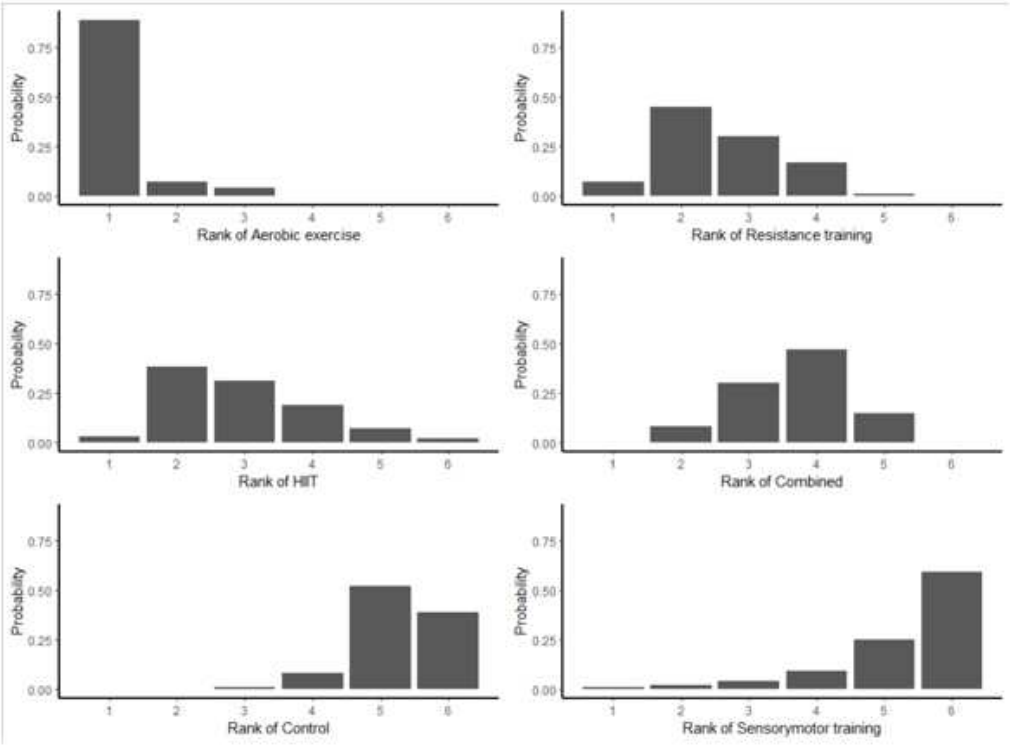


Figure S6. Heatplot.



Cumulative ranking probabilities

	1	*2*	*3*	*4*	*5*	*6*
Aerobic exercise	0.9	1.0	1.0	1.0	1.0	1.0
Combined	0.0	0.1	0.4	0.9	1.0	1.0
HIIT	0.0	0.4	0.7	0.9	0.1	1.0
Resistance training	0.1	0.5	0.8	0.1	1.0	1.0
Sensory motor training	0.0	0.0	0.1	0.2	0.4	1.0
Control	0.0	0.0	0.0	0.1	0.6	1.0

Figure S7. Rankogram for each intervention of physical exercise.

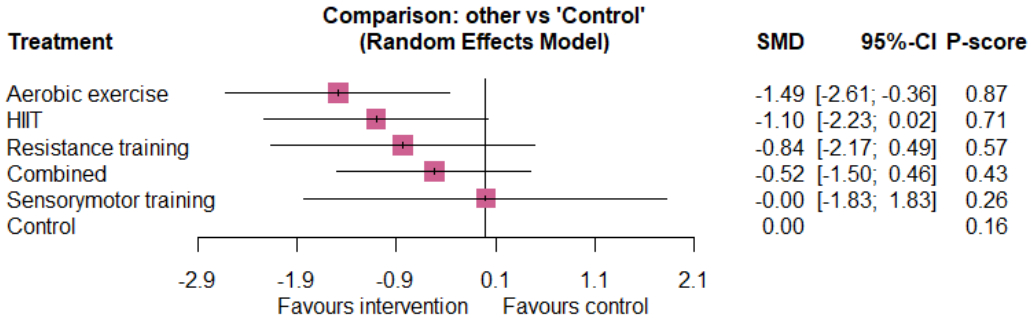


Figure S8. Forest plot of the pooled effect of each modality of exercise compared to the control group without high risk of bias studies

