

Supplementary Appendix

Effects of exercise on multiple health outcomes in children and adolescents with overweight or obesity: a meta-analysis of 176 randomized controlled trials and its implications for global obesity prevention

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Appendix 1. Search strategy used in each database

Database	Search terms
PubMed	#1 search ("adolescent"[MeSH Terms] OR "children"[Title/Abstract] OR "youngster"[Title/Abstract] OR "teenager"[Title/Abstract] OR "kid"[Title/Abstract] OR "youth"[Title/Abstract] OR "student"[Title/Abstract])
	#2 search ("obesity"[MeSH Terms] OR "adiposity"[Title/Abstract] OR "overweight"[Title/Abstract] OR "fat"[Title/Abstract] OR "body mass index"[Title/Abstract])
	#3 search ("exercise"[MeSH Terms] OR "sport"[Title/Abstract] OR "physical activity"[Title/Abstract] OR "physical training"[Title/Abstract] OR "exercise training"[Title/Abstract] OR "aerobic exercise"[Title/Abstract] OR "resistance training"[Title/Abstract] OR "acute exercise"[Title/Abstract] OR "endurance exercise"[Title/Abstract])
	#4 search ("body mass index"[MeSH Terms] OR "waist circumference"[MeSH Terms] OR "body composition"[MeSH Terms] OR "oxygen consumption"[MeSH Terms] OR "heart rate"[MeSH Terms] OR "blood pressure"[MeSH Terms] OR "blood pressure determination"[MeSH Terms] OR "arterial pressure"[MeSH Terms] OR "cholesterol"[MeSH Terms] OR "triglycerides"[MeSH Terms] OR "glucose"[MeSH Terms] OR "insulin"[MeSH Terms] OR "depressive disorder"[MeSH Terms] OR "depression"[MeSH Terms] OR "anxiety"[MeSH Terms] OR "self concept"[MeSH Terms] OR "self-esteem"[MeSH Terms] OR "self-worth"[Title/Abstract])
	#5 Search (#1 AND #2 AND #3 AND #4)
Embase	#1 'adolescent'/exp OR 'adolescent':ab,ti OR 'children':ab,ti OR 'youngster':ab,ti OR 'teenager':ab,ti OR 'kid':ab,ti OR 'youth':ab,ti OR 'student':ab,ti
	#2 'obesity'/exp OR 'obesity':ab,ti OR 'adiposity':ab,ti OR 'overweight':ab,ti OR 'fat':ab,ti OR 'body mass index':ab,ti
	#3 'exercise'/exp OR 'exercise':ab,ti OR 'sport':ab,ti OR 'physical activity':ab,ti OR 'physical training':ab,ti OR 'exercise training':ab,ti OR 'aerobic exercise':ab,ti OR 'resistance training':ab,ti OR 'acute exercise':ab,ti OR 'endurance exercise':ab,ti
	#4 'body mass index'/exp OR 'body mass index':ab,ti OR 'waist circumference'/exp OR 'waist circumference':ab,ti OR 'body composition'/exp OR 'body composition':ab,ti OR 'oxygen consumption'/exp OR 'oxygen consumption':ab,ti OR 'heart rate'/exp OR 'heart rate':ab,ti OR 'blood pressure'/exp OR 'blood pressure':ab,ti OR 'blood pressure determination'/exp OR 'blood pressure determination':ab,ti OR 'arterial pressure'/exp OR 'arterial pressure':ab,ti OR 'cholesterol'/exp OR 'cholesterol':ab,ti OR 'triglycerides'/exp OR 'triglycerides':ab,ti OR 'glucose'/exp OR 'glucose':ab,ti OR 'insulin'/exp OR 'insulin':ab,ti OR 'depressive disorder'/exp OR 'depressive disorder':ab,ti OR 'depression'/exp OR 'depression':ab,ti OR 'anxiety'/exp OR 'anxiety':ab,ti OR 'self concept'/exp OR 'self concept':ab,ti OR 'self esteem'/exp OR 'self esteem':ab,ti OR 'self worth'/exp OR 'self worth':ab,ti
	#5 #1 AND #2 AND #3 AND #4
Cochrane	#1 (Adolescent):MeSH OR (adolescent):ti,ab,kw OR (children):ti,ab,kw OR (youngster):ti,ab,kw OR (teenager):ti,ab,kw OR (kid):ti,ab,kw OR (youth):ti,ab,kw OR (student):ti,ab,kw
	#2 (Obesity):MeSH OR (obesity):ti,ab,kw OR (adiposity):ti,ab,kw OR (overweight):ti,ab,kw OR (fat):ti,ab,kw OR (body mass index):ti,ab,kw
	#3 (Exercise):MeSH OR (exercise):ti,ab,kw OR (sport):ti,ab,kw OR (physical activity):ti,ab,kw OR (physical training):ti,ab,kw OR (exercise training):ti,ab,kw OR (aerobic exercise):ti,ab,kw OR (resistance training):ti,ab,kw OR (acute exercise):ti,ab,kw OR (endurance exercise):ti,ab,kw
	#4 (Body mass index):MeSH OR (body mass index):ti,ab,kw OR (Waist circumference):MeSH OR (waist circumference):ti,ab,kw OR (Body composition):MeSH OR (body composition):ti,ab,kw OR (Oxygen consumption):MeSH OR (oxygen consumption):ti,ab,kw OR (Heart rate):MeSH OR (heart rate):ti,ab,kw OR (Blood pressure):MeSH OR (blood pressure):ti,ab,kw OR (Blood pressure determination):MeSH OR (blood pressure determination):ti,ab,kw OR (Arterial pressure):MeSH OR (arterial pressure):ti,ab,kw OR (Cholesterol):MeSH OR (cholesterol):ti,ab,kw OR (Triglycerides):MeSH OR (triglycerides):ti,ab,kw OR (Glucose):MeSH OR (glucose):ti,ab,kw OR (Insulin):MeSH OR (insulin):ti,ab,kw OR (Depressive disorder):MeSH OR (depressive disorder):ti,ab,kw OR (Depression):MeSH OR (depression):ti,ab,kw OR (Anxiety):MeSH OR (anxiety):ti,ab,kw OR (Self concept):MeSH OR (self concept):ti,ab,kw OR (Self esteem):MeSH OR (self esteem):ti,ab,kw OR (Self worth):MeSH OR (self worth):ti,ab,kw
	#5 #1 AND #2 AND #3 AND #4

Database	Search terms
Web of Science	#1 (TS=(adolescent) OR TS=(children) OR TS=(youngster) OR TS=(teenager) OR TS=(kid) OR TS=(youth) OR TS=(student)) NOT (SILOID=="PPRN") OR SILOID=="RC")) #2 (TS=(obesity) OR TS=(adiposity) OR TS=(overweight) OR TS=(fat) OR TS=(body mass index)) NOT (SILOID=="PPRN") OR SILOID=="RC")) #3 (TS=(exercise) OR TS=(sport) OR TS=(physical activity) OR TS=(physical training) OR TS=(exercise training) OR TS=(aerobic exercise) OR TS=(resistance training) OR TS=(acute exercise) OR TS=(endurance exercise)) NOT (SILOID=="PPRN") OR SILOID=="RC")) #4 (TS=(body mass index) OR TS=(waist circumference) OR TS=(body composition) OR TS=(oxygen consumption) OR TS=(heart rate) OR TS=(blood pressure) OR TS=(blood pressure determination) OR TS=(arterial pressure) OR TS=(cholesterol) OR TS=(triglycerides) OR TS=(glucose) OR TS=(insulin) OR TS=(depressive disorder) OR TS=(depression) OR TS=(anxiety) OR TS=(self concept) OR TS=(self-esteem) OR TS=(self-worth)) NOT (SILOID=="PPRN") OR SILOID=="RC")) #5 (TS=(clinical trials) OR TS=(randomized controlled trial) OR TS=(controlled clinical trial) OR TS=(randomized) OR TS=(placebo) OR TS=(randomly)) NOT (SILOID=="PPRN") OR SILOID=="RC")) #6 #1 AND #2 AND #3 AND #4 AND #5
CNKI	(SU="儿童青少年" OR SU="儿童" OR SU="青少年") AND (SU="运动" OR SU="有氧运动" OR SU="体育运动" OR SU="身心锻炼" OR SU="力量训练" OR SU="抗阻运动" OR SU="急性运动" OR SU="体育锻炼") AND (SU="肥胖" OR SU="超重") AND (SU="身体形态" OR SU="身体成分" OR SU="心肺机能" OR SU="心肺适能" OR SU="心肺功能" OR SU="有氧能力" OR SU="心肺耐力" OR SU="生化指标" OR SU="血脂代谢" OR SU="代谢" OR SU="脂蛋白" OR SU="胆固醇" OR SU="高密度脂蛋白" OR SU="低密度脂蛋白" OR SU="空腹血糖" OR SU="心理健康" OR SU="心理亚健康" OR SU="身心健康" OR SU="焦虑" OR SU="抑郁" OR SU="情绪" OR SU="自尊" OR SU="自我价值")
Wanfang Data	(主题:"儿童青少年" or 主题:"儿童" or 主题:"青少年") and (主题:"运动" or 主题:"有氧运动" or 主题:"体育运动" or 主题:"身心锻炼" or 主题:"力量训练" or 主题:"抗阻运动" or 主题:"急性运动" or 主题:"体育锻炼") and (主题:"肥胖" or 主题:"超重") and (主题:"身体形态" or 主题:"身体成分" or 主题:"心肺机能" or 主题:"心肺适能" or 主题:"心肺功能" or 主题:"有氧能力" or 主题:"心肺耐力" or 主题:"生化指标" or 主题:"血脂代谢" or 主题:"代谢" or 主题:"脂蛋白" or 主题:"胆固醇" or 主题:"高密度脂蛋白" or 主题:"低密度脂蛋白" or 主题:"空腹血糖" or 主题:"心理健康" or 主题:"心理亚健康" or 主题:"身心健康" or 主题:"焦虑" or 主题:"抑郁" or 主题:"情绪" or 主题:"自尊" or 主题:"自我价值")

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Appendix 2. Methodological details for risk of bias assessment and certainty assessment

Risk of bias assessment

We adhered to the comprehensive guidelines provided by the Cochrane Risk of Bias Tool for Randomised Trials (RoB 2) to evaluate the risk of bias across each outcome in the included studies. Utilizing response options: Yes (Y), Probably yes (PY), Probably no (PN), No (N), and No information (NI), we responded to the signalling questions within each domain of risk of bias to reach an overall risk-of-bias judgment for each domain (see below) The responses to the signalling questions feed into algorithms that were developed to guide users of the tools to proposed judgments about the overall risk-of-bias judgment for each domain. The risk-of-bias assessments were categorized into the following levels: low risk, some concerns, and high risk.

