

Supplemental Materials

Supplemental Material 1. Search Strategy

Database	Results	Search Strategy
PubMed	4824	(("Child, Preschool"[MeSH Terms] OR "Child"[MeSH Terms] OR "Adolescent"[MeSH Terms] OR child*[Title/Abstract] OR adolescen*[Title/Abstract] OR teen*[Title/Abstract] OR youth*[Title/Abstract] OR pediatric*[Title/Abstract] OR paediatric*[Title/Abstract] OR schoolchild*[Title/Abstract] OR "school age"[Title/Abstract] OR "school aged"[Title/Abstract] OR "school-age"[Title/Abstract] OR "school-aged"[Title/Abstract] OR boy*[Title/Abstract] OR girl*[Title/Abstract]) AND ("Exercise"[MeSH Terms] OR "Exercise Therapy"[MeSH Terms] OR "Physical Education and Training"[MeSH Terms] OR "Sports"[MeSH Terms] OR "Resistance Training"[MeSH Terms] OR "High-Intensity Interval Training"[MeSH Terms] OR "Endurance Training"[MeSH Terms] OR "Plyometric Exercise"[MeSH Terms] OR "Exergaming"[MeSH Terms] OR exercis*[Title/Abstract] OR "physical activity"[Title/Abstract] OR "physical activities"[Title/Abstract] OR "physical education"[Title/Abstract] OR "exercise training"[Title/Abstract] OR "aerobic exercise"[Title/Abstract] OR "aerobic training"[Title/Abstract] OR "endurance exercise"[Title/Abstract] OR "endurance training"[Title/Abstract] OR "continuous exercise"[Title/Abstract] OR "continuous training"[Title/Abstract] OR "high-intensity interval training"[Title/Abstract] OR "high intensity interval training"[Title/Abstract] OR HIIT[Title/Abstract] OR "sprint interval training"[Title/Abstract] OR "sprint interval exercise"[Title/Abstract] OR "interval training"[Title/Abstract] OR "interval exercise"[Title/Abstract] OR "resistance exercise"[Title/Abstract] OR "resistance training"[Title/Abstract] OR "strength exercise"[Title/Abstract] OR "strength training"[Title/Abstract] OR "weight training"[Title/Abstract] OR "weight-bearing exercise"[Title/Abstract] OR "muscle strengthening"[Title/Abstract] OR "combined exercise"[Title/Abstract] OR "combined training"[Title/Abstract] OR "concurrent exercise"[Title/Abstract] OR "concurrent training"[Title/Abstract] OR "circuit exercise"[Title/Abstract] OR "circuit training"[Title/Abstract] OR plyometric*[Title/Abstract] OR calisthenic*[Title/Abstract] OR running[Title/Abstract] OR jogging[Title/Abstract] OR walking[Title/Abstract] OR cycling[Title/Abstract] OR bicycling[Title/Abstract] OR swimming[Title/Abstract] OR rowing[Title/Abstract] OR football[Title/Abstract] OR soccer[Title/Abstract] OR basketball[Title/Abstract] OR handball[Title/Abstract] OR volleyball[Title/Abstract] OR dance[Title/Abstract] OR dancing[Title/Abstract] OR "sport-based exercise"[Title/Abstract] OR "sports-based exercise"[Title/Abstract] OR "small-sided game"[Title/Abstract] OR "small-sided games"[Title/Abstract] OR "active game"[Title/Abstract] OR "active games"[Title/Abstract] OR exergam*[Title/Abstract] OR "active video game"[Title/Abstract] OR "active video games"[Title/Abstract] OR yoga[Title/Abstract] OR "tai chi"[Title/Abstract] OR taiji[Title/Abstract] OR qigong[Title/Abstract] OR baduanjin[Title/Abstract]) AND ("Cardiorespiratory Fitness"[MeSH Terms] OR "Physical Fitness"[MeSH Terms] OR "Exercise Tolerance"[MeSH Terms] OR "Oxygen Consumption"[MeSH Terms] OR "Cardiopulmonary Exercise Testing"[MeSH Terms] OR "cardiorespiratory fitness"[Title/Abstract] OR "cardio-respiratory fitness"[Title/Abstract] OR "cardiopulmonary fitness"[Title/Abstract] OR "aerobic fitness"[Title/Abstract] OR "aerobic capacity"[Title/Abstract] OR "aerobic endurance"[Title/Abstract] OR "aerobic power"[Title/Abstract] OR "cardiorespiratory capacity"[Title/Abstract] OR "cardiopulmonary capacity"[Title/Abstract] OR VO2max[Title/Abstract] OR "VO2 max"[Title/Abstract] OR VO2peak[Title/Abstract] OR "VO2 peak"[Title/Abstract] OR "maximal oxygen uptake"[Title/Abstract] OR "maximum oxygen uptake"[Title/Abstract] OR "peak oxygen uptake"[Title/Abstract] OR "maximal oxygen consumption"[Title/Abstract] OR "maximum oxygen consumption"[Title/Abstract] OR "peak oxygen consumption"[Title/Abstract] OR "cardiopulmonary exercise test"[Title/Abstract] OR "cardiopulmonary

		exercise testing"[Title/Abstract] OR CPET[Title/Abstract] OR "graded exercise test"[Title/Abstract] OR GXT[Title/Abstract] OR "incremental exercise test"[Title/Abstract] OR "maximal exercise test"[Title/Abstract] OR "treadmill test"[Title/Abstract] OR "cycle ergometer test"[Title/Abstract] OR ergometr*[Title/Abstract] OR "20 m shuttle run"[Title/Abstract] OR "20-m shuttle run"[Title/Abstract] OR "20 meter shuttle run"[Title/Abstract] OR "20-meter shuttle run"[Title/Abstract] OR "multistage fitness test"[Title/Abstract] OR "multi-stage fitness test"[Title/Abstract] OR "beep test"[Title/Abstract] OR PACER[Title/Abstract] OR "progressive aerobic cardiovascular endurance run"[Title/Abstract] OR "Cooper test"[Title/Abstract] OR "12-minute run"[Title/Abstract] OR "12 minute run"[Title/Abstract] OR "physical work capacity"[Title/Abstract] OR PWC170[Title/Abstract]) AND ("Randomized Controlled Trial"[Publication Type] OR "Controlled Clinical Trial"[Publication Type] OR randomized[Title/Abstract] OR randomised[Title/Abstract] OR randomly[Title/Abstract] OR placebo[Title/Abstract] OR trial[Title/Abstract] OR groups[Title/Abstract] OR "cluster randomized"[Title/Abstract] OR "cluster randomised"[Title/Abstract])
Embase	2914	('child'/exp OR 'adolescent'/exp OR child*,ab,kw OR adolescen*,ab,kw OR teen*,ab,kw OR youth*,ab,kw OR pediatric*,ab,kw OR paediatric*,ab,kw OR schoolchild*,ab,kw OR 'school age',ab,kw OR 'school aged',ab,kw OR 'school-age',ab,kw OR 'school-aged',ab,kw OR boy*,ab,kw OR girl*,ab,kw) AND ('exercise'/exp OR 'exercise therapy'/exp OR 'physical activity'/exp OR 'physical education'/exp OR 'sport'/exp OR 'aerobic exercise'/exp OR 'resistance training'/exp OR 'high intensity interval training'/exp OR 'endurance training'/exp OR exercis*,ab,kw OR 'physical activity',ab,kw OR 'physical activities',ab,kw OR 'physical education',ab,kw OR 'exercise training',ab,kw OR 'aerobic exercise',ab,kw OR 'aerobic training',ab,kw OR 'endurance exercise',ab,kw OR 'endurance training',ab,kw OR 'continuous exercise',ab,kw OR 'continuous training',ab,kw OR 'high-intensity interval training',ab,kw OR 'high intensity interval training',ab,kw OR hiit,ab,kw OR 'sprint interval training',ab,kw OR 'sprint interval exercise',ab,kw OR 'interval training',ab,kw OR 'interval exercise',ab,kw OR 'resistance exercise',ab,kw OR 'resistance training',ab,kw OR 'strength exercise',ab,kw OR 'strength training',ab,kw OR 'weight training',ab,kw OR 'weight-bearing exercise',ab,kw OR 'muscle strengthening',ab,kw OR 'combined exercise',ab,kw OR 'combined training',ab,kw OR 'concurrent exercise',ab,kw OR 'concurrent training',ab,kw OR 'circuit exercise',ab,kw OR 'circuit training',ab,kw OR plyometric*,ab,kw OR calisthenic*,ab,kw OR running,ab,kw OR jogging,ab,kw OR walking,ab,kw OR cycling,ab,kw OR bicycling,ab,kw OR swimming,ab,kw OR rowing,ab,kw OR football,ab,kw OR soccer,ab,kw OR basketball,ab,kw OR handball,ab,kw OR volleyball,ab,kw OR dance,ab,kw OR dancing,ab,kw OR 'sport-based exercise',ab,kw OR 'sports-based exercise',ab,kw OR 'small-sided game',ab,kw OR 'small-sided games',ab,kw OR 'active game',ab,kw OR 'active games',ab,kw OR exergam*,ab,kw OR 'active video game',ab,kw OR 'active video games',ab,kw OR yoga,ab,kw OR 'tai chi',ab,kw OR taiji,ab,kw OR qigong,ab,kw OR baduanjin,ab,kw) AND ('cardiorespiratory fitness'/exp OR 'physical fitness'/exp OR 'exercise tolerance'/exp OR 'oxygen consumption'/exp OR 'exercise test'/exp OR 'cardiorespiratory fitness',ab,kw OR 'cardio-respiratory fitness',ab,kw OR 'cardiopulmonary fitness',ab,kw OR 'aerobic fitness',ab,kw OR 'aerobic capacity',ab,kw OR 'aerobic endurance',ab,kw OR 'aerobic power',ab,kw OR 'cardiorespiratory capacity',ab,kw OR 'cardiopulmonary capacity',ab,kw OR vo2max,ab,kw OR 'vo2 max',ab,kw OR vo2peak,ab,kw OR 'vo2 peak',ab,kw OR 'maximal oxygen uptake',ab,kw OR 'maximum oxygen uptake',ab,kw OR 'peak oxygen uptake',ab,kw OR 'maximal oxygen consumption',ab,kw OR 'maximum oxygen consumption',ab,kw OR 'peak oxygen consumption',ab,kw OR 'cardiopulmonary exercise test',ab,kw OR 'cardiopulmonary exercise testing',ab,kw OR cpet,ab,kw OR 'graded exercise test',ab,kw OR gxt,ab,kw OR 'incremental exercise test',ab,kw OR 'maximal exercise test',ab,kw OR 'treadmill test',ab,kw OR 'cycle ergometer test',ab,kw OR ergometr*,ab,kw OR '20 m shuttle run',ab,kw OR '20-m shuttle run',ab,kw OR '20 meter shuttle run',ab,kw OR '20-meter shuttle run',ab,kw OR 'multistage fitness test',ab,kw OR 'multi-stage fitness test',ab,kw OR 'beep