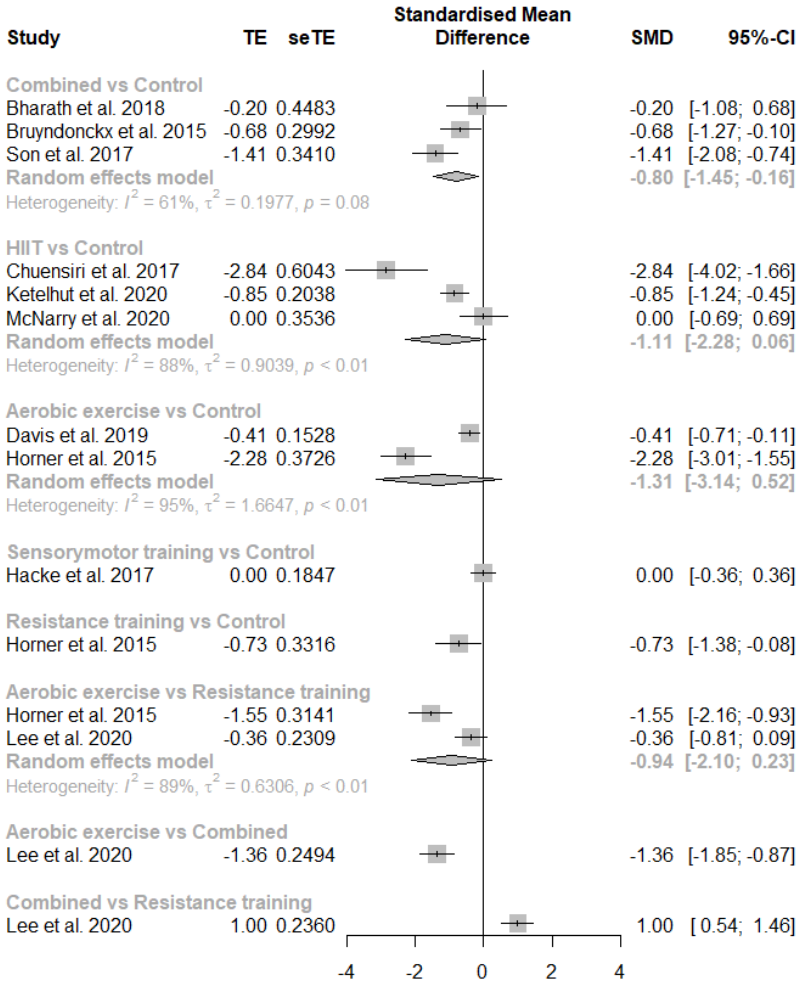


Figure S9. Pairwise comparisons without high risk of bias studies

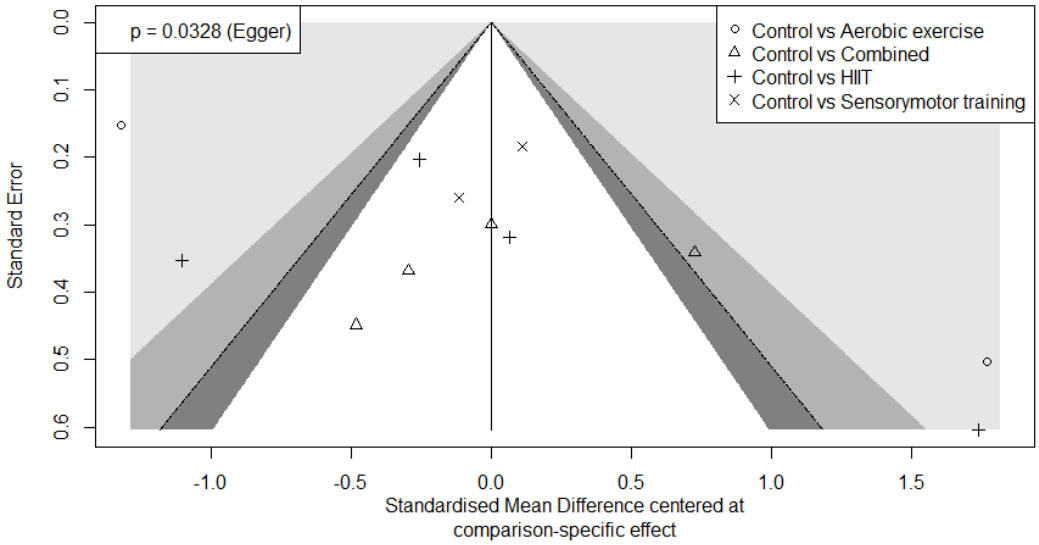


Figure S10. Contour-enhanced funnel plot for pooled mean differences.