Risk of bias domains and signalling questions according to RoB 2:

(1) Randomisation process

- (1.1) Was the allocation sequence random?
- (1.2) Was the allocation sequence concealed until participants were enrolled and assigned to interventions?
- (1.3) Did baseline differences between intervention groups suggest a problem with the randomisation process?

(2) Deviations from intended interventions (effect of assignment to intervention/ITT)

- (2.1) Were participants aware of their assigned intervention during the trial?
- (2.2) Were carers and people delivering the interventions aware of participants' assigned intervention during the trial?
- (2.3) If Y/PY/NI to 2.1 or 2.2: Were there deviations from the intended intervention that arose because of the trial context?
- (2.4) If Y/PY to 2.3: Were these deviations likely to have affected the outcome?
- (2.5) If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups? (2.6) Was an appropriate analysis used to estimate the effect of assignment to intervention?
- (2.7) If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyse participants in the group to which they were randomised?

(2) Deviations from intended interventions (effect of adhering to intervention/PP)

- (2.1) Were participants aware of their assigned intervention during the trial?
- (2.2) Were carers and people delivering the interventions aware of participants' assigned intervention during the trial?
- (2.3) Were there failures in implementing the intervention that could have affected the outcome?
- (2.4) Y/PY/NI to 2.3: Was an appropriate analysis used to estimate the effect of adhering to intervention?

(3) Missing outcome data

- (3.1) Were data for this outcome available for all, or nearly all, participants randomised?
- (3.2) If N/PN/NI to 3.1: Is there evidence that the result was not biased by missing outcome data? (3.3) If N/PN to 3.2: Could missingness in the outcome depend on its true value?

(3.4) If Y/PY/NI to 3.3: Is it likely that missingness in the outcome depended on its true value?

(4) Measurement of the outcome

(4.1) Was the method of measuring the outcome inappropriate?

(4.2) Could measurement or ascertainment of the outcome have differed between intervention groups?

(4.3) If N/PN/NI to 4.1 and 4.2: Were outcome assessors aware of the intervention received by study participants?

(4.4) If Y/PY/NI to 4.3: Could assessment of the outcome have been influenced by knowledge of intervention received?

(4.5) If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?

(5) Selection of the reported result

(5.1) Were the data that produced this result analysed in accordance with a pre-specified analysis plan that was finalised before unblinded outcome data were available for analysis?

(5.2) Is the numerical result being assessed likely to have been selected, on the basis of the results, from multiple eligible outcome measurements (e.g., scales, definitions, time points) within the outcome domain?

(5.3) Is the numerical result being assessed likely to have been selected, on the basis of the results, from multiple eligible analyses of the data?

Certainty assessment:

We followed the detailed guidance given by the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) Handbook to assess the certainty in the body of evidence for each outcome. The certainty of the evidence, as defined by the GRADE Working Group, reflects the extent to which we are confident that an effect estimate is correct and refers to an assessment of how good an indication the research provides of the likely effect. Regarding to randomized controlled trials, we initiated our assessment with the assumption of high certainty, which we then adjusted based on five GRADE criteria: study limitations, inconsistency, indirectness, imprecision, and publication bias, each of which could potentially downgrade the evidence's certainty. The intended interpretation of each level of certainty is provided in the subsequent sections.

Factors/reasons for downgrading the certainty of the evidence included risk of bias, inconsistency, indirectness, imprecision, and publication bias.

The four grades of certainty of the evidence were:

(1) High: further research is unlikely to change the confidence in the effect estimate.

(2) Moderate: further research is likely to have an important impact on the confidence in the effect estimate and may change the estimate.

(3) Low: further research is very likely to have an important impact on the confidence in the effect estimate and is likely to change the estimate.

(4) Very low: any effect estimate is very uncertain.

Appendix 3. Distribution of included studies and participants by country (32 countries, 176 studies, 11 696 participants)

A total of 176 studies comprising 11 696 participants from 32 countries were included in this systematic review and meta-analysis. The number of included studies and participants per country were as follows: China (39 studies, 2 723 participants), United States (34, 2 420), Brazil (14, 657), South Korea (13, 468), Iran (12, 657), Tunisia (10, 371), Spain (6, 359), Australia (5, 206), Canada (4, 1 015), United Kingdom (4, 193), Belgium (3, 124), New Zealand (3, 322), Switzerland (3, 609), Denmark (2, 141), Estonia (2, 56), France (2, 72), Israel (2, 220), Norway (2, 84), Serbia (2, 79), Turkey (2, 79), Chile (1, 274), Egypt (1, 30), Germany (1, 67), India (1, 69), Italy (1, 70), Mexico (1, 105), Poland (1, 22), Portugal (1,40), Saudi Arabia (1, 27), Singapore (1,24), Sweden (1, 76), Thailand (1, 37).

Appendix 4. Supplementary tables and figures

Table S1. The detailed basic characteristics of the included studies(N=176)

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Abassi et al.	2020	Tunisia	Overweight and obesity	15.11 to 17.57	16.9±1.64	16(0/16)	8(0/8)	Mode of motion: running Exercise time:55 min Exercise frequency: three times per week Exercise intensity:70-80% or 100-110% of MAS	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,8,14,15
Abassi et al.	2022	Tunisia	Overweight and obesity	16.7±0.20	16.7±0.20	26(0/26)	12(0/12)	Mode of motion: running Exercise time:40 min Exercise frequency: three times per week Exercise intensity:100-110% or 70-80% of MAS	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,6,7,8
Abassi et al.	2023	Tunisia	Overweight and Obesity	16.4±1.2	16.4±1.2	26(0/26)	12(0/12)	Mode of motion: HIIT and MIIT Exercise time:42 min Exercise frequency: three times per week Exercise intensity:100-110% or 70-80% MAS	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3
Aguilar-Cordero et al.	2020	Spain	Overweight and obesity	10.43±1.35	10.43±1.35	49	49	Mode of motion: aerobic exercise Exercise time:90 min Exercise frequency: four times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	36 weeks	36 weeks	3,6,7
Ahmadi et al.	2020	Iran	Overweight and obesity	11.09-17.10	12.70±2.64	86(31/55)	27(14/13)	Mode of motion: HIIT and resistance training Exercise time:50 min Exercise frequency: three times per week Exercise intensity: medium or high intensity	Mode of motion: daily activities	8 weeks	8 weeks	1,2,10,11,12,13
Alberga et al.	2016	Canada	Obesity	14.1 to 17.4	15.6±1.3	228	76	Mode of motion: cycling, running and strength training Exercise time:20-45/ 30-40 min Exercise frequency: four times per week Exercise intensity:70-85% HRmax	Mode of motion: daily activities	22 weeks	22 weeks	5
Alves et al.	2019	Portugal	Overweight and obesity	14.77±1.49	14.77±1.49	30	10	Mode of motion: aerobic and strength training Exercise time:60 min Exercise frequency: two or three times per week Exercise intensity:75%VO ₂ max	Mode of motion: daily activities	10 weeks	10 weeks	1,3,4

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Azad et al.	2011	Iran	Overweight and obesity	16.53±0.83	16.6±0.81	15(15/0)	15(15/0)	Mode of motion: running Exercise time:30 min Exercise frequency: three times per week Exercise intensity:75-85%VO ₂ max	Mode of motion: daily activities	24 weeks	24 weeks	1
Barbeau et al.	2007	American	Overweight	8-12	8-12	118(0/118)	83(0/83)	Mode of motion: physical activity Exercise time:80 min Exercise frequency: five times per week Exercise intensity: above 150 bpm HR	Mode of motion: daily activities	40 weeks	40 weeks	1,2,3
Ben et al.	2010	Tunisia	Obesity	13.1±0.8	13.3±0.6	14(7/7)	14(7/7)	Mode of motion: aerobic exercise Exercise time:90 min Exercise frequency: four times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	8 weeks	8 weeks	1,3
Benson et al.	2008	New Zealand	Overweight and Obesity	12.3±1.3	12.2±1.3	32	38	Mode of motion: resistance training Exercise time:60 min Exercise frequency: two times per week Exercise intensity: high intensity	mode of motion: daily activities	8 weeks	8 weeks	1,2,5,10,12,13,14,15
Bezerra et al.	2023	Brazil	Overweight	7.9±1.0	7.9±1.0	20	21	Mode of motion: physical activity Exercise time:60 min Exercise frequency: three times per week Exercise intensity: medium and high intensity	Mode of motion: daily activities	10 weeks	10 weeks	1,2,6,7,10,11,12,13,14
Bharath et al.	2018	America	Obesity	14.6±1.0	14.8±1.0	20(0/20)	20(0/20)	Mode of motion: resistance and aerobic exercise Exercise time:60 min Exercise frequency: five times per week Exercise intensity:40-70%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,4,6,7,9,14,15
Boer et al.	2014	Belgium	Overweight	13.1-21.2	17.4±2.4	32(21/11)	14(9/5)	Mode of motion: cycling Exercise time:40 min Exercise frequency: two times per week Exercise intensity: medium and high intensity	Mode of motion: daily activities	15 weeks	15 weeks	1,2,3,6,7,10,11,12,13,14
Boff et al.	2020	Brazil	Overweight and Obesity	16.42±1.17	16.46±1.01	34	31	Mode of motion: physical exercise Exercise time:30 min Exercise frequency: one time per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,2,6,7,11,12,13,20