		test',ab,kw OR pacer,ab,kw OR 'progressive aerobic cardiovascular endurance run',ab,kw OR 'cooper test',ab,kw OR '12-minute run',ab,kw OR '12 minute run',ab,kw OR 'physical work capacity',ab,kw OR pwc170,ab,kw) AND ('randomized controlled trial'/exp OR 'controlled clinical trial'/exp OR 'randomization'/exp OR random*,ab,kw OR trial,ab,kw OR placebo*,ab,kw OR 'controlled study',ab,kw OR 'controlled trial',ab,kw OR 'clinical trial',ab,kw OR 'cluster randomized',ab,kw OR 'cluster randomised',ab,kw) NOT ('animal'/exp NOT 'human'/exp)
Cochrane Library	2277	#1 MeSH descriptor: [Child, Preschool] explode all trees #2 MeSH descriptor: [Child] explode all trees #3 MeSH descriptor: [Adolescent] explode all trees #4 (child* OR adolescen* OR teen* OR youth* OR pediatric* OR paediatric* OR schoolchild* OR "school age" OR "school aged" OR "school-age" OR "school-aged" OR boy* OR girl*),ab,kw #5 #1 OR #2 OR #3 OR #4 #6 MeSH descriptor: [Exercise] explode all trees #7 MeSH descriptor: [Exercise Therapy] explode all trees #8 MeSH descriptor: [Physical Education and Training] explode all trees #9 MeSH descriptor: [Sports] explode all trees #10 MeSH descriptor: [Resistance Training] explode all trees #11 MeSH descriptor: [High-Intensity Interval Training] explode all trees #12 MeSH descriptor: [Endurance Training] explode all trees #13 MeSH descriptor: [Plyometric Exercise] explode all trees #14 MeSH descriptor: [Exergaming] explode all trees #15 (exercis* OR "physical activity" OR "physical activities" OR "physical education" OR "exercise training" OR "aerobic exercise" OR "aerobic training" OR "endurance exercise" OR "endurance training" OR "continuous exercise" OR "continuous training" OR "high-intensity interval training" OR "high intensity interval training" OR HIIT OR "sprint interval training" OR "sprint interval exercise" OR "interval training" OR "interval exercise" OR "resistance exercise" OR "resistance training" OR "strength exercise" OR "strength training" OR "weight training" OR "weight-bearing exercise" OR "muscle strengthening" OR "combined exercise" OR "combined training" OR "concurrent exercise" OR "concurrent training" OR "circuit exercise" OR "circuit training" OR plyometric* OR calisthenic* OR running OR jogging OR walking OR cycling OR bicycling OR swimming OR rowing OR football OR soccer OR basketball OR handball OR volleyball OR dance OR dancing OR "sport-based exercise" OR "sports-based exercise" OR "small-sided game" OR "small-sided games" OR "active game" OR "active games" OR exergam* OR "active video game" OR "active video games" OR yoga OR "tai chi" OR taiji OR qigong OR baduanjin),ab,kw #16 #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 #17 MeSH descriptor: [Cardiorespiratory Fitness] explode all trees #18 MeSH descriptor: [Physical Fitness] explode all trees #19 MeSH descriptor: [Exercise Tolerance] explode all trees #20 MeSH descriptor: [Oxygen Consumption] explode all trees #21 MeSH descriptor: [Cardiopulmonary Exercise Testing] explode all trees #22 ("cardiorespiratory fitness" OR "cardio-respiratory fitness" OR "cardiopulmonary fitness" OR "aerobic fitness" OR "aerobic capacity" OR "aerobic endurance" OR "aerobic power" OR "cardiorespiratory capacity" OR "cardiopulmonary capacity" OR VO2max OR "VO2 max" OR VO2peak OR "VO2 peak" OR "maximal oxygen uptake" OR "maximum oxygen uptake" OR "peak oxygen uptake" OR "maximal oxygen consumption" OR "maximum oxygen consumption" OR "peak oxygen consumption" OR "cardiopulmonary exercise test" OR

		"cardiopulmonary exercise testing" OR CPET OR "graded exercise test" OR GXT OR "incremental exercise test" OR "maximal exercise test" OR "treadmill test" OR "cycle ergometer test" OR ergometr* OR "20 m shuttle run" OR "20-m shuttle run" OR "20 meter shuttle run" OR "20-meter shuttle run" OR "multistage fitness test" OR "multi-stage fitness test" OR "beep test" OR PACER OR "progressive aerobic cardiovascular endurance run" OR "Cooper test" OR "12-minute run" OR "12 minute run" OR "physical work capacity" OR PWC170),ab,kw #23 #17 OR #18 OR #19 OR #20 OR #21 OR #22 #24 #5 AND #16 AND #23
Web of Science	2407	TS=(child* OR adolescen* OR teen* OR youth* OR pediatric* OR paediatric* OR schoolchild* OR "school age" OR "school aged" OR "school-age" OR "school-aged" OR boy* OR girl*) AND TS=(exercis* OR "physical activity" OR "physical activities" OR "physical education" OR "exercise training" OR "aerobic exercise" OR "aerobic training" OR "endurance exercise" OR "endurance training" OR "continuous exercise" OR "continuous training" OR "high-intensity interval training" OR "high intensity interval training" OR HIIT OR "sprint interval training" OR "sprint interval exercise" OR "interval training" OR "interval exercise" OR "resistance exercise" OR "resistance training" OR "strength exercise" OR "strength training" OR "weight training" OR "weight-bearing exercise" OR "muscle strengthening" OR "combined exercise" OR "combined training" OR "concurrent exercise" OR "concurrent training" OR "circuit exercise" OR "circuit training" OR plyometric* OR calisthenic* OR running OR jogging OR walking OR cycling OR bicycling OR swimming OR rowing OR football OR soccer OR basketball OR handball OR volleyball OR dance OR dancing OR "sport-based exercise" OR "sports-based exercise" OR "small-sided game" OR "small-sided games" OR "active game" OR "active games" OR exergam* OR "active video game" OR "active video games" OR yoga OR "tai chi" OR taiji OR qigong OR baduanjin) AND TS=("cardiorespiratory fitness" OR "cardio-respiratory fitness" OR "cardiopulmonary fitness" OR "aerobic fitness" OR "aerobic capacity" OR "aerobic endurance" OR "aerobic power" OR "cardiorespiratory capacity" OR "cardiopulmonary capacity" OR VO2max OR "VO2 max" OR VO2peak OR "VO2 peak" OR "maximal oxygen uptake" OR "maximum oxygen uptake" OR "peak oxygen uptake" OR "maximal oxygen consumption" OR "maximum oxygen consumption" OR "peak oxygen consumption" OR "cardiopulmonary exercise test" OR "cardiopulmonary exercise testing" OR CPET OR "graded exercise test" OR GXT OR "incremental exercise test" OR "maximal exercise test" OR "treadmill test" OR "cycle ergometer test" OR ergometr* OR "20 m shuttle run" OR "20-m shuttle run" OR "20 meter shuttle run" OR "20-meter shuttle run" OR "multistage fitness test" OR "multi-stage fitness test" OR "beep test" OR PACER OR "progressive aerobic cardiovascular endurance run" OR "Cooper test" OR "12-minute run" OR "12 minute run" OR "physical work capacity" OR PWC170) AND TS=(random* OR "randomized controlled trial" OR "randomised controlled trial" OR "controlled clinical trial" OR "controlled trial" OR "clinical trial" OR placebo* OR "cluster randomized" OR "cluster randomised" OR groups)