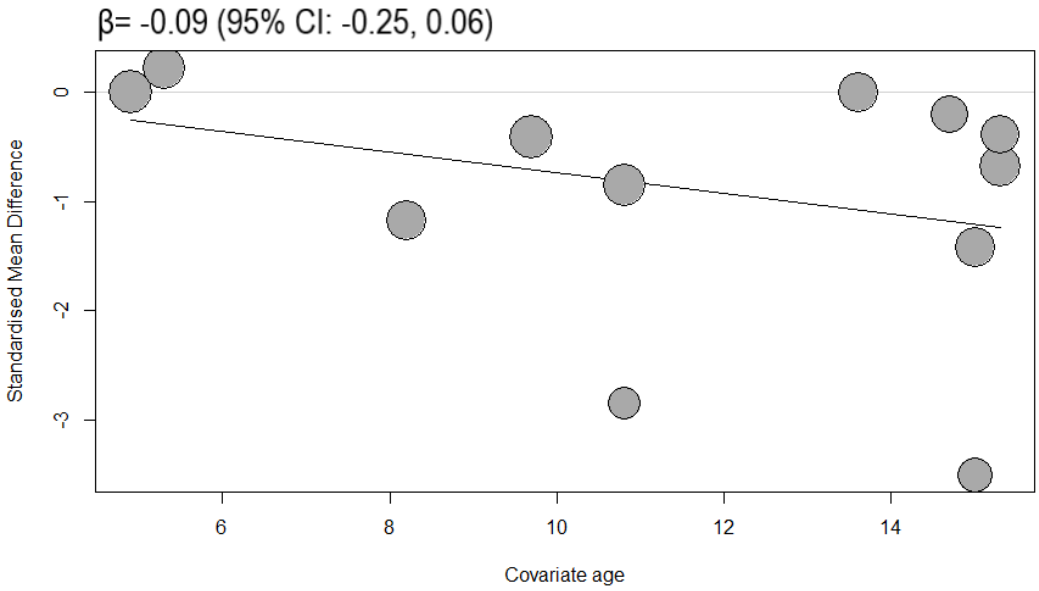


Figure S11. Meta-regression by mean age of participants

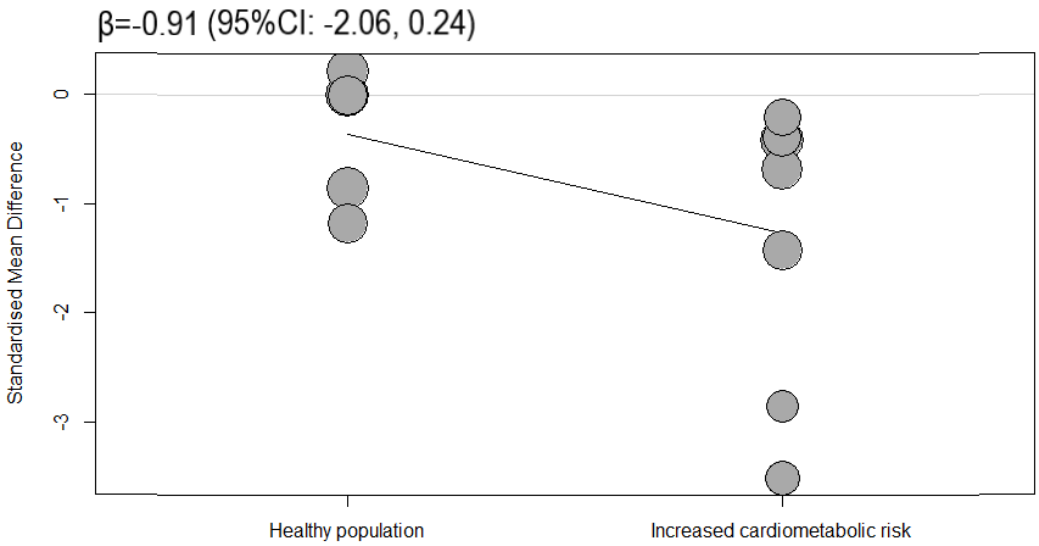


Figure S12. Meta-regression by type of population.