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Bowen et al.	2010	China	Overweight and Obesity	12-16	12-16	22	18	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: above three times per week Exercise intensity:50-60%VO ₂ max	Mode of motion: daily activities	10 weeks	10 weeks	1,3,10,11,12,13,14,15
Brennan et al.	2012	Australia	Overweight and Obese	14.3±1.9	14.3±1.9	42	21	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: once a week Exercise intensity: medium and low intensity	Mode of motion: daily activities	24 weeks	24 weeks	16,17,19
Bruyndonckx et al.	2015	Belgium	Obesity	15.4±1.5	15.1±1.2	27	21	Mode of motion: aerobic exercise and resistance training Exercise time:40 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	40 weeks	40 weeks	1,3,6,7,10,12,13
Cao et al.	2022	China	Obesity	11.2±0.7	10.9±0.4	20(10/10)	20(10/10)	Mode of motion: running Exercise time:38 min Exercise frequency: three times per week Exercise intensity:100% of MAS	Mode of motion: daily activities	12 weeks	12 weeks	1,3,4,8,9
Carrel et al.	2005	American	Obesity	12.5±0.5	12.5±0.7	27(13/14)	23(13/10)	Mode of motion: aerobic exercise Exercise time:45 min Exercise frequency: five times every two weeks Exercise intensity: medium and low intensity	Mode of motion: daily activities	36 weeks	36 weeks	1,3,4,14,15
Chae et al.	2010	Korea	Obesity	10.4±3.1	10.6±3.8	19(11/8)	19(10/9)	Mode of motion: aerobic exercise and resistance training Exercise time:90 min Exercise frequency: two times per week Exercise intensity: medium and high intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,3,4,10,11,12,13
Chuensiri et al.	2018	Thailand	Obesity	10.7-11.3	10.6±0.3	26(26/0)	11(11/0)	Mode of motion: cycling Exercise time:23 min Exercise frequency: three times per week Exercise intensity:90% or 170% of peak power output	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,5,6,7,10,11,12,13
CROKER et al.	2012	UK	Overweight and Obesity	10.8±1.6	9.8±1.4	33	30	Mode of motion: physical activity Exercise time:90 min Exercise frequency: everyday Exercise intensity: medium and low intensity	Mode of motion: daily activities	24 weeks	24 weeks	1,2,16,17

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Crova et al.	2014	Italy	Overweight	9.6±0.5	9.6±0.5	37(20/17)	33(15/18)	Mode of motion: tennis-specific training Exercise time:120 min Exercise frequency: one time per week Exercise intensity: average heart rate 150.5±6.4	Mode of motion: daily activities	21 weeks	21 weeks	1,4,8
Cvetković et al.	2018	Serbia	Overweight and obesity	11-13	11-13	21(21/0)	14(14/0)	Mode of motion: football training and running Exercise time:60 or 38 min Exercise frequency: three times per week Exercise intensity:100% of MAS	Mode of motion: daily activities	12 weeks	12 weeks	1,3,6,7,8,9
Daley et al.	2006	UK	Obesity	11-16	11-16	49	26	Mode of motion: aerobic exercise and light body-conditioning/stretching exercises Exercise time:30 min Exercise frequency: three times per week Exercise intensity: < 59% of HR reserve	Mode of motion: daily activities	8 weeks	8 weeks	9,16,18
Danielsen et al.	2013	Norway	Obesity	10.68±1.24	10.68±1.24	22	20	Mode of motion: body activity Exercise time:30 min Exercise frequency: everyday Exercise intensity: medium and low intensity	Mode of motion: daily activities	12 weeks	12 weeks	16,18
Davis et al.(1)	2009	America	Overweight	15.5±1.0	15.5±1.0	17(8/9)	21(11/10)	Mode of motion: strength training Exercise time:60 min Exercise frequency: two times per week Exercise intensity: medium and high intensity	Mode of motion: daily activities	16 weeks	16 weeks	1,14,15
DAVIS et al.(2)	2009	America	Overweight	13.8-16.9	15.3±1.1	24(0/24)	10(0/10)	Mode of motion: cardiovascular activity and strength training Exercise time:60 min Exercise frequency: two times per week Exercise intensity: medium and high intensity	Mode of motion: daily activities	16 weeks	16 weeks	1,14,15
Davis et al.	2020	America	Overweight and obesity	9.6±0.73	9.7±0.94	90(23/67)	85(30/55)	Mode of motion: aerobic exercise Exercise time:40 min Exercise frequency: five times per week Exercise intensity:>140 beats per minute	Mode of motion: sedentary activities	32 weeks	32 weeks	1,2,3,5,6,7,10,11,12,13,14,15
DeBar et al.	2012	America	Overweight	14.12±1.48	14.03±1.50	100(0/100)	95(0/95)	Mode of motion: Yoga, Dance Video Games and aerobic training Exercise time:30-60 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	24 weeks	24 weeks	10,11,12,13,14,17

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Dennis et al.	2013	America	Overweight and obesity	9,3±1.1	9,3±1.1	70	42	Mode of motion: aerobic exercise Exercise time:20 or 40 min Exercise frequency: five times per week Exercise intensity:167±7 beats per minute	Mode of motion: daily activities	13 weeks	13 weeks	1,2,3,5
Dias et al.	2018	Australia	Obesity	9,5-14,3	11,8±2.4	41	21	Mode of motion: running Exercise time:25 or 44 min Exercise frequency: three times per week Exercise intensity:60%-95%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,3,5,10,11,12,13,14,20
Duft et al.	2020	Brazil	Overweight and obesity	14,44±1.04	14,72±1.07	18(9/9)	19(9/10)	Mode of motion: resistance training and aerobic training Exercise time:60 min Exercise frequency: three times per week Exercise intensity:50-85%VO ₂ peak	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,5,10,14
Elmahgoub et al.	2009	Belgium	Overweight and obesity	14-22	14-22	15	15	Mode of motion: strength and endurance exercises Exercise time:50 min Exercise frequency: three times per week Exercise intensity:60-75%HRmax	Mode of motion: daily activities	10 weeks	10 weeks	1,2,5,10,11,12,13
Elnaggar et al.	2021	Saudi Arabia	Obesity	12,69±2.53	13,36±2.17	13	14	Mode of motion: aerobic exercise Exercise time:25-60 min Exercise frequency: three times per week Exercise intensity: 40-80% of HRmax	Mode of motion: daily activities	8 weeks	8weeks	5,8
Eskandari et al.	2020	Iran	Overweight and obesity	15,4±1.1	15,4±1.1	24(24/0)	12(12/0)	Mode of motion: jump rope exercise Exercise time:40 min Exercise frequency: five times per week Exercise intensity:60-90 jumps/min	Mode of motion: daily activities	6 weeks	6 weeks	1
Espinoza-Silva et al.	2019	Chile	Overweight and obesity	8,12±1.50	8,12±1.50	210	64	Mode of motion: HIIT Exercise time:40-50 min Exercise frequency: two times per week Exercise intensity: high intensity	Mode of motion: daily activities	28 weeks	28 weeks	1,2,3,6,7
Faria et al.	2020	Brazil	Overweight	14,6-17,1	16,5±1.0	50(21/29)	26(11/15)	Mode of motion: running and resistance training Exercise time:53 or 47 min Exercise frequency: two times per week Exercise intensity:55%-65% or 90%VO ₂ max	Mode of motion: daily activities	12 weeks	12 weeks	2,3,5,6,7,10,11,12,13,14,15,20

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Farpour-Lambert et al.	2009	Switzerland	Obesity	9.1±1.4	8.8±1.6	22(9/13)	22(7/15)	Mode of motion: aerobic exercises and strengthening exercises Exercise time:60 min Exercise frequency: three times per week Exercise intensity:55-65%VO ₂ max	Mode of motion: daily activities	12 weeks	12 weeks	1,3,4,6,7,10,11,12,13,14,15
Farpour-Lambert et al.	2019	Switzerland	Obesity	8.3-10.8	9.7±1.0	47	19	Mode of motion: aerobic exercises and resistance training Exercise time:60 min Exercise frequency: two times per week Exercise intensity: medium or high intensity	Mode of motion: daily activities	24 weeks	24 weeks	1,2,3
Ghorbanian et al.	2013	Iran	Overweight and obesity	17.35±1.07	16.90±1.15	15(15/0)	15(15/0)	Mode of motion: endurance rope training Exercise time:40 min Exercise frequency: four times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	8 weeks	8 weeks	1,3,4,10,11,12,13,14
Goldfield et al.	2015	Canada	Obesity	14-17	15.6±1.3	228(67/161)	76(24/52)	Mode of motion: aerobic exercise and resistance training Exercise time:20-45 min Exercise frequency: four times per week Exercise intensity:65-85%HRmax	Mode of motion: daily activities	22 weeks	22 weeks	16,17,18
Gonzalez-Galvez et al.	2024	Spain	Overweight and Obesity	12.51±0.75	12.51±0.75	20	12	Mode of motion: sprint interval training Exercise time:12 min Exercise frequency: twice per week Exercise intensity:80%-85%/90%-95%HRmax	Mode of motion: daily activities	8 weeks	8 weeks	1,3,4,6,7
Guijun	2009	China	Obesity	11.76-12.67	12.56±0.25	16	10	Mode of motion: aerobic exercise Exercise time:70-90 min Exercise frequency: three-four times per week Exercise intensity:50-70%HRmax	Mode of motion: daily activities	24 weeks	24 weeks	1,6,7,10,11,12,13
Gulijianati et al.	2022	China	Overweight	10.76±1.35	10.35±1.69	47(29/18)	46(27/19)	Mode of motion: aerobic exercise Exercise time:40 min Exercise frequency: four times per week Exercise intensity:140-160 beats per minute	Mode of motion: daily activities	12 weeks	12 weeks	1,3,10,11,12,13,14,15
Guo et al.	2015	China	Overweight and obesity	8-10	8-10	23	12	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: unclear Exercise intensity:70-80%HRmax	Mode of motion: daily activities	48 weeks	48 weeks	1,2,10,11,12,13,14