Supplemental Material 2. Characteristics of Included Studies

2.1 Study and Intervention Characteristics

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Alberga et al., 2015										
Canada	Y	75	70	15.6 (1.4)	34.6 (4.5)	MAE	Y	22	30	864
Canada	Y	78	70	15.6 (1.4)	34.6 (4.5)	RE	Y	22	30	384
Canada	Y	75	70	15.6 (1.4)	34.6 (4.5)	CE	Y	22	60	1272
Canada	Y	76	70	15.6 (1.4)	34.6 (4.5)	CG health education	N	22	0	0
Benson et al., 2008										
New Zealand	Y	29	41	12.3 (1.3)	23.2 (5.4)	RE	Y	8	60	348
New Zealand	Y	34	41	12.3 (1.3)	21.9 (3.6)	CG wait-list control	N	8	0	0
Børrestad et al., 2012										
Norway	N	26	46.1	10.9 (0.7)	18.8 (2.5)	MAE	Y	12	17.5	428.7
Norway	N	27	48.1	10.9 (0.7)	18.4 (2.4)	CG usual activity	N	12	0	0
Cao et al., 2022										
China	Y	20	50	11 (0.6)	23.6 (1.5)	SIT	Y	12	18	502.2
China	Y	20	50	10.9 (0.4)	23.8 (1.5)	CG usual activity	N	12	0	0
Carrel et al., 2005										
USA	Y	27	52	12.5 (0.5)	32 (6)	MAE	Y	36	42	588
USA	Y	23	43	12.5 (0.7)	30 (4)	CG usual PE	N	36	0	0
Chae et al., 2010										
Korea	N	19	42.1	10.4 (3.1)	26.6 (0.8)	CE	Y	12	90	1152
Korea	N	19	43.4	10.6 (3.8)	26.2 (1)	CG health education	N	12	0	0

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Cheng et al., 2012										
China	Y	30	0	13.5 (0.5)	29.3 (4.5)	CE	Y	8	65	845
China	Y	30	0	13.5 (0.5)	29.1 (4.3)	CG usual PE	N	8	0	0
Comeras-Chueca et al., 2022										
Spain	Y	20	46.4	10 (0.8)	25.3 (2.8)	CE	Y	20	60	648
Spain	Y	8	50	9.7 (0.8)	24.1 (1.7)	CG usual activity	N	20	0	0
D'Alleva et al., 2023										
Italy	Y	10	0	16.1 (1.5)	37.8 (4.5)	HAE	Y	3	36	234
Italy	Y	11	0	16.2 (1.1)	37.1 (3.1)	MAE	Y	3	45	207
Dias et al., 2018										
Australia, Norway	Y	33	51.5	12.4 (1.9)	28.8 (3.8)	HIIT	Y	12	40	888
Australia, Norway	Y	29	53.1	11.9 (2.4)	30.4 (5)	HAE	Y	12	44	844.8
Australia, Norway	Y	31	55.9	11.8 (2.4)	29.6 (4.3)	CG health education	N	12	0	0
Domaradzki, Murawska-Ciałowicz, et al., 2025										
Poland	Y	16	0	16.5 (0.4)	20.9 (3.6)	HIIT	Y	6	20	252
Poland	Y	12	0	16.5 (0.5)	22.2 (3.3)	HIIT	Y	6	24	276
Poland	Y	11	0	16.7 (0.4)	21.2 (2.6)	HIIT	Y	6	20	252
Poland	Y	11	0	16.6 (0.6)	20.2 (3.6)	CG usual PE	N	6	0	0
Poland	Y	16	0	16.9 (0.5)	21.7 (2.4)	CG usual PE	N	6	0	0
Poland	Y	12	100	16.5 (0.5)	19.3 (2.3)	HIIT	Y	6	16	252
Poland	Y	16	100	16.8 (0.4)	21.0 (3.2)	HIIT	Y	6	16	252
Poland	Y	12	100	16.5 (0.5)	20.0 (2.8)	HIIT	Y	6	18	300

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Poland	Y	15	100	16.9 (0.5)	25.6 (20.7)	CG usual PE	N	6	0	0
Poland	Y	16	100	16.6 (0.2)	22.6 (4.6)	CG usual PE	N	6	0	0
Domaradzki, Popowczak, et al., 2025										
Poland	Y	45	0	14.8 (0.4)	20.5 (2.4)	CE	Y	8	14	173.6
Poland	Y	45	0	15 (0.6)	21.3 (2.8)	HIIT	Y	8	16	240
Poland	Y	24	0	14.9 (0.5)	21 (3.3)	CE	Y	8	14	210
Poland	Y	30	100	15.1 (0.5)	21.2 (3.6)	HIIT	Y	8	14	210
Dridi et al., 2021										
Tunisia	N	8	0	17 (1)	NA	HAE	Y	8	70	1911
Tunisia	N	8	0	17.1 (0.6)	NA	MAE	Y	8	90	1953
Duft et al., 2020										
Brazil	Y	18	50	14.4 (1)	28.3 (2.3)	CE	Y	12	60	918
Brazil	Y	19	52	14.7 (1.1)	29.5 (2.8)	CG usual activity	N	12	0	0
Faria et al., 2020										
Brazil	N	24	57.9	16.1 (1)	25.5 (6.3)	CE	Y	12	34.5	462.3
Brazil	N	26	57.7	15.5 (0.9)	25.2 (5.6)	CE	Y	12	40	480
Brazil	N	26	57.7	16.5 (1)	23 (4.9)	CG no intervention	N	12	0	0
Farpour-Lambert et al., 2009										
Switzerland	Y	22	59.1	9.1 (1.4)	25.4 (4.6)	CE	Y	24	60	930
Switzerland	Y	22	68.2	8.8 (1.6)	25.1 (4.7)	CG no intervention	N	12	0	0
Switzerland	Y	22	59.1	9.1 (1.4)	25.4 (4.6)	CE	Y	12	60	925.2
Switzerland	Y	22	68.2	8.8 (1.6)	25.1 (4.7)	CG no intervention	N	24	0	0

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Gao et al., 2024										
China	Y	13	50	11 (0.6)	23.4 (1.8)	HIIT	Y	12	18	421.2
China	Y	13	50	11 (0.6)	23.8 (1.8)	HIIT	Y	12	18	280.8
China	Y	13	50	11 (0.6)	22.7 (0.6)	HIIT	Y	12	18	140.4
China	Y	12	50	11 (0.7)	23.8 (1.1)	CG usual PE	N	12	0	0
Gao et al., 2025										
China	Y	10	50	10.1 (0.7)	24.5 (1.3)	SIT	Y	8	30	268.2
China	Y	10	50	10.1 (0.7)	24.6 (0.5)	CE	Y	8	20	260
China	Y	10	50	10.1 (0.7)	23.7 (0.6)	CG usual PE	N	8	0	0
Gejl et al., 2024										
Denmark	Y	27	68	17.8 (0.8)	20.8 (2.8)	SIT	Y	9	30	720
Denmark	Y	23	68	17.9 (0.8)	21.3 (2.4)	HAE	Y	9	30	603
Denmark	Y	35	68	17.9 (0.9)	21.5 (3.4)	CG usual activity	N	9	0	0
Ghorbanian et al., 2013										
Iran	Y	15	0	17.3 (1.0)	28.2 (2.5)	HIIT	Y	8	40	1072
Iran	Y	15	0	16.9 (1.1)	28.3 (2.4)	CG usual PE	N	8	0	0
González-Gálvez, López-Gil, et al., 2024										
Spain	Y	20	50	12.5 (0.7)	20.7 (1.0)	HIIT	Y	8	12	184.8
Spain	Y	20	50	12.5 (0.7)	22.6 (1.2)	SIT	Y	8	12	196.8
Spain	Y	20	50	12.5 (0.7)	24.9 (1.3)	CG usual PE	N	8	0	0
González-Gálvez, Soler-Marín, et al., 2024										
Spain	Y	15	45.5	12.5 (0.7)	22.9 (1)	HIIT	Y	8	12	184.8