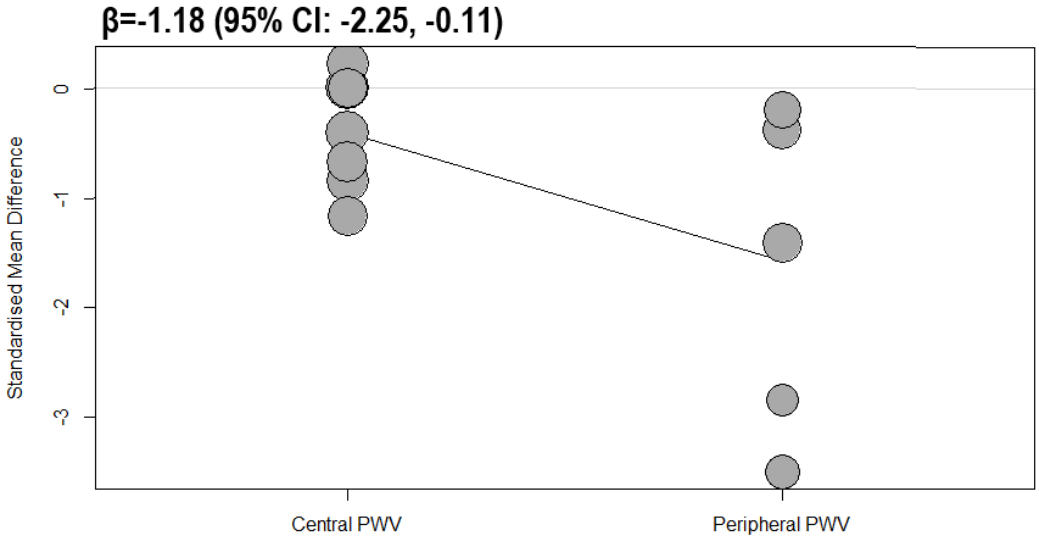


Figure S13. Meta-regression by type of PWV measurement

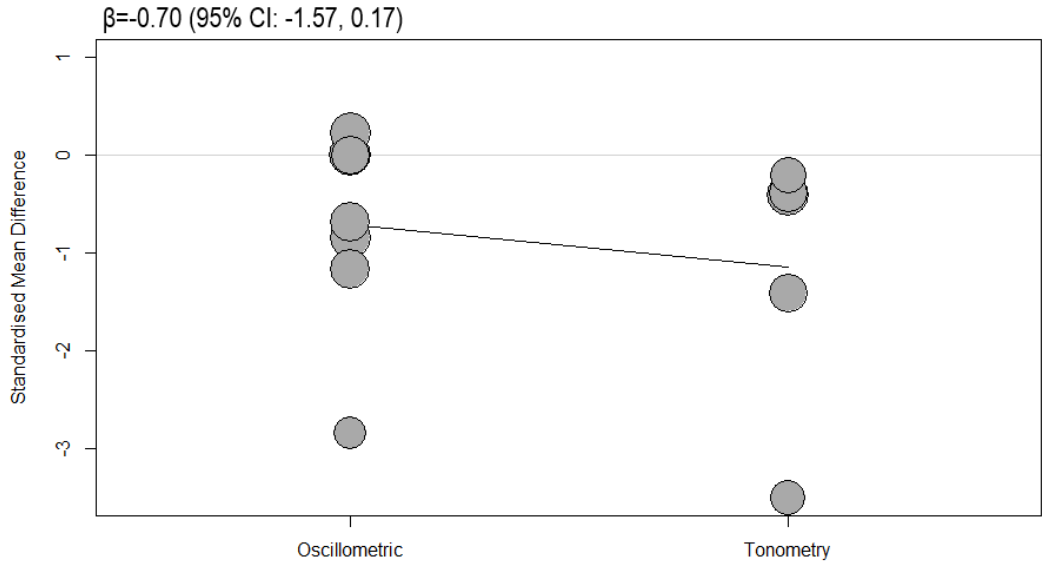


Figure S14. Meta-regression by type of PWV measurement method