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Haiying et al.	2023	China	Obesity	15±1.08	15±1.12	20	20	Mode of motion: aerobic exercise Exercise time:110 min Exercise frequency: everyday Exercise intensity: 60% to 80% VO ₂ max	Mode of motion: daily activities	4 weeks	4 weeks	3
Hamila et al.	2018	Tunisia	Overweight and obesity	13.3-15.5	14.5±0.9	23(9/14)	8(3/5)	Mode of motion: walking Exercise time:60 min Exercise frequency: three times per week Exercise intensity:95-159 beats per minute	Mode of motion: daily activities	8 weeks	8 weeks	1,2,3,4,6,7,9
Harder-Lauridsen et al.	2014	Denmark	Overweight	8.8±0.9	8.7±0.9	18	17	Mode of motion: aerobic and resistance exercise Exercise time:105 min Exercise frequency: one time per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	20 weeks	20 weeks	1,2,3,6,7,9,10,11,12,13,14,20
Hay et al.	2016	Canada	Overweight and obesity	13.3-17.0	15.2±1.7	70(12/58)	33	Mode of motion: running Exercise time:30-45 min Exercise frequency: three times per week Exercise intensity:40-55% or 70-85%HRmax	Mode of motion: daily activities	24 weeks	24 weeks	2,3,5
Heidarianpour et al.	2023	Iran	Overweight and obesity	8.51±0.44	8.35±0.59	15(0/15)	15(0/15)	Mode of motion: aerobic and resistance training Exercise time:60 min Exercise frequency: three times per week Exercise intensity:55-65% of individual maximal cardiorespiratory fitness	Mode of motion: daily activities	12 weeks	12 weeks	2,5,6,7,9,16,19
Hong et al.	2016	China	Obesity	8.3±5.4	8.4±5.9	55	55	Mode of motion: running, skipping rope and ball sports Exercise time:60 min Exercise frequency: everyday Exercise intensity: medium and low intensity	Mode of motion: daily activities	unclear	unclear	1,10,11
Hongling et al.	2012	China	Obesity	13-14	13-14	30(30/0)	30(30/0)	Mode of motion: aerobic and resistance exercise Exercise time:60-70 min Exercise frequency: two times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	8 weeks	8 weeks	1,3,4,6,7,9,10,11,12,13,14
Horner et al.	2015	America	Obesity	12.7-16.5	14.9±1.8	50	16	Mode of motion: aerobic or resistance exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity: 60-75%VO ₂ max or 8-12RM	Mode of motion: daily activities	12 weeks	12 weeks	6,7,10,11,12,13

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group		
Jain et al.	2022	Indian	Overweight and obesity	11.7±1.7	11.4±1.8	41	28	Mode of motion: yoga Exercise time:60 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	18 weeks 18 weeks	1,2,6,7,9
Jelalian et al.	2011	America	Obesity	13-16	13-16	44	45	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: one time per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	16 weeks 16 weeks	1
Jelalian et al.	2019	American	Overweight and obesity	15.25±1.51	14.44±1.67	24(7/17)	9(2/7)	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: once a week Exercise intensity: medium and low intensity	Mode of motion: Cognitive Behavioral Therapy	24 weeks 24 weeks	1,16
Jiafen et al.	2017	China	Obesity	6.0-13.0	6.0-12.0	78(44/34)	78(46/32)	Mode of motion: aerobic exercise Exercise time:60-90 min Exercise frequency: six-twelve times per week Exercise intensity:60-70%HRmax	Mode of motion: daily activities	10 weeks 10 weeks	14
Jian et al.	2014	China	Obesity	19.8±2.5	19.8±2.5	44(0/44)	44(0/44)	Mode of motion: belly dance Exercise time:60 min Exercise frequency: five times per week Exercise intensity:60-80%HRmax	Mode of motion: daily activities	16 weeks 16 weeks	1,2,6,7,9,10,11,12,13
Jianjun et al.	2012	China	Obesity	18.24±1.57	18.28±1.02	20(20/0)	15(15/0)	Mode of motion: swimming and brisk walking and running Exercise time:120-130 min Exercise frequency: six times per week Exercise intensity:3-7MET	Mode of motion: daily activities	12 weeks 12 weeks	1,2,3,10,11,12,13,14,15
Julian et al.	2022	France	Obesity	11.9-14.1	13.2±1.0	38	11	Mode of motion: cycling training Exercise time:15 or 45 min Exercise frequency: two times per week Exercise intensity:60% or 75-90%VO ₂ max	Mode of motion: daily activities	16 weeks 16 weeks	1,3
Jun et al.	2006	China	Obesity	8-12	8-12	68	63	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: five time per week Exercise intensity: 65%HRmax	Mode of motion: daily activities	12 weeks 12 weeks	3,10,11,12,13,14

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Kai et al.	2024	China	Obesity	14.8±0.8	15.0±0.8	20(0/20)	24(0/24)	Mode of motion: jump rope and taekwondo Exercise time:50 min Exercise frequency: five times per week Exercise intensity:40%~70%HRR	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,4,6,7
Karacabey	2009	Turkey	Obesity	11.8±0.5	11.2±0.8	20(20/0)	20(20/0)	Mode of motion: walking and jogging Exercise time:30-65 min Exercise frequency: three times per week Exercise intensity:60-65%HRR	Mode of motion: daily activities	12 weeks	12 weeks	1,12,13
Ke et al.	2024	China	Obesity	16.7±0.7	16.6±0.8	10	10	Mode of motion: HIIT Exercise time:60 min Exercise frequency: three times per week Exercise intensity: 65%-80%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,10,11,12,13,14
Kelishadi et al.	2008	Iran	Obesity	7.7±1.2	7.7±1.2	45	47	Mode of motion: physical training Exercise time:40 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	24 weeks	24 weeks	1,2,6,7,10,11,12,13,14
Kelly et al.	2004	America	Overweight	11.0±0.63	11.0±0.71	10	10	Mode of motion: aerobic exercise Exercise time:40 min Exercise frequency: four times per week Exercise intensity:50-80% of VO ₂ peak	Mode of motion: daily activities	8 weeks	8 weeks	1,3,5,6,7,10,11,12,13,14,15
Kelly et al.	2019	America	Obesity	15.29±0.95	15.58±0.99	13(13/0)	13(13/0)	Mode of motion: resistance exercise Exercise time: ≤60 min Exercise frequency: two times per week Exercise intensity:62-97%1RM	Mode of motion: daily activities	16 weeks	16 weeks	14
Khan et al.	2014	America	Overweight and obesity	8.8±0.5	8.8±0.6	46	42	Mode of motion: aerobic exercise Exercise time:70 min Exercise frequency: five times per week Exercise intensity: medium and high intensity	Mode of motion: daily activities	36weeks	36weeks	1,3,4
Kim et al.	2007	Korea	Obesity	17±0.11	17±0.11	14(14/0)	12(12/0)	Mode of motion: jump rope exercise training Exercise time:40 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	6 weeks	6 weeks	1,2,3,6,7,9,10,11,12,13,14,15

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Kim et al.	2011	Korea	Obesity	12.7±0.2	12.6±0.2	12(12/0)	10(10/0)	Mode of motion: aerobic exercise Exercise time:50 min Exercise frequency: three times per week Exercise intensity:60-70%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,6,7
Kim et al.	2020	America	Obesity	15±1	15±1	24(0/24)	24(0/24)	Mode of motion: jump rope exercise Exercise time:50 min Exercise frequency: five times per week Exercise intensity:40-70%HRR	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,6,7,14,15
Kim et al.	2022	Korea	Overweight and obesity	16-18	16-18	13(0/13)	13(0/13)	Mode of motion: aerobic and resistance exercise Exercise time:50 min Exercise frequency: three times per week Exercise intensity:55-75%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,10,11,12,13,14
Lambrick et al.	2016	UK	Obesity	9.3±0.8	9.4±0.8	15(10/5)	14(7/7)	Mode of motion: active games Exercise time:40 min Exercise frequency: two times per week Exercise intensity: high intensity	Mode of motion: daily activities	6 weeks	6 weeks	1,2,3,4,5,8
Larsen et al.	2016	Denmark	Overweight and obesity	12±0.4	12±0.4	55	51	Mode of motion: Fun Sports Exercise time:180 min Exercise frequency: seven times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	6 weeks	6 weeks	1,2,3,6,11
Lee et al.	2010	Korea	Obesity	12-14	12-14	36	18	Mode of motion: aerobic and resistance training exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity:60-80%VO ₂ max	Mode of motion: daily activities	10 weeks	10 weeks	1,2,4,6,10,11,12,13,14
Lee et al.	2012	America	Obesity	13.1-17.1	14.8±1.4	31(31/0)	11(11/0)	Mode of motion: aerobic and resistance exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity:50-75%VO ₂ peak or 60% of baseline repetition maximum	Mode of motion: daily activities	12 weeks	12 weeks	1,2,5,14,15
Lee et al.	2013	America	Obesity	12.7-16.7	15.0±2.2	28(0/28)	8(0/8)	Mode of motion: running and body exercises Exercise time:60 min Exercise frequency: three times per week Exercise intensity:60-75%VO ₂ peak	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,5,14,15