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Spain	Y	15	33.3	12.5 (0.7)	25.1 (1.1)	SIT	Y	8	12	196.8
Spain	Y	15	50	12.5 (0.7)	26.3 (1.1)	CG usual PE	N	8	0	0
Grendstad & Hallén, 2024										
Norway	Y	22	68.2	12.2 (0.3)	17.9 (2.1)	CE	Y	8	75	2130
Norway	Y	12	66.7	12.3 (0.3)	18.5 (2.3)	CE	Y	8	60	1128
Norway	Y	25	56	12.3 (0.3)	20.8 (4.7)	CG usual activity	N	8	0	0
Guijarro-Romero et al., 2020										
Spain	Y	19	57.9	13.9 (0.8)	23 (4.2)	MAE	Y	9	40	456
Spain	Y	23	47.8	13.7 (0.7)	18.3 (1.6)	MAE	Y	9	40	456
Spain	Y	38	68.4	13.6 (0.6)	21 (3.4)	CG usual PE	N	9	0	0
Guijarro-Romero et al., 2022										
Spain	Y	39	52.2	12.5 (0.7)	21.6 (4.1)	HAE	Y	15	50	670
Spain	Y	34	32.4	12.5 (0.7)	21.4 (2.8)	MAE	Y	15	50	410
Spain	Y	19	53	11.8 (0.7)	23.5 (4.1)	CG usual PE	N	15	0	0
Hay et al., 2016										
Canada	Y	38	76	15.3 (1.7)	32.6 (4.8)	HAE	Y	24	37.5	810
Canada	Y	32	78.1	15.1 (1.8)	31.9 (4.8)	MAE	Y	24	44.5	720.9
Canada	Y	36	64	15.2 (1.7)	32.9 (5.4)	CG usual activity	N	24	0	0
Jovanović et al., 2024										
Serbia	N	30	0	16.3 (0.6)	21.5 (3.6)	HIIT	Y	12	9	71.3
Serbia	N	30	0	16.3 (0.6)	23 (3.9)	CG usual PE	N	12	0	0
Jovanović et al., 2025										

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Serbia	N	20	100	16.4 (0.6)	20.2 (1.8)	HIIT	Y	12	15	261
Serbia	N	20	100	16.7 (0.6)	20.6 (2.3)	CG usual PE	N	12	0	0
Kilit et al., 2025										
Turkey	N	16	0	13.5 (0.3)	20 (1.8)	CE	Y	6	52.5	1134
Turkey	N	16	0	13.5 (0.3)	20 (1.8)	CE	Y	6	52.5	1023.7
Kucuk Yetgin et al., 2018										
Turkey	Y	8	0	16.6 (1)	32.5 (3.0)	RE	Y	24	60	810
Turkey	Y	8	0	17 (0.7)	32.1 (3.2)	HAE	N	24	60	1404
Lee et al., 2010										
Korea	Y	16	16.7	13 (-)	26.3 (2.3)	MAE	Y	10	60	1422
Korea	Y	20	16.7	13 (-)	26.1 (2.4)	CE	Y	10	60	1206
Korea	Y	18	16.7	13 (-)	27.3 (3.0)	CG usual activity	N	10	0	0
Mendonça et al., 2022										
Brazil	Y	19	57.9	15.9 (1)	25.3 (6.9)	CE	Y	12	50	580
Brazil	Y	20	57.7	15.5 (1)	25.5 (5.6)	CE	Y	12	55	682
Brazil	Y	24	62.5	16.6 (1)	23.2 (5)	CG usual activity	Y	12	0	0
Meng et al., 2022										
China	Y	15	0	11.2 (0.7)	24.5 (1.1)	SIT	Y	12	25	690
China	Y	15	0	11.2 (0.7)	24.4 (0.9)	HAE	Y	12	30	666
China	Y	15	0	11.2 (0.7)	23.8 (0.8)	CG usual activity	N	12	0	0
Miguelles et al., 2022										
Spain	Y	47	39	10 (1.1)	27.4 (3.1)	CE	Y	20	80	1632

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Spain	Y	52	48	10.1 (1.1)	26.3 (2.9)	CG usual activity	N	20	0	0
Mon Redee Sut Txi et al., 2020										
Malaysia	Y	7	42.9	15 (1.7)	24.7 (4.3)	MAE	Y	12	35	413
Malaysia	Y	7	42.9	15 (1.7)	24.7 (4.3)	CE	Y	12	35	504
Malaysia	Y	7	42.9	15 (1.7)	24.7 (4.3)	CG usual activity	N	12	0	0
Moslehi et al., 2019										
Iran	Y	10	0	11.1 (0.5)	29.9 (2.0)	HAE	Y	8	32.5	721.5
Iran	Y	10	0	10.8 (0.5)	30.2 (2.0)	HAE	Y	8	32.5	702
Iran	Y	10	0	10.9 (0.3)	29.6 (1.8)	CG usual activity	N	8	0	0
Müller et al., 2019										
South Africa	Y	300	50	10.0 (0.9)	NA	MAE	Y	20	40	320
South Africa	Y	446	49.8	9.9 (1)	NA	CG usual activity	N	20	0	0
Racil et al., 2013										
Tunisia	Y	11	100	15.9 (0.7)	30.8 (1.6)	SIT	Y	12	42.5	1109.2
Tunisia	Y	11	100	16.3 (0.5)	30.8 (1.6)	HIIT	Y	12	42.5	854.2
Tunisia	Y	12	100	15.9 (1.2)	30.8 (1.6)	CG no intervention	N	12	0	0
Racil et al., 2016										
Tunisia	Y	23	100	16.6 (0.9)	NA	SIT	Y	12	65	1852.5
Tunisia	Y	26	100	16.5 (1.2)	NA	HIIT	Y	12	45	1188
Tunisia	Y	19	100	16.9 (1)	NA	CG no intervention	N	12	0	0
Racil et al., 2024										
Tunisia	N	12	100	14.3 (1.1)	NA	HIIT	Y	8	35	934.5

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
Tunisia	N	12	100	14.1 (0.9)	NA	HIIT	Y	8	35	871.5
Tunisia	N	11	100	14.5 (1.2)	NA	CG usual activity	N	8	0	0
Ramírez Lechuga et al., 2012										
Spain	Y	27	0	16.7 (1)	NA	HAE	Y	8	30	558
Spain	Y	27	0	16.7 (1)	NA	HAE	Y	8	30	558
Spain	Y	27	0	16.7 (1)	NA	CG usual PE	N	8	0	0
Spain	Y	11	100	16.7 (1)	NA	HAE	Y	8	30	372
Spain	Y	11	100	16.7 (1)	NA	HAE	Y	8	30	372
Spain	Y	11	100	16.7 (1)	NA	CG usual PE	N	8	0	0
Reif et al., 2022										
Austria	Y	23	43.5	11.2 (0.5)	17.4 (2.2)	MAE	Y	20	50	600
Austria	Y	21	47.6	11.3 (0.5)	18.2 (3.0)	CG usual PE	N	20	0	0
Salus et al., 2022										
Estonia	Y	14	0	13.1 (1.3)	30.3 (3.2)	SIT	Y	12	30	810
Estonia	Y	14	0	13.7 (1.6)	32.6 (5.9)	CG usual activity	N	12	0	0
Sammoud et al., 2022										
Tunisia	N	11	0	12.7 (0.3)	NA	CE	Y	12	37.5	585
Tunisia	N	11	0	12.8 (0.2)	NA	CE	Y	12	37.5	472.5
Tunisia	N	11	0	12.8 (0.3)	NA	CG usual activity	N	12	0	0
Shao & Cao, 2025										
China	Y	40	50	12.4 (0.6)	24.8 (0.9)	HIIT	Y	12	10	213
China	Y	40	50	12.4 (0.6)	24.6 (1.3)	HIIT	Y	12	10	213

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
China	Y	40	50	12.4 (0.6)	24.6 (1.1)	CG usual PE	N	12	0	0
Su et al., 2024										
China	Y	22	0	15 (1)	32.1 (1.2)	HIIT	Y	8	40	1044
China	Y	22	0	14 (1)	31.1 (1.2)	HAE	Y	8	40	888
Sun et al., 2011										
China	Y	25	28	13.6 (0.7)	26.2 (2.7)	MAE	Y	10	60	1444.8
China	Y	17	58.8	13.6 (0.7)	27.9 (3.8)	CG usual activity + health education		10	0	0
Tas et al., 2023										
USA	Y	31	59	15.2 (1.5)	36.9 (6)	HIIT	Y	4	30	441
USA	Y	6	67	15.4 (1)	34.9 (5.9)	CG usual activity	N	4	0	0
Van der Fels et al., 2020										
Netherlands	Y	209	51.1	9.3 (0.7)	16.9 (2.4)	HAE	Y	14	35	455
Netherlands	Y	228	52.9	9.1 (0.6)	16.9 (2.5)	MAE	Y	14	30	440
Netherlands	Y	403	49.1	9.2 (0.7)	16.6 (2.4)	CG usual PE	N	14	0	0
Vasconcellos et al., 2016										
Brazil	Y	10	20	14.1 (1.1)	31.1 (5.2)	MAE	Y	12	60	1386
Brazil	Y	10	40	14.8 (1.4)	32.2 (4.9)	CG usual activity	N	12	0	0
Yu et al., 2016										
Hong Kong	Y	19	37	12.3 (0.4)	18.6 (2.4)	RE	Y	10	70	546
Hong Kong	Y	19	32	12.1 (0.3)	17.7 (2.3)	CG usual activity	N	10	0	0
Zuo et al., 2023										

Country	Funding	n	% Female	Mean Age (SD/Range)	Mean BMI (SD/Range)	Exercise modality/control condition	Supervise	Weeks	Session duration	METy min per week
China	N	20	0	8 (0.8)	21.6 (1.8)	HIIT	Y	8	25	600
China	N	20	0	7.9 (0.6)	21.6 (1.4)	MAE	Y	8	35	588

Note: Y = yes; N = no; NA = not available; n = sample size per study arm; BMI = body mass index (kg/m²); SD = standard deviation; HIIT = high-intensity interval training; SIT = sprint interval training; HAE = high-intensity aerobic exercise; MAE = moderate-intensity aerobic exercise; CE = combined exercise; RE = resistance exercise; CG = control group; PE: physical education; supervised = supervised by a health professional; unsupervised = not supervised; session duration = duration of each exercise session; METy = youth metabolic equivalents.

2.2 Intervention Implementation and Participant Characteristics

Author(s), year	Intensity monitoring	Adherence	Baseline training status	Health status
Alberga et al., 2015	RM + repetitions/sets + workload progression.	MAE 62%;RE 56%; CE 64%.	Previously inactive.	Overweight/obesity.
Benson et al., 2008	RPE + workload/1RM controlled combined methods.	77%.	NR.	Mixed weight status.
Børrestad et al., 2012	NR.	NR.	Previously inactive.	Healthy.
Cao et al., 2022	NR.	NR.	Physically active.	Overweight/obesity.
Carrel et al., 2005	NR.	NR.	School PE only.	Overweight/obesity.
Chae et al., 2010	NR.	NR.	NR.	Overweight/obesity.
Cheng et al., 2012	NR.	NR.	School PE only.	Overweight/obesity.
Comeras-Chueca et al., 2022	NR.	≥75%.	Previously inactive.	Overweight/obesity.
D'Alleva et al., 2023	%VO _{2max} + heart-rate monitoring + speed/incline controlled	Both groups completed 28 ± 2 exercise sessions;.	NR.	Overweight/obesity.
Dias et al., 2018	Heart-rate monitoring.	NR.	NR.	Overweight/obesity.
Domaradzki, Murawska-Ciałowicz, et al., 2025	Heart-rate monitoring + speed/workload controlled.	NR.	Trained.	Healthy.
Domaradzki, Popowczak, et al., 2025	HR monitoring + all-out + time/repetition controlled.	NR.	Previously inactive.	Healthy.
Dridi et al., 2021	Heart-rate controlled.	96%.	Physically active.	Healthy.
Duft et al., 2020	%VO _{2max} controlled + repetition prescription.	NR.	School PE only.	Overweight/obesity.
Faria et al., 2020	%VO _{2max} + RM + lactate monitoring.	93%; 89%.	Previously inactive.	Mixed weight status.
Farpour-Lambert et al., 2009	%VO _{2max} + heart-rate monitoring + repetitions/sets controlled.	83%.	Regular PE.	Overweight/obesity.
Gao et al., 2025	Maximal effort.	SIT 97%; CE 95%.	Previously inactive.	Overweight/obesity.

Author(s), year	Intensity monitoring	Adherence	Baseline training status	Health status
Gao et al., 2024	Heart-rate + speed/MAS controlled.	>90%.	Previously inactive.	Overweight/obesity.
Gejl et al., 2024	HRR combined with heart-rate monitoring.	91%	Previously inactive.	Overweight/obesity.
Ghorbanian et al., 2013	Jumps/min + work/rest interval controlled.	NR.	School PE only.	Overweight/obesity.
González-Gálvez, López-Gil, et al., 2024	%HRR + heart-rate monitoring + work/rest time controlled	NR.	Regular PE.	Healthy.
González-Gálvez, Soler-Marín, et al., 2024	%HRR + heart-rate monitoring + work/rest controlled.	NR.	School PE only.	Healthy.
Grendstad & Hallén, 2024	Heart-rate monitoring + session RPE + work/recovery controlled.	NR.	Mixed training status.	NR.
Guijarro-Romero et al., 2020	Heart-rate monitoring.	92.6%.	School PE only.	Healthy.
Guijarro-Romero et al., 2022	HR monitor + RPE combined methods.	≥80%.	School PE only.	Healthy.
Hay et al., 2016	%HRR + HR monitoring + energy controlled.	HAE 61%; MAE 55%.	Previously inactive.	Overweight/obesity + metabolic risk.
Jovanović et al., 2024	%HR _{max} controlled.	NR.	School PE only.	Healthy.
Jovanović et al., 2025	Heart-rate controlled.	NR.	School PE only.	Healthy.
Kilit et al., 2025	Speed/workload controlled + RPE.	NR.	Physically active.	NR.
Kucuk Yetgin et al., 2018	Heart-rate monitored.	NR.	Untrained.	Obesity.
Lee et al., 2010	Strength/load controlled.	NR.	NR.	Obesity.
Mendonça et al., 2022	Speed/workload + repetition-load combined methods.	87.5%; 100%.	Untrained.	Mixed weight status.
Meng et al., 2022	HRR combined with heart-rate monitoring.	SIT 91%/85%/91%; HAE 84%/85%/87%.	Previously inactive.	Obesity.

Author(s), year	Intensity monitoring	Adherence	Baseline training status	Health status
Migueles et al., 2022	Heart-rate monitoring; >80% HR _{max} exposure; combined aerobic + body-weight resistance.	NR.	NR.	Overweight/obesity + metabolic risk.
Mon Redee Sut Txi et al., 2020	NR.	NR.	Trained.	Healthy.
Moslehi et al., 2019	Heart-rate monitoring + speed/distance controlled.	NR.	NR.	Overweight/obesity.
Müller et al., 2019	NR.	NR.	NR.	Special conditions.
Racil et al., 2013	Speed/MAS controlled + heart-rate monitoring combined methods.	NR.	Previously inactive.	Obesity.
Racil et al., 2016	%VO _{2max} + work/recovery time controlled.	NR.	Untrained.	Obesity.
Racil et al., 2024	Speed/MAS controlled.	NR.	Untrained.	Obesity.
Ramírez Lechuga et al., 2012	%VO _{2max} + heart-rate monitoring.	NR.	Regular PE.	NR.
Reif et al., 2022	NR.	NR.	Regular PE.	Healthy.
Salus et al., 2022	Power/cadence + HR monitoring.	SIT 89%/81%/80%.	School PE only.	Obesity.
Sammoud et al., 2022	Maximal effort.	95%.	Trained.	Healthy.
Shao & Cao, 2025	Cadence/workload controlled + heart-rate monitoring.	91%; 88%.	NR.	Overweight/obesity.
Su et al., 2024	Heart-rate monitoring + RPE + speed/workload controlled.	NR.	Previously inactive.	Obesity.
Sun et al., 2011	Speed/workload + repetition-load combined methods.	55%.	NR.	Overweight/obesity.
Tas et al., 2023	Heart-rate monitoring + RPE+ equipment workload controlled.	97%.	NR.	Obesity + MASLD risk.

Author(s), year	Intensity monitoring	Adherence	Baseline training status	Health status
van der Fels et al., 2020	HR monitoring.	NR.	School PE only.	NR.
Vasconcellos et al., 2016	Heart-rate monitoring; %HR _{max} .	NR.	Untrained.	Obesity.
Yu et al., 2016	workload controlled.	83%.	Physically active.	Healthy.
Zuo et al., 2023	%MAS + %HR _{max} + speed/workload controlled.	100%.	School PE only.	Overweight.

Note: NR = not reported; PE = physical education; RM = repetition maximum; 1RM = one-repetition maximum; RPE = rating of perceived exertion; VO_{2max} = maximal oxygen uptake; HR = heart rate; HRR = heart rate reserve; HR_{max} = maximal heart rate; HIIT = high-intensity interval training; SIT = sprint interval training; HAE = high-intensity aerobic exercise; MAE = moderate-intensity aerobic exercise; CE = combined exercise; RE = resistance exercise; CG = control group; MASLD = metabolic dysfunction-associated steatotic liver disease.