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Lee et al.	2016	Korea	Obesity	9-12	9-12	15(4/11)	15(12/3)	Mode of motion: fun health sports Exercise time: unclear Exercise frequency: unclear Exercise intensity: medium and low intensity	Mode of motion: daily activities	10 weeks	10 weeks	1,17
Liangmei et al.	2015	China	Obesity	13-14	13-14	12(6/6)	12(6/6)	Mode of motion: aerobic exercise Exercise time:50 min Exercise frequency: three times per week Exercise intensity:60%-70%VO ₂ peak	Mode of motion: daily activities	24 weeks	24 weeks	1,2,10,11,12,13
Lidan et al.	2012	China	Obesity	10±2.4	10±2.4	30	30	Mode of motion: aerobic exercise Exercise time: 60 min Exercise frequency: five times per week Exercise intensity: 140-160 beats/min of HR	Mode of motion: daily activities	12 weeks	12 weeks	10,11,14
Lima et al.	2020	Switzerland	Overweight and obesity	9.01±0.45	9.01±0.45	293	206	Mode of motion: aerobic and strength exercises Exercise time:45 min Exercise frequency: two times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	36 weeks	36 weeks	11,14
Lingling	2021	China	Overweight and obesity	16.1±1.2	15.9±1.2	20(20/0)	20(20/0)	Mode of motion: running Exercise time:33-78 min Exercise frequency: three times per week Exercise intensity:100-110%MAP	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,4,8,10,11,12,13
Liqun et al.	2014	China	Overweight and obesity	7-11	7-11	76(40/36)	97(53/44)	Mode of motion: unclear Exercise time:10 min Exercise frequency: ten times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	48 weeks	48 weeks	1,2,6,7,10,11,12,13
Lira et al.	2017	Brazil	Obesity	13.6-16.30	14.72±1.35	51	33	Mode of motion: running Exercise time:34-58 min Exercise frequency: three times per week Exercise intensity: medium or high intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,10,11,12,13,14,15
Liu et al.	2018	China	Obesity	14.6±0.7	14.7±0.8	30(0/30)	20(0/20)	Mode of motion: aerobic exercises Exercise time:120 min Exercise frequency: twelve times per week Exercise intensity:100-140 beats per minute	Mode of motion: daily activities	4 weeks	4 weeks	1,2,10,11,12,13,14,15

Author	Year	Country	Weight status	Age	Sample		Intervention measure		Intervention duration	Outcome indicator		
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group				control group
Lofrano-Prado et al.	2022	Brazil	Obesity	15±1	15±1	37(17/20)	37(17/20)	Mode of motion: recreational physical activity Exercise time:60 min Exercise frequency: two times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	12 weeks	12 weeks	2,3,16
Lopes et al.	2016	Brazil	Overweight	14.6±1.15	14.4±1.16	17(0/17)	16(0/16)	Mode of motion: resistance and aerobic training Exercise time:60 min Exercise frequency: three times per week Exercise intensity:50-85%VO ₂ peak	Mode of motion: daily activities	12 weeks	12 weeks	1,3,5,10,11,12,13,14,15
Luo et al.	2013	China	Obesity	11.11-12.93	11.22-13.26	95(52/43)	72(38/34)	Mode of motion: aerobic exercise Exercise time:180 min Exercise frequency: twelve times per week Exercise intensity:120-150 beats per minute	Mode of motion: daily activities	6 weeks	6 weeks	1,2,3,6,7,10,11,12,13,14,15
Machado et al.	2022	Brazil	Overweight and Obesity	10.3±1.8	10.9±2.1	20(9/11)	15(5/10)	Mode of motion: aerobic exercise Exercise time:50 min Exercise frequency: two times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	24 weeks	24 weeks	6,7,11,12,13,14,15
Maddison et al.	2011	New Zealand	Overweight and obesity	11.6±1.1	11.6±1.1	115	116	Mode of motion: active video games Exercise time: 80 min Exercise frequency: three times per week Exercise intensity: medium and high intensity	Mode of motion: daily activities	24 weeks	24 weeks	1,2,3,4
McCormack et al.	2014	America	Obesity	13.8±2.2	12.1±1.2	10(8/2)	8(5/3)	Mode of motion: aerobic and resistance training Exercise time:80 min Exercise frequency: three times per week Exercise intensity:60-80%HRR	Mode of motion: daily activities	8 weeks	8 weeks	1,3,14,15
McNarry et al.	2015	UK	Obesity	9.3±0.9	9.3±0.9	13	13	Mode of motion: high-intensity games Exercise time:60 min Exercise frequency: two times per week Exercise intensity: high intensity	Mode of motion: daily activities	6 weeks	6 weeks	1
Medrano et al.	2019	Spain	Overweight and obesity	10.9±1.1	11.0±1.1	26	17	Mode of motion: aerobic and strength exercises Exercise time:90 min Exercise frequency: three times per week Exercise intensity:76%HRmax	Mode of motion: daily activities	22 weeks	22 weeks	1,3

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Meng et al.	2022	China	Obesity	10.5-12.2	11.0±0.7	23(23/0)	13(13/0)	Mode of motion: running Exercise time:11-30mins Exercise frequency: three times per week Exercise intensity:60-70% or 90-100% of MAS	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,5,6,7,10,11,12,13,14,15
Meyer et al.	2006	Germany	Obesity	13.7±2.1	14.1±2.4	33(17/16)	34(17/17)	Mode of motion: aerobic training Exercise time:60-90 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	mode of motion: daily activities	24 weeks	24 weeks	1,3,6,11,12,13,15,20
Miguelés et al.	2023	Spain	Overweight and obesity	10±1.1	10±1.1	47	45	Mode of motion: Aerobic and resistance exercise Exercise time:90 min Exercise frequency: three to five times per week Exercise intensity:80% HRmax(38 min above 80%)	Mode of motion: daily activities	20 weeks	20 weeks	1,2,4,11,12,13,14,15,16,17,19
Mohammadi et al.	2019	Iran	Overweight	12.40±1.71	11.80±2.20	10(0/10)	10(0/10)	Mode of motion: aerobic and resistance training Exercise time:75 min Exercise frequency: three time per week Exercise intensity:60-80%HHR	Mode of motion: daily activities	8 weeks	8 weeks	1,2,3,10,11,12,13,14
Monteiro et al.	2015	Brazil	Obesity	10.08-12.76	11.32±1.90	32	16	Mode of motion: aerobic and resistance training Exercise time:50 min Exercise frequency: three times per week Exercise intensity:65%-85%VO ₂ peak	Mode of motion: daily activities	20 weeks	20 weeks	1,2,3,10,11,12,13
Moon et al.	2004	Korea	Obesity	10-12	10-12	34(22/12)	28(16/12)	Mode of motion: behavior modification Exercise time:60-70 min Exercise frequency: once a week Exercise intensity: medium and low intensity	mode of motion: daily activities	8 weeks	8 weeks	3,16
Morgan et al.	2021	Egypt	Obesity	14.10±1.25	14.20±1.196	15	15	Mode of motion: aerobic exercise Exercise time:50 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: routine medical treatment	12 weeks	12 weeks	1,10,11,12,13
Moslehi et al.	2019	Iran	Obesity	10.33-11.63	10.93±0.53	20(20/0)	10(10/0)	Mode of motion: running Exercise time:25-40 min Exercise frequency: three times per week Exercise intensity:65-85%HRmax	Mode of motion: daily activities	8 weeks	8 weeks	1,3,4

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Murphy et al.	2009	America	Overweight	10.21±1.67	10.21±1.67	23	12	Mode of motion: an active vedio game(Dance Dance Revolution) Exercise time:10-30 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,5,6,7,10,11,12,13,14
Naczki et al.	2021	Poland	Overweight	14.9±2.35	14.4±1.97	11(7/4)	11(7/4)	Mode of motion: swimming Exercise time:70-90 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	33 weeks	33 weeks	1,3,4,8
Naylor et al.	2016	Australia	Obesity	17.3±0.8	15.3±0.8	8(2/6)	5(1/4)	Mode of motion: aerobic and resistance exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity:65-85%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,3,5,20
Nobre et al.	2017	Brazil	Overweight and obesity	9,8±0.9	9.9±1.1	40 (40/0)	19 (19/0)	Mode of motion: plyometric training Exercise time:20 min Exercise frequency: two times per week Exercise intensity: medium and low and high intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,3
Nowicka et al.	2009	Sweden	Obesity	11.8±0.9	11.6±0.9	38	38	Mode of motion: aerobic exercise Exercise time: 30 min Exercise frequency: one-two times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	24 weeks	24 weeks	1,3
Park et al.	2007	Korea	Obesity	14.2±0.5	14.1±0.5	19(0/19)	21(0/21)	Mode of motion: walking Exercise time:10-50 min Exercise frequency: six times per week Exercise intensity:55–75% HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,6,7,10,12,13,14,15,20
Pena et al.	2022	America	Obesity	14±1	14±2	79(46/33)	38(24/14)	Mode of motion: physical activity Exercise time:60 min Exercise frequency: twice times per week Exercise intensity: above 150 bpm HR	Mode of motion: daily activities	24 weeks	24 weeks	1,2,3,9,14,15,20
Pena et al.	2023	America	Obesity	13.4±1.4	13.2±1.4	40(24/16)	24(15/9)	Mode of motion: physical activity Exercise time:60 min Exercise frequency: twice times per week Exercise intensity: above 150 bpm	Mode of motion: daily activities	24 weeks	24 weeks	1,3