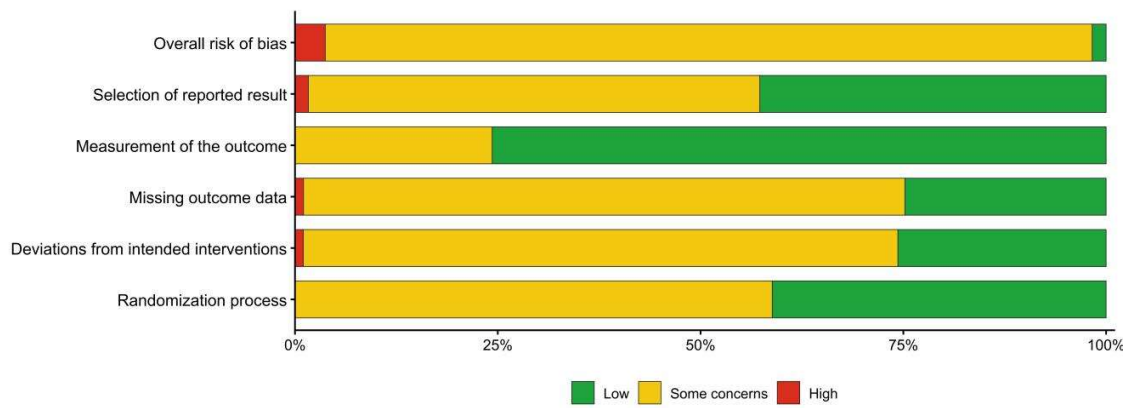
Supplemental Material 3.Risk of Bias in Individual Studies (ROB2)

Author, Year	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall bias
Alberga et al, 2015	Low	Some concerns	Some concerns	Low	Some concerns	Some concerns
Benson et al., 2008	Low	Some concerns	Low	Low	Some concerns	Some concerns
Børrestad et al., 2012	Some concerns	High	Some concerns	Some concerns	Low	High
Cao et al., 2022	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
Carrel et al., 2005	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Chae et al., 2010	Low	Some concerns	Low	Low	Low	Some concerns
Cheng et al., 2012	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Comeras-Chueca et al., 2022	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
D'Alleva et al., 2023	Some concerns	Low	Low	Some concerns	Low	Some concerns
Dias et al., 2018	Low	Low	Low	Some concerns	Low	Some concerns
Domaradzki, Murawska-Ciawicz, et al., 2025	Some concerns	Some concerns	Some concerns	Low	Some concerns	Some concerns
Domaradzki, Popowczak, et al., 2025	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Dridi et al., 2021	Some concerns	Low	Low	Some concerns	Low	Some concerns
Duft et al., 2020	Low	Low	Low	Low	Low	Low
Faria et al., 2020	Some concerns	Some concerns	Some concerns	Low	Some concerns	Some concerns
Farpour-Lambert et al., 2009	Low	Some concerns	Low	Low	Low	Some concerns
Gao et al.,2024	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Gao et al., 2025	Some concerns	Some concerns	Some concerns	Low	Low	Some concerns
Gejl et al., 2024	Some concerns	Low	Some concerns	Some concerns	Low	Some concerns
Ghorbanian et al., 2013	Low	Low	Low	Low	Low	Some concerns
González-Gálvez, López-Gil, et al., 2024	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
González-Gálvez, Soler-Marín, et al., 2024	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns

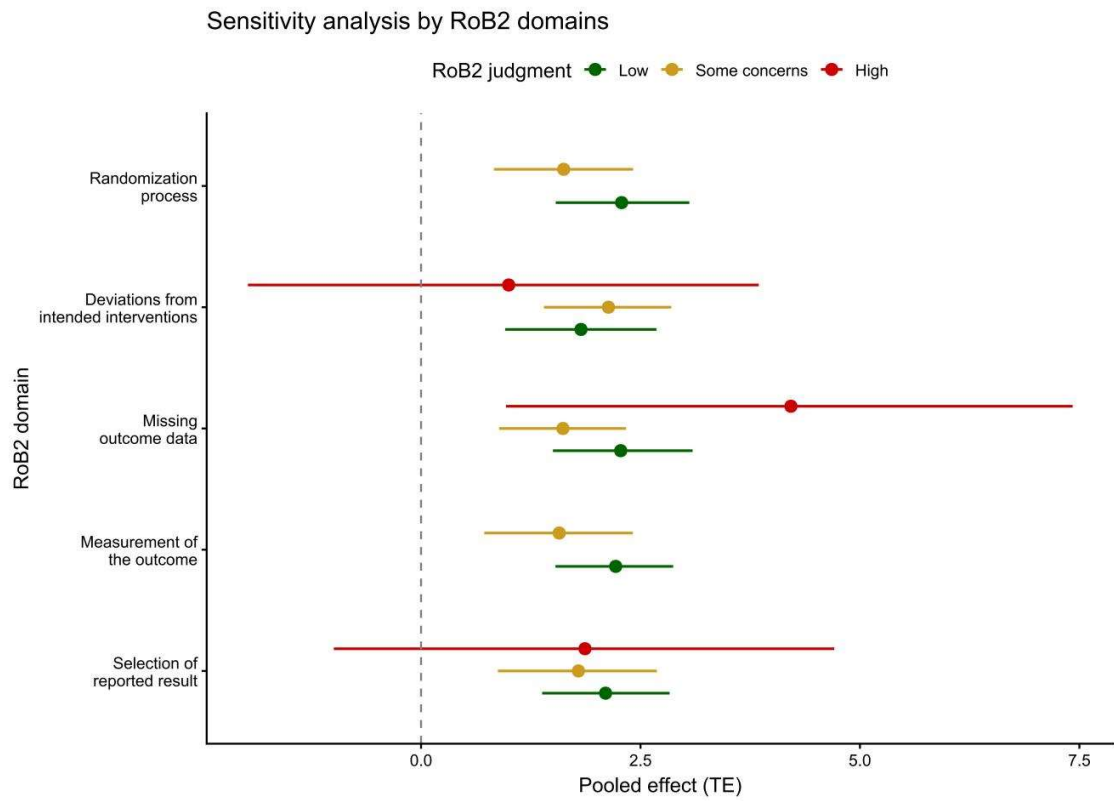
Author, Year	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall bias
Grendstad & Hallén, 2024	Some concerns	Some concerns	Some concerns	Low	Low	Some concerns
Guijarro-Romero et al., 2020	Some concerns	Some concerns	Some concerns	Low	Some concerns	Some concerns
Guijarro-Romero et al., 2022	Low	Some concerns	Low	Low	High	High
Hay et al., 2016	Low	High	Low	Some concerns	Low	High
Jovanović et al., 2024	Some concerns	Some concerns	Low	Low	Low	Some concerns
Jovanović et al., 2025	Low	Some concerns	Some concerns	Low	Some concerns	Some concerns
Kilit et al., 2025	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Kucuk Yetgin et al., 2018	Some concerns	Low	Low	Low	Some concerns	Some concerns
Lee et al., 2010	Low	Low	Low	Low	Low	Some concerns
Mendonça et al., 2022	Low	Low	Some concerns	Low	Low	Some concerns
Meng et al., 2022	Low	Some concerns	High	Low	Some concerns	High
Migueles et al., 2022	Low	Low	Low	Some concerns	Low	Some concerns
Mon Redee Sut Txi et al., 2020	Some concerns	Some concerns	Some concerns	Some concerns	Low	Some concerns
Moslehi et al., 2019	Low	Low	Low	Low	Low	Low
Müller et al., 2019	Low	Some concerns	Some concerns	Low	Low	Some concerns
Racil et al., 2013	Low	Low	Some concerns	Low	Low	Some concerns
Racil et al., 2016	Low	Low	Some concerns	Low	Low	Some concerns
Racil et al., 2024	Low	Some concerns	Low	Low	Low	Some concerns
Ramírez Lechuga et al., 2012	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Reif et al., 2022	Some concerns	Some concerns	Some concerns	Low	High	High
Salus et al., 2022	Low	Low	Some concerns	Low	Low	Some concerns
Sammoud et al., 2022	Some concerns	Low	Low	Low	Some concerns	Some concerns
Shao & Cao, 2025	Low	Low	Some concerns	Low	Some concerns	Some concerns
Su et al., 2024	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Sun et al., 2011	Low	Low	Some concerns	Low	Low	Some concerns
Tas et al., 2023	Low	Low	Low	Low	Low	Low
van der Fels et al., 2020	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns

Author, Year	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall bias
Vasconcellos et al., 2016	Low	Some concerns	Low	Low	Low	Some concerns
Yu et al., 2016	Low	Some concerns	Low	Low	Some concerns	Some concerns
Zuo et al., 2023	Some concerns	Low	Some concerns	Some concerns	Low	Some concerns

Supplemental Material 4.ROB Summary



Supplemental Material 5.Sensitivity Analysis by Risk of Bias Criteria



Supplemental Material 6. Confidence in Network Meta-Analysis (CINeMA) Assessment

Intervention	Number of studies (k)	Participants (n)	Effect (MD, 95% CrI)	Risk of bias (within-study)	Reporting bias	Indirectness	Imprecision	Heterogeneity	Inconsistency	Overall confidence
HIIT	16	345	2.50 [1.46, 3.51]	Serious	Serious	No	No	Some‡	Some§	Low
SIT	9	139	2.05 [0.85, 3.22]	Serious	Serious	No	No	Some‡	Some§	Low
CE	17	430	1.95 [0.87, 2.98]	Serious	Serious	No	No	Some‡	Some§	Low
HAE	12	427	1.25 [0.09, 2.41]	Serious	Serious	No	No	Some‡	Some§	Low
MAE	16	825	0.92 [-0.18, 2.01]	Serious	Serious	No	Serious	Some‡	Some§	Low
RE	4	134	0.20 [-1.41, 1.83]	Serious	Serious	No	Serious	Some‡	Some§	Very low

Abbreviations: CINeMA, Confidence in Network Meta-Analysis; HIIT, high intensity interval training; SIT, sprint interval training; CE, combined exercise; HAE, high intensity aerobic exercise; MAE, moderate intensity aerobic exercise; RE, resistance exercise; CG, control group; MD, mean difference; CrI, credible interval; k, number of studies; n, number of participants.