Author	Year	Country	Weight status	Age	Sample		Intervention measure		Intervention duration	Outcome indicator		
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group				control group
Petty et al.	2009	America	Overweight	8.3-10.9	8.2-10.6	125	59	Mode of motion: low/high aerobic exercise Exercise time:20-40 min Exercise frequency: seven times per week Exercise intensity: low/high intensity	mode of motion: daily activities	10-15 weeks	10-15 weeks	16,18
Plavsic et al.	2020	Serbia	Obesity	16.6±1.3	15.8±1.5	22(0/22)	22(0/22)	Mode of motion: aerobic exercise Exercise time:43 min Exercise frequency: two times per week Exercise intensity:60-90%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,5,6,7,8,9,10,11,12,13,20
Prado et al.	2009	Brazil	Obesity	10.6±0.2	10.6±0.3	21	17	Mode of motion: aerobic and recreational exercises Exercise time:60 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	16 weeks	16 weeks	1,3,5
Prado et al.	2010	Brazil	Obesity	10.6±0.2	10.4±0.3	18	15	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	16 weeks	16 weeks	1,3,5
Qiong et al.	2015	China	Obesity	10.4-18.0	14.4±3.2	45(45/0)	15(15/0)	Mode of motion: aerobic exercise and resistance training Exercise time:55-60 min Exercise frequency: three times per week Exercise intensity:60%VO ₂ max	Mode of motion: daily activities	8 weeks	8 weeks	1,3,4
Racil et al.(1)	2016	Tunisia	Obesity	14.2±1.2	14.2±1.2	33(0/33)	14(0/14)	Mode of motion: HIIT/MIIT Exercise time:36-40 min Exercise frequency: three times per week Exercise intensity:100%/50% or 80%/50% MAS	Mode of motion: daily activities	12 weeks	12 weeks	2,3,6,7,8,9,14,15
Racil et al.(2)	2016	Tunisia	Obesity	15.3-17.7	16.9±1.0	49(0/49)	19(0/19)	Mode of motion: plyometric exercise + HIIT Exercise time:30-34 min Exercise frequency: three times per week Exercise intensity:50-100%VO ₂ peak	Mode of motion: daily activities	12 weeks	12 weeks	2,3,5,14,15
Racil et al.	2013	Tunisia	Obesity	14.9-16.82	15.9±1.2	22(0/22)	12(0/12)	Mode of motion: HIIT/MIIT Exercise time:40 min Exercise frequency: three times per week Exercise intensity:70-80% or 100-110%MAS	Mode of motion: daily activities	12 weeks	12 weeks	2,3,5,10,11,12,13,14,15

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Racil et al.	2024	Tunisia	Obesity	13.22-15.46	14.50±1.22	24(0/24)	11(0/11)	Mode of motion: HIIT/MIIT Exercise time:28 min Exercise frequency: three times per week Exercise intensity: 50%-1000%MAS	Mode of motion: daily activities	8 weeks	8 weeks	2,3,4,6,7,8,14
Ramezani et al.	2017	Iran	Obesity	10.05±1.41	10.05±1.41	45(45/0)	15(15/0)	Mode of motion: endurance and resistance exercise Exercise time:50-65 min Exercise frequency: four times per week Exercise intensity: 50%-75%HRmax	Mode of motion: daily activities	8 weeks	8 weeks	10,11,12,13,14
Regaieg et al.	2013	Tunisia	Obesity	10.92±0.61	10.64±0.72	14(8/6)	14(8/6)	Mode of motion: Aerobic Exercise Exercise time:60 min Exercise frequency: four times per week Exercise intensity:70-85%HRmax	Mode of motion: daily activities	16 weeks	16 weeks	1,2,3,8
Roh et al.	2020	Korea	Overweight and obesity	12.60±0.52	12.50±0.53	10(7/3)	10(7/3)	Mode of motion: taekwondo training Exercise time:60 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	16 weeks	16 weeks	1,4
Romero-Perez et al.	2020	Mexico	Obesity	10.02±0.79	10.02±0.79	54(24/30)	51(21/30)	Mode of motion: aerobic exercise + playful activities Exercise time:50 min Exercise frequency: two times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	20 weeks	20 weeks	16,19
Salus et al.(1)	2022	Estonia	Obesity	13.1±0.3	13.7±0.4	14(14/0)	14(14/0)	Mode of motion: cycling Exercise time:29-30 min Exercise frequency: three times per week Exercise intensity: high intensity	Mode of motion: daily activities	12 weeks	12 weeks	2,3,5,6,7,8,9
Salus et al.(2)	2022	Estonia	Obesity	13.1±1.3	13.7±1.6	14(14/0)	14(14/0)	Mode of motion: cycling Exercise time:29-30 min Exercise frequency: three times per week Exercise intensity: high intensity	mode of motion: daily activities	12 weeks	12 weeks	5,10,11,12,13,14,15
Savoye et al.	2007	America	Obesity	12.0±2.4	12.2±2.1	75(33/42)	44(17/27)	Mode of motion: aerobic exercise Exercise time:50 min Exercise frequency: two times per week/month Exercise intensity:65-80%HRmax	Mode of motion: daily activities	48 weeks	48 weeks	1,3,6,7,10,11,12,13,14,15

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Savoye et al.	2011	America	Obesity	12.0±2.5	12.5±2.3	75	44	Mode of motion: aerobic exercise Exercise time:50-100 min Exercise frequency: twice a week for 6 months and then twice a month Exercise intensity:65-80%HRmax	Mode of motion: daily activities	48 weeks	48 weeks	1,3,6,7,10,11,12,13,14,15
Saygin et al.	2011	Turkey	Obesity	10-12	10-12	20(0/20)	19(0/19)	Mode of motion: aerobic exercise Exercise time:60-90 min Exercise frequency: three times per week Exercise intensity:50-60%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,4,6,9,10,11,12,13
Schranz et al.	2014	Australia	Overweight and obesity	14.9±1.4	15.1±1.6	26(26/0)	23(23/0)	Mode of motion: resistance exercise Exercise time:75 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	mode of motion: daily activities	24 weeks	24 weeks	1,3,17,18
Seo et al.	2012	Korea	Obesity	14.70±0.48	14.60±0.96	10(10/0)	10(10/0)	Mode of motion: yoga(asana) Exercise time:60 min Exercise frequency: three times per week Exercise intensity:40-60%HRR	Mode of motion: daily activities	8 weeks	8 weeks	1,3,10,11,12,13,14,15
Seo et al.	2019	Korea	Obesity	12.80±1.72	12.09±2.20	26(17/9)	44(28/16)	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity:60-90%HRmax	Mode of motion: daily activities	16 weeks	16 weeks	2,3,6,7,11,12,13
Shaibi et al.	2006	America	Overweight	15.1±0.5	15.6±0.5	11(11/0)	11(11/0)	Mode of motion: resistance exercise Exercise time: not exceed 60 min in duration Exercise frequency: twice times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	16 weeks	16 weeks	1,3,14,15
Shalitin et al.	2009	Israel	Obesity	8.2±1.56	8.51±1.52	55(32/23)	55(26/29)	Mode of motion: aerobic and resistance exercise Exercise time:90 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,6,7,10,11,12,13,14,15
Shu et al.	2023	China	Obesity	11.0±0.8	11.0±0.8	31	16	Mode of motion: running Exercise time: 20-40 min Exercise frequency: three times per week Exercise intensity: 60-80%/100-120% MAS(70%~80% />80% HRmax)	Mode of motion: daily activities	12weeks	12weeks	1,2,3,4,6,7,8,9

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group		
Sigal et al.	2014	Canada	Overweight and obesity	14.1-17.4	15.6±1.3	228(67/161)	76(24/52)	Mode of motion: aerobic and resistance exercise Exercise time:20-90 min Exercise frequency: four times per week Exercise intensity:65-85%HRmax	Mode of motion: daily activities	22 weeks 22 weeks	1,2,3,6,7
Silva et al.	2012	Brazil	Overweight	13-17	13-17	9	5	Mode of motion: aerobic exercise Exercise time:30-40 min Exercise frequency: three times per week Exercise intensity:85%HRmax	Mode of motion: daily activities	12 weeks 12 weeks	1,3,8
Son et al.	2017	Korea	Obesity	15±1	15±1	20(0/20)	20(0/20)	Mode of motion: aerobic and resistance exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity:40-70%HRR	Mode of motion: daily activities	12 weeks 12 weeks	1,2,3,6,7,14,15
Staiano et al.	2013	America	Overweight and obesity	15-19	15-19	19	16	Mode of motion: exergame Exercise time: 30-60 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	mode of motion: daily activities	10-20 weeks 10-20 weeks	17
Staiano et al.	2017	America	Overweight and obesity	15.3±1.2	16.1±1.4	20(0/20)	18(0/18)	Mode of motion: dance exergaming Exercise time:60 min Exercise frequency: three times per week Exercise intensity:60-75%HRmax	Mode of motion: daily activities	12 weeks 12 weeks	2,3,10,11,12,13,14,15
Staiano et al.	2018	America	Overweight and obesity	11.2±0.8	11.2±0.8	22	23	Mode of motion: gaming console Exercise time:10-60 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	24 weeks 24 weeks	3,10,11,12,13,14
Suarez-Villadat et al.	2020	Spain	Obesity	14.3±1.25	14.11±1.21	15(8/7)	30(17/13)	Mode of motion: swimming Exercise time:50 min Exercise frequency: three times per week Exercise intensity:110-180 beats per minute	Mode of motion: daily activities	36 weeks 36 weeks	1,2,3
Suarez-Villadat et al.	2023	Spanish	Overweight and obesity	14.83±1.17	14.98±0.95	24(14/10)	25(16/9)	Mode of motion: exergames Exercise time:60 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	20 weeks 20 weeks	1,2,3