Notes:

1) Analytical framework: This study was based primarily on an arm-based Bayesian multilevel network meta-analysis using CG (control group) as the common comparator. Supplementary frequentist network procedures were performed using the netmeta package for network visualization, design-by-treatment inconsistency assessment, node-splitting analyses, and treatment ranking summaries.

2) Effect size and interval: Treatment effects were expressed as mean differences (MDs) and are reported with 95% credible intervals (95% CrI). Positive values favour the intervention over the control group (CG).**

3) Risk-of-bias basis: Individual study risk of bias was assessed using the Cochrane Risk of Bias 2 tool (RoB 2). Overall within-study bias was judged as serious because most included trials were rated as having some concerns or high risk of bias.**

Judgement principles for the six CINeMA domains

A. Within-study bias: Rated as serious for all intervention categories. Most included trials had some concerns or high risk of bias in one or more RoB 2 domains. In exercise intervention trials, blinding of participants and personnel is often not feasible, which may increase the risk of performance and detection bias.

B. Reporting bias: Rated as serious for all intervention categories. Formal regression-based tests such as Egger's test were not performed; reporting bias was assessed primarily using graphical and sensitivity-based approaches. Therefore, small-study effects and selective reporting could not be fully excluded.

C. Indirectness: Rated as no concerns for all intervention categories. The included studies enrolled broadly comparable populations, used prespecified intervention classifications, and assessed closely related CRF outcomes.

D. Imprecision: Rated as no concerns for HIIT, CE, SIT, and HAE, but serious for MAE and RE. The 95% CrI for MAE and RE crossed the null value, indicating limited precision in these estimates.

E. Heterogeneity: Rated as some concerns for all intervention categories. Substantial between-study heterogeneity was observed across the network, which is consistent with the diversity of exercise interventions, participant characteristics, and outcome assessment methods.

F. Incoherence (inconsistency): Rated as some concerns for all intervention categories. Global design-by-treatment testing suggested between-design inconsistency, whereas node-splitting analyses did not identify important local inconsistency in the most clinically relevant comparisons. Therefore, incoherence was interpreted cautiously in the context of substantial heterogeneity.

‡ (Heterogeneity): Substantial residual heterogeneity was observed across the network; all interventions were therefore judged as having some concerns for this domain.

§ (Incoherence): Global inconsistency was detected in the design-by-treatment model, although no important local inconsistency was identified in node-splitting analyses of the clinically most relevant comparisons.

|| (Imprecision): MAE and RE were judged as serious because their 95% CrI crossed the null value.

“Effect (MD, 95% CrI)” refers to the posterior mean estimate and corresponding 95% CrI. Positive values favour the intervention over the control group (CG).

Number of studies (k) and participants (n) represent the number of studies and the total sample size contributing to each intervention category in the network.

Supplemental Material 7. Node-Splitting Analysis: Testing for Inconsistency between Direct and Indirect Evidence

Comparison	k	Direct Evidence Proportion	NMA Effect (MD)	Direct Effect (MD)	Indirect Effect (MD)	Difference (Direct vs. Indirect)	z-score	p-value
CE:CG	15	0.87	2.3582	2.5933	0.7803	1.8130	1.36	0.1738
CE:HIIT	2	0.17	-0.7670	-1.4355	-0.6274	-0.8081	-0.53	0.5968
CE:MAE	3	0.29	1.1976	-0.4029	1.8628	-2.2657	-1.74	0.0823
CE:RE	1	0.45	1.8189	0.7000	2.7254	-2.0254	-0.93	0.3520
CE:SIT	1	0.16	-0.4640	-3.0000	0.0200	-3.0200	-1.74	0.0810
HAE:CG	8	0.71	1.7310	1.8777	1.3743	0.5034	0.43	0.6672
HIIT:CG	13	0.82	3.1253	2.8278	4.4538	-1.6260	-1.52	0.1294
MAE:CG	13	0.80	1.1607	1.1898	1.0473	0.1426	0.13	0.8967
RE:CG	3	0.72	0.5393	0.5149	0.6033	-0.0885	-0.04	0.9694
SIT:CG	9	0.87	2.8223	2.6404	3.9915	-1.3511	-0.94	0.3447
HAE:HIIT	2	0.15	-1.3943	-2.4677	-1.1996	-1.2681	-0.72	0.4737
HAE:MAE	5	0.57	0.5703	0.8587	0.1817	0.6770	0.57	0.5670
HAE:RE	1	0.12	1.1917	0.6900	1.2582	-0.5682	-0.16	0.8707
HAE:SIT	2	0.23	-1.0913	-2.2041	-0.7553	-1.4488	-0.90	0.3705
HIIT:MAE	1	0.12	1.9646	2.3000	1.9179	0.3821	0.22	0.8278
HIIT:SIT	4	0.58	0.3030	0.7362	-0.2924	1.0286	0.91	0.3625
MAE:RE	1	0.43	0.6213	1.8000	-0.2754	2.0754	0.95	0.3400

Abbreviations: NMA, network meta-analysis; MD, mean difference; HIIT, high intensity interval training; SIT, sprint interval training; CE, combined exercise; HAE, high intensity aerobic exercise; MAE, moderate intensity aerobic exercise; RE, resistance exercise; CG, control group; k, number of studies providing direct evidence; z, standard normal test statistic; p, P value; Q, global inconsistency test statistic; df, degrees of freedom.

Column Definitions:

- 1) k: Number of studies providing direct head-to-head evidence for the comparison.
- 2) Direct Evidence Proportion: The proportion of the network estimate that is informed by direct evidence.
- 3) NMA Effect (MD): The final estimated effect size (Mean Difference) from the network meta-analysis.
- 4) Direct Effect (MD): The estimated effect size derived only from direct, head-to-head trial evidence.
- 5) Indirect Effect (MD): The estimated effect size derived from indirect evidence via a common comparator.
- 6) Difference (Direct vs. Indirect): The arithmetic difference between the direct and indirect estimates. A large difference suggests potential inconsistency.
- 7) z-score & p-value: Statistical test results for the disagreement between direct and indirect evidence. A low p-value (e.g., < 0.05) indicates a statistically significant inconsistency for that specific comparison.

Global Test of Inconsistency:

The overall inconsistency test indicates significant differences among different research designs:

Q statistic (between designs) = 142.77

Degrees of freedom (df) = 22

p-value < 0.0001

Supplemental Material 8. Predicted Exercise Effects on Cardiorespiratory Fitness by Weekly exercise dose

weekly dose	pred	se	lower	upper
0	-0.09968	0.42596	-0.93456	0.73519
100	-0.01288	0.36149	-0.72138	0.69563
200	0.07385	0.30796	-0.52975	0.67744
300	0.16004	0.27133	-0.37177	0.69184
400	0.24444	0.25637	-0.25804	0.74692
500	0.32501	0.26236	-0.18921	0.83923
600	0.39918	0.2839	-0.15725	0.95561
700	0.46409	0.3154	-0.15408	1.08225
800	0.51697	0.35246	-0.17385	1.20778
900	0.55548	0.39075	-0.21038	1.32133
1000	0.5779	0.42599	-0.25703	1.41282
1100	0.58332	0.45474	-0.30796	1.47459
1200	0.57185	0.47544	-0.35999	1.50369
1300	0.54482	0.48915	-0.41389	1.50353
1400	0.50393	0.49838	-0.47288	1.48075
1500	0.4509	0.50624	-0.54131	1.44312
1600	0.38744	0.51605	-0.62399	1.39887
1700	0.31527	0.53095	-0.72538	1.35591
1800	0.23609	0.55344	-0.84863	1.32081
1900	0.15162	0.58491	-0.99478	1.29803
2000	0.06358	0.62561	-1.16258	1.28975
2100	-0.02642	0.67512	-1.34963	1.29679
2200	-0.11695	0.73245	-1.55253	1.31863

Supplemental Material 9. Predicted Exercise Effects on Cardiorespiratory Fitness by Session duration

session duration	pred	se	lower	upper
9	-0.46817	0.45979	-1.36933	0.433
11	-0.34412	0.42592	-1.17891	0.49066
13	-0.2207	0.39542	-0.9957	0.55431
15	-0.09879	0.36903	-0.82207	0.62448
17	0.02043	0.34739	-0.66044	0.70131
19	0.13563	0.3309	-0.51293	0.78419
21	0.24534	0.31955	-0.38096	0.87164
23	0.34815	0.31286	-0.26505	0.96135
25	0.44275	0.31004	-0.16492	1.05042
27	0.52796	0.31008	-0.07978	1.1357
29	0.60274	0.31196	-0.00868	1.21416
31	0.6661	0.31478	0.04914	1.28305
33	0.71714	0.31787	0.09414	1.34015
35	0.75511	0.32083	0.1263	1.38392
37	0.77936	0.32359	0.14514	1.41358
39	0.78973	0.32645	0.1499	1.42957
41	0.78637	0.32999	0.13961	1.43313
43	0.76962	0.33486	0.1133	1.42594
45	0.74002	0.34176	0.07017	1.40987
47	0.69824	0.35124	0.00982	1.38665
49	0.64502	0.36362	-0.06766	1.35771
51	0.58118	0.37899	-0.16163	1.32398
53	0.50751	0.39718	-0.27094	1.28596
55	0.42487	0.41786	-0.39413	1.24386
57	0.33412	0.44064	-0.52952	1.19776
59	0.23612	0.46502	-0.6753	1.14754
61	0.13174	0.49048	-0.82958	1.09306
63	0.02178	0.51656	-0.99066	1.03422
65	-0.09299	0.54291	-1.15709	0.9711
67	-0.21185	0.56925	-1.32756	0.90386
69	-0.33416	0.59545	-1.50122	0.8329
71	-0.45933	0.62145	-1.67736	0.75869
73	-0.58687	0.64731	-1.85557	0.68184
75	-0.71634	0.67317	-2.03573	0.60305
77	-0.84739	0.69921	-2.21781	0.52303
79	-0.97977	0.72566	-2.40205	0.4425
81	-1.11328	0.75278	-2.58871	0.36214
83	-1.24771	0.78077	-2.77799	0.28256
85	-1.38286	0.80979	-2.97002	0.20429
87	-1.51853	0.83996	-3.16483	0.12777
89	-1.6545	0.87138	-3.36238	0.05338

Supplemental Material 10. Predicted Exercise Effects on Cardiorespiratory Fitness by METy

METy	pred	se	lower	upper
3	-0.74876	0.57537	-1.87647	0.37895
3.5	-0.6345	0.49239	-1.59956	0.33056
4	-0.51925	0.41855	-1.3396	0.30109
4.5	-0.39748	0.35806	-1.09927	0.30431
5	-0.26033	0.3129	-0.8736	0.35293
5.5	-0.10129	0.28104	-0.65212	0.44954
6	0.07964	0.25988	-0.42972	0.58899
6.5	0.2702	0.25099	-0.22174	0.76214
7	0.44635	0.25563	-0.05468	0.94738
7.5	0.58183	0.26768	0.05718	1.10648
8	0.65789	0.28015	0.10881	1.20697
8.5	0.67116	0.29565	0.0917	1.25062
9	0.63256	0.32578	-0.00597	1.27108
9.5	0.56078	0.37929	-0.18261	1.30417
10	0.47381	0.45419	-0.41639	1.36401

Supplemental Material 11. Predicted Exercise Effects on Cardiorespiratory Fitness by BMI

BMI	pred	se	lower	upper
16	-0.06056	0.38042	-0.80616	0.68504
16.5	-0.02987	0.36129	-0.73799	0.67826
17	0.00083	0.34331	-0.67204	0.6737
17.5	0.03152	0.32664	-0.60867	0.67172
18	0.06221	0.3115	-0.54831	0.67274
18.5	0.09288	0.29809	-0.49136	0.67713
19	0.12353	0.28657	-0.43813	0.68519
19.5	0.15412	0.27701	-0.38881	0.69706
20	0.18465	0.26942	-0.3434	0.7127
20.5	0.21508	0.26366	-0.30168	0.73184
21	0.24538	0.25955	-0.26334	0.7541
21.5	0.27549	0.25689	-0.228	0.77897
22	0.30531	0.25548	-0.19543	0.80604
22.5	0.33471	0.25523	-0.16552	0.83495
23	0.36356	0.25609	-0.13837	0.86549
23.5	0.3917	0.25812	-0.11421	0.89761
24	0.41896	0.26145	-0.09348	0.93139
24.5	0.44515	0.26624	-0.07668	0.96698
25	0.4701	0.27266	-0.0643	1.0045
25.5	0.49365	0.28083	-0.05676	1.04406
26	0.51568	0.29082	-0.05431	1.08567
26.5	0.5361	0.30262	-0.05702	1.12921
27	0.55481	0.31612	-0.06478	1.17439
27.5	0.57173	0.33114	-0.07729	1.22075
28	0.58677	0.34741	-0.09414	1.26768
28.5	0.59983	0.36463	-0.11483	1.3145
29	0.61084	0.38247	-0.13879	1.36047
29.5	0.6197	0.40059	-0.16544	1.40483
30	0.62635	0.41868	-0.19425	1.44694
30.5	0.63076	0.43652	-0.2248	1.48632
31	0.63292	0.45391	-0.25672	1.52256
31.5	0.63282	0.47067	-0.28968	1.55531
32	0.63048	0.48675	-0.32354	1.58449
32.5	0.62597	0.50218	-0.35828	1.61022
33	0.61947	0.51715	-0.39413	1.63307
33.5	0.61118	0.53194	-0.4314	1.65376
34	0.60129	0.54679	-0.47039	1.67297
34.5	0.59	0.56194	-0.51138	1.69137
35	0.5775	0.5776	-0.55458	1.70958
35.5	0.56401	0.59396	-0.60013	1.72815
36	0.54971	0.61115	-0.64813	1.74755

36.5	0.53481	0.62929	-0.69857	1.76819
37	0.5195	0.64842	-0.75138	1.79039
37.5	0.50398	0.66859	-0.80642	1.81439
38	0.48839	0.68976	-0.86351	1.8403

Supplemental Material 12. Predicted Exercise Effects on Cardiorespiratory Fitness by Weight

weight	pred	se	lower	upper
30	-0.46043	0.57225	-1.58202	0.66117
32	-0.41523	0.53545	-1.4647	0.63423
34	-0.37002	0.5005	-1.35098	0.61094
36	-0.32453	0.46782	-1.24144	0.59238
38	-0.27828	0.43785	-1.13646	0.57989
40	-0.23079	0.41095	-1.03624	0.57466
42	-0.18151	0.38737	-0.94075	0.57772
44	-0.12984	0.36719	-0.84951	0.58984
46	-0.07513	0.35025	-0.7616	0.61134
48	-0.01682	0.3362	-0.67576	0.64212
50	0.04553	0.3246	-0.59066	0.68173
52	0.11222	0.315	-0.50517	0.72961
54	0.18337	0.30714	-0.41861	0.78535
56	0.25881	0.30108	-0.33129	0.84892
58	0.33785	0.29734	-0.24493	0.92063
60	0.4193	0.29675	-0.16232	1.00093
62	0.50173	0.30011	-0.08648	1.08994
64	0.58365	0.3079	-0.01983	1.18713
66	0.66357	0.32013	0.03612	1.29102
68	0.74012	0.33636	0.08086	1.39938
70	0.81216	0.35584	0.11472	1.5096
72	0.87881	0.37771	0.13851	1.61912
74	0.93953	0.40122	0.15316	1.7259
76	0.99386	0.42567	0.15955	1.82816
78	1.04133	0.45049	0.15839	1.92428
80	1.08169	0.47523	0.15025	2.01313
82	1.11494	0.49971	0.13553	2.09435
84	1.14118	0.52383	0.11449	2.16786
86	1.16053	0.5476	0.08725	2.23381
88	1.17335	0.5712	0.05382	2.29289
90	1.18008	0.59486	0.01418	2.34599
92	1.18114	0.61883	-0.03175	2.39403
94	1.17697	0.64336	-0.084	2.43793
96	1.16798	0.66867	-0.14258	2.47855
98	1.15462	0.69495	-0.20747	2.51671
100	1.13731	0.72238	-0.27853	2.55315
102	1.11649	0.75108	-0.3556	2.58857
104	1.09257	0.78113	-0.43841	2.62355
106	1.066	0.81257	-0.52661	2.65862
108	1.03721	0.84543	-0.6198	2.69422
110	1.00661	0.87966	-0.7175	2.73072

112	0.97465	0.91522	-0.81914	2.76844
114	0.94172	0.95201	-0.92419	2.80763
116	0.90817	0.98997	-1.03214	2.84848
118	0.87433	1.02901	-1.14248	2.89115
120	0.84046	1.06902	-1.25477	2.9357

Supplemental Material 13. Predicted Exercise Effects on Cardiorespiratory Fitness by Female

female	pred	se	lower	upper
0	0.41654	0.3227	-0.21594	1.04903
5	0.37906	0.2989	-0.20678	0.96491
10	0.3424	0.28283	-0.21194	0.89674
15	0.30736	0.27468	-0.231	0.84571
20	0.27475	0.27314	-0.26059	0.81009
25	0.2454	0.2758	-0.29516	0.78595
30	0.2201	0.27991	-0.32851	0.76871
35	0.19967	0.28316	-0.35531	0.75465
40	0.18449	0.2846	-0.37332	0.74229
45	0.17445	0.28469	-0.38353	0.73242
50	0.16913	0.28482	-0.3891	0.72736
55	0.16728	0.28678	-0.39479	0.72935
60	0.16735	0.29148	-0.40395	0.73865
65	0.16794	0.29878	-0.41766	0.75353
70	0.16792	0.30792	-0.43559	0.77143
75	0.16679	0.31875	-0.45794	0.79153
80	0.1647	0.33228	-0.48655	0.81595
85	0.16184	0.34969	-0.52354	0.84722
90	0.1584	0.37188	-0.57046	0.88726
95	0.15458	0.39915	-0.62774	0.9369
100	0.15056	0.43124	-0.69464	0.99577

Supplemental Material 14. Power Funnel Plots for All Exercise