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration		Outcome indicator
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Sun et al.	2011	China	Overweight	13.6±0.7	13.6±0.7	25(18/7)	17(7/10)	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: four times per week Exercise intensity:40-60%VO ₂ max	Mode of motion: daily activities	10 weeks	10 weeks	1,2,3,4,10,11,12,13
Tan et al.	2010	China	Obesity	9.4±0.5	9.5±0.5	30(17/13)	30(17/13)	Mode of motion: aerobic exercise Exercise time:50 min Exercise frequency: five times per week Exercise intensity:average165beat/min	Mode of motion: daily activities	8 weeks	8 weeks	1,2
Tan et al.	2016	China	Obesity	9.0±0.9	9.4±1.3	11(11/0)	13(13/0)	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: five times per week Exercise intensity: individualized HR of FAT max intensity(average140±6beats/min)	Mode of motion: daily activities	10weeks	10weeks	1,3,4
Tas et al.	2023	America	Obesity	15.2±1.5	15.4±1.0	31(14/17)	6(2/4)	Mode of motion: running or biking(HIIT) Exercise time:45 min Exercise frequency: three times per week Exercise intensity:80-90%HRmax	Mode of motion: daily activities	4 weeks	4 weeks	3,5,10,11,12,13,14,15
Tjonna et al.	2009	Norway	Overweight and obesity	13.9±0.3	14.2±0.3	20	22	Mode of motion: aerobic exercise Exercise time:40 min Exercise frequency: two times per week Exercise intensity:70-95%Hfmax	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,4,6,7,11,12,14,15,20
Toulabi et al.	2012	Iran	Obesity	15.87±1.0	15.87±1.0	76	76	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	6 weeks	6 weeks	1,2
Tsang et al.	2009	Australia	Overweight and Obesity	13.1±2.1	13.1±2.1	11(5/6)	8(3/5)	Mode of motion: kung fu Exercise time:60 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	Mode of motion: Tai Chi	24 weeks	24 weeks	10,11,12,13,14,15,20
Vasconcellos et al.	2016	Brazil	Obesity	14.1±1.1	14.8±1.4	10(8/2)	10(6/4)	Mode of motion: soccer program Exercise time:60 min Exercise frequency: three times per week Exercise intensity: high intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,5,6,7,10,11,12,13,14,15

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Velez et al.	2010	America	Overweight and obesity	16.14±0.19	16.14±0.19	13(8/5)	15(8/7)	Mode of motion: resistance training Exercise time:35-40 min Exercise frequency: three times per week Exercise intensity: medium intensity	Mode of motion: daily activities	12 weeks	12 weeks	1,3
Wagener et al.	2012	America	Obesity	14±1.66	14±1.66	20	20	Mode of motion: exergame exercise (Dance Dance Revolution) Exercise time: 40-75 min Exercise frequency: three times per week Exercise intensity: medium and low intensity	mode of motion: daily activities	10 weeks	10 weeks	16,17,19
Weintraub et al.	2008	America	Overweight	10-11	10-11	9	12	Mode of motion: after-school soccer program Exercise time:75 min Exercise frequency: three to four times per week Exercise intensity: medium and low intensity	mode of motion: daily activities	24 weeks	24 weeks	1,16,17
Wen et al.	2008	China	Obesity	12.6±0.8	12.2±0.1	24	13	Mode of motion: aerobic and resistance exercise Exercise time:120-150/50-60mins Exercise frequency: four to five times per week Exercise intensity:3-7MET	Mode of motion: daily activities	36 weeks	36 weeks	10,11,12,13,14,15
Williams et al.	2019	America	Overweight and Obesity	10.4±0.87	10.4±0.89	90(30/60)	85(38/47)	Mode of motion: aerobic activities and games Exercise time:40 min Exercise frequency: seven times per week Exercise intensity: high intensity	Mode of motion: daily activities	32 weeks	32 weeks	3,5,16,18
Williams et al.	2024	New Zealand	Overweight and Obesity	14.8±1.6	14.9±1.4	10	11	Mode of motion: running Exercise time: 49.1±10.6 min Exercise frequency: 6-10 times per 10 weeks Exercise intensity: unclear	Mode of motion: daily activities	10 weeks	10 weeks	1,3,20
Wong et al.	2008	Singapore	Obesity	13.75±1.06	14.25±1.54	12(12/0)	12(12/0)	Mode of motion: aerobic exercises, resistance training and game activities Exercise time:45-60 min Exercise frequency: two times per week Exercise intensity:65-85%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,3,6,7,9,10,11,12,13,14
Wong et al.	2018	America	Obesity	15.2±1.2	15.3±1.1	15(0/15)	15(0/15)	Mode of motion: aerobic and resistance exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity:40-70%HRR	Mode of motion: daily activities	12 weeks	12 weeks	1,2,3,9,14,15

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Woo et al.	2004	China	Overweight and obesity	10.1±1.0	10.0±0.9	41(27/14)	41(27/14)	Mode of motion: Aerobic training Exercise time:75 min Exercise frequency: two times per week Exercise intensity:60-70%HRmax	Mode of motion: daily activities	6 weeks	6 weeks	1,3,10,11,12,13,14
Woo et al.	2012	Korean	Overweight	11.30±1.17	11.30±1.17	10	10	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: three times per week Exercise intensity:45-65%HRR	mode of motion: daily activities	12weeks	12weeks	3,5,6,7,10,11
Wu et al.	2017	China	Overweight and obesity	16.22±1.47	17.79±0.37	14(6/8)	14(5/9)	Mode of motion: aerobic and resistance exercise Exercise time:50 min Exercise frequency: five times per week Exercise intensity:84%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,3,8
Xianbo et al.	2011	China	Overweight and Obesity	13.6±0.7	13.6±0.7	25(18/7)	17(7/10)	Mode of motion: aerobic activities Exercise time:60 min Exercise frequency: four times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	10 weeks	10 weeks	1,2,3,10,13,14
Xinhui et al.	2016	China	Obesity	13.12±1.32	13.12±1.32	14(7/7)	14(7/7)	Mode of motion: aerobic exercise Exercise time:50-100 min Exercise frequency: three times per week Exercise intensity:60-70%VO ₂ peak	Mode of motion: daily activities	24 weeks	24 weeks	1,2,10,11,12,13
Xishao et al.	2009	China	Obesity	8.3±1.2	8.3±1.2	34	33	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: five times per week Exercise intensity: 140-160 bpm HR	Mode of motion: daily activities	12 weeks	12 weeks	10,11,14
Xishao et al.	2010	China	Obesity	8.3±1.2	8.3±1.2	100	100	Mode of motion: aerobic exercise Exercise time:60 min Exercise frequency: five times per week Exercise intensity:50% of VO ₂ peak (65% of HRpeak)	Mode of motion: daily activities	24 weeks	24 weeks	10,11,14
Yackobovitch-Gavan et al.	2009	Israel	Obesity	8.2±0.2	8.5±0.2	55(32/23)	55(26/29)	Mode of motion: aerobic and resistance training exercises Exercise time:90 min Exercise frequency: three times per week Exercise intensity:75%HRmax	Mode of motion: daily activities	12 weeks	12 weeks	1,3

Author	Year	Country	Weight status	Age	Sample		Intervention measure		Intervention duration		Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group				control group
Yanqin et al.	2017	China	Obesity	10.3±1.21	10.7±1.34	35(18/17)	33(17/16)	Mode of motion: aerobic exercise Exercise time:30-60 min Exercise frequency: three-five times per week Exercise intensity:75%HRmax	Mode of motion: daily activities	48 weeks	48 weeks	1,2,10,11
Youssef et al.	2015	France	Overweight and Obesity	16.1±0.3	16.3 ± 0.5	14(0/14)	9(0/9)	Mode of motion: aerobic exercises Exercise time:40-90 min Exercise frequency: three times per week Exercise intensity:70-100% HRrest	Mode of motion: daily activities	12 weeks	12 weeks	1,3,5
Yu et al.	2008	China	Overweight and Obesity	10.5±1.0	10.5±1.0	41	41	Mode of motion: aerobic and resistance training Exercise time:75 min Exercise frequency: three times per week Exercise intensity: 60%-70%HRmax	Mode of motion: daily activities	6weeks	6weeks	1,3
Yu et al.	2020	China	Obesity	9.9±0.7	9.7±0.6	99(82/17)	72(54/18)	Mode of motion: aerobic activities Exercise time:60 min Exercise frequency: five times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	32 weeks	32 weeks	1,2,6,7,11,12,14,16,19
Yuanyuan et al.	2019	China	Obesity	11.13±1.26	11.14±1.28	29(19/10)	10(6/4)	Mode of motion: football exercise Exercise time:50 min Exercise frequency: three times per week Exercise intensity:54-85%HRmax	Mode of motion: daily activities	16 weeks	16 weeks	1,2,3,6,7
Zehsaz et al.	2016	Iran	Obesity	10.8±0.9	10.3±0.9	16(16/0)	16(16/0)	Mode of motion: walking and band exercises Exercise time:85-90 min Exercise frequency: two times per week Exercise intensity:55-75%HRmax	Mode of motion: daily activities	16 weeks	16 weeks	1,2,3,10,11,12,13,14,15
Zehsaz et al.	2017	Iran	Overweight and obesity	10.8±0.9	10.3±0.9	16(16/0)	16(16/0)	Mode of motion: aerobic and resistance exercises Exercise time:60 min Exercise frequency: two times per week Exercise intensity:65-85%HRmax	Mode of motion: daily activities	16 weeks	16 weeks	1,2,3,10,11,12,13,14
Zhaogang et al.	2021	China	Obesity	16.18±0.79	15.36±0.68	49(19/30)	49(26/23)	Mode of motion: aerobic exercise Exercise time: 30 min Exercise frequency: 7 times per week Exercise intensity: medium and low intensity	Mode of motion: daily activities	48 weeks	48 weeks	6,7,10,14

Author	Year	Country	Weight status	Age		Sample		Intervention measure		Intervention duration	Outcome indicator	
				experimental group	control group	experimental group (boys/girls)	control group (boys/girls)	experimental group	control group			
Zhihui	2017	China	Obesity	16.28±3.03	16.83±3.52	40	40	Mode of motion: core strength training Exercise time: 150 min Exercise frequency: once a day Exercise intensity: high intensity	Mode of motion: daily activities	4 weeks	4 weeks	1,2,3

Notes: 1. BMI, 2. WC, 3. BF%, 4. VO_2max , 5. VO_2peak , 6. SBP, 7. DBP, 8. HRmax, 9. HRrest, 10. TC, 11. TG, 12. HDL-C, 13. LDL-C, 14. FPG, 15. FINS, 16. Depression, 17. Self-esteem, 18. Self-worth, 19. Anxiety, 20. HbA1c

BMI, body mass index; WC, waist circumference; BF%, percentage of body fat; VO_2max , maximal oxygen consumption; VO_2peak , peak oxygen uptake; HRmax, max heart rate; HRrest, resting heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FPG, fasting plasma glucose; HbA1c, hemoglobin A1c; FINS, fasting insulin; MAS, maximal aerobic speed; MET, metabolic equivalent; HRR, heart rate reserve; MAP, heart rate reserve; Hfmax, maximal heart frequency; RM, repetition maximum; HIIT, High-Intensity Interval Training; MICT, Moderate-Intensity Continuous Training.

Table S2. Summary of subgroup analyses of meta-analysis results of exercise interventions in children and adolescents with overweight or obesity

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
BMI					
Type of exercise					
Aerobic	93	-1.49 [-1.82, -1.17]	76	<0.00001**	0.04*
Anaerobic	25	-1.20 [-1.91, -0.50]	63	0.0008**	
Resistance	12	0.18 [-1.10, 1.45]	44	0.79	
Combined aerobic and resistance	37	-0.83 [-1.47, -0.19]	69	0.01*	
Exercise intensity					
Moderate-to-low	97	-1.50 [-1.89, -1.11]	78	<0.00001**	0.02*
High	70	-0.90 [-1.24, -0.55]	58	<0.00001**	
Duration per session					
<50 min	56	-1.17 [-1.58, -0.76]	75	<0.00001**	0.70
≥50 min	111	-1.28 [-1.63, -0.93]	72	<0.00001**	
Frequency					
<3 sessions/week	40	-0.70 [-1.15, -0.24]	37	0.003**	0.01*
≥3 sessions/week	127	-1.41 [-1.71, -1.10]	76	<0.00001**	
Weekly duration					
<150 min/week	65	-1.03 [-1.47, -0.58]	69	<0.00001**	0.22
≥150 min/week	102	-1.37 [-1.70, -1.05]	74	<0.00001**	
Intervention duration					
<12 weeks	47	-1.03 [-1.62, -0.44]	71	0.0007**	0.40
≥12 weeks	120	-1.31 [-1.61, -1.02]	73	<0.00001**	
Region					
Asia	71	-1.52 [-1.86, -1.17]	76	<0.00001**	0.004**
Europe	31	-0.75 [-1.44, -0.05]	77	0.04*	
Africa	12	-3.01 [-4.41, -1.61]	53	<0.0001**	
North America	31	-0.84 [-1.46, -0.23]	54	0.007**	
South America	15	-0.98 [-1.71, -0.25]	30	0.009**	
Oceania	7	-0.07 [-1.11, 0.98]	18	0.90	
Economic status					
Lower-middle income	13	-2.82 [-4.14, -1.50]	56	<0.0001**	0.0004**

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Upper-middle income	72	-1.55 [-1.91, -1.19]	75	<0.00001**	
High income	82	-0.74 [-1.10, -0.38]	62	<0.0001**	
Weight status					
Overweight	20	-0.69 [-1.42, 0.03]	53	0.06	0.02*
Obesity	91	-1.70 [-2.11, -1.29]	77	<0.00001**	
Sex					
Boys	31	-1.61 [-2.27, -0.95]	67	<0.00001**	0.83
Girls	26	-1.71 [-2.35, -1.08]	49	<0.00001**	
Metabolic status					
MHO	9	-0.19 [-0.71, 0.34]	0	0.49	0.004**
MUO	15	-1.80 [-2.78, -0.83]	81	0.0003**	
WC					
Type of exercise					
Aerobic	58	-2.93 [-3.87, -1.99]	74	<0.00001**	0.72
Anaerobic	24	-3.47 [-4.89, -2.05]	37	<0.00001**	
Resistance	6	-0.93 [-6.78, 4.92]	76	0.76	
Combined aerobic and resistance	22	-2.64 [-3.62, -1.67]	25	<0.00001**	
Exercise intensity					
Moderate-to-low	62	-3.14 [-4.03, -2.24]	72	<0.00001**	0.24
High	48	-2.35 [-3.29, -1.42]	41	<0.00001**	
Duration per session					
<50 min	41	-1.99 [-2.62, -1.36]	0	<0.00001**	0.02*
≥50 min	69	-3.34 [-4.28, -2.39]	74	<0.00001**	
Frequency					
<3 sessions/week	18	-1.99 [-3.17, -0.81]	13	0.0010**	0.14
≥3 sessions/week	92	-3.04 [-3.79, -2.30]	68	<0.00001**	
Weekly duration					
<150 min/week	43	-1.83 [-2.52, -1.13]	0	<0.00001**	0.006**
≥150 min/week	67	-3.43 [-4.34, -2.52]	75	<0.00001**	
Intervention duration					
<12 weeks	25	-3.35 [-5.72, -0.99]	79	0.005**	0.58
≥12 weeks	85	-2.66 [-3.28, -2.03]	53	<0.00001**	

Health outcomes	k	MD[95%CI]	I (%)	P-value of Q test	Subgroup Differences
Region					
Asia	46	-3.74 [-4.96, -2.51]	80	<0.00001**	0.12
Europe	15	-1.48 [-2.41, -0.55]	0	0.002**	
Africa	18	-2.18 [-3.33, -1.04]	0	0.0002**	
North America	18	-2.33 [-3.32, -1.33]	25	<0.00001**	
South America	11	-2.08 [-3.77, -0.39]	25	0.02*	
Oceania	2	0.53 [-7.98, 9.05]	90	0.90	
Economic status					
Lower-middle income	19	-2.21 [-3.32, -1.09]	0	0.0001**	0.01*
Upper-middle income	46	-4.05 [-5.30, -2.79]	80	<0.00001**	
High income	45	-1.92 [-2.53, -1.30]	14	<0.00001**	
Weight status					
Overweight	10	-1.16 [-2.67, 0.35]	10	0.13	0.002**
Obesity	61	-3.93 [-4.88, -2.98]	74	<0.00001**	
Sex					
Boys	14	-4.39 [-7.42, -1.35]	79	0.005**	0.47
Girls	31	-3.18 [-4.37, -2.00]	72	<0.00001**	
Metabolic status					
MHO	9	-0.87 [-2.17, 0.42]	0	0.18	0.05
MUO	10	-5.51 [-9.95, -1.08]	90	0.01*	
BF%					
Type of exercise					
Aerobic	74	-2.59 [-3.12, -2.05]	70	<0.00001**	0.12
Anaerobic	32	-2.27 [-3.36, -1.17]	77	<0.0001**	
Resistance	7	-0.75 [-2.15, 0.66]	0	0.30	
Combined aerobic and resistance	33	-2.32 [-3.36, -1.29]	65	<0.0001**	
Exercise intensity					
Moderate-to-low	82	-2.61 [-3.18, -2.03]	72	<0.00001**	0.26
High	64	-2.11 [-2.75, -1.47]	67	<0.00001**	
Duration per session					
<50 min	60	-1.60 [-2.14, -1.07]	60	<0.00001**	0.0008**
≥50 min	86	-2.99 [-3.60, -2.38]	71	<0.00001**	

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Frequency					
<3 sessions/week	34	-2.45 [-3.16, -1.73]	33	<0.00001**	0.88
≥3 sessions/week	112	-2.38 [-2.87, -1.88]	75	<0.00001**	
Weekly duration					
<150 min/week	67	-1.83 [-2.36, -1.30]	56	<0.00001**	0.01*
≥150 min/week	79	-2.86 [-3.49, -2.24]	75	<0.00001**	
Intervention duration					
<12 weeks	37	-2.54 [-3.41, -1.66]	62	<0.00001**	0.70
≥12 weeks	109	-2.34 [-2.83, -1.85]	72	<0.00001**	
Region					
Asia	51	-3.46 [-4.25, -2.68]	80	<0.00001**	0.0005**
Europe	28	-2.32 [-3.48, -1.15]	56	0.0001**	
Africa	19	-1.19 [-2.02, -0.37]	62	0.004**	
North America	28	-1.69 [-2.42, -0.96]	45	<0.00001**	
South America	14	-2.47 [-3.51, -1.43]	15	<0.00001**	
Oceania	6	-0.63 [-2.05, 0.79]	0	0.39	
Economic status					
Lower-middle income	19	-1.19 [-2.02, -0.37]	62	0.004**	0.0003**
Upper-middle income	53	-3.46 [-4.26, -2.66]	80	<0.00001**	
High income	74	-1.90 [-2.40, -1.40]	41	<0.00001**	
Weight status					
Overweight	16	-1.94 [-3.04, -0.85]	52	0.0005**	0.08
Obesity	82	-3.06 [-3.67, -2.46]	76	<0.00001**	
Sex					
Boys	27	-2.56 [-3.76, -1.36]	67	<0.0001**	0.38
Girls	30	-1.94 [-2.66, -1.22]	75	<0.00001**	
Metabolic status					
MHO	10	-1.18 [-2.38, 0.02]	0	0.05	0.002**
MUO	10	-4.03 [-5.39, -2.68]	63	<0.00001**	
VO₂max					
Type of exercise					
Aerobic	21	2.93 [2.08, 3.78]	77	<0.00001**	0.64

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Anaerobic	7	3.42 [1.76, 5.08]	67	<0.0001**	
Resistance	1	1.80 [-2.17, 5.77]	-	0.37	
Combined aerobic and resistance	9	2.11 [0.62, 3.61]	71	0.006**	
Exercise intensity					
Moderate-to-low	25	2.63 [1.79, 3.47]	78	<0.00001**	0.46
High	13	3.20 [1.97, 4.42]	75	<0.00001**	
Duration per session					
<50 min	14	3.30 [2.42, 4.18]	50	<0.00001**	0.26
≥50 min	24	2.60 [1.75, 3.45]	79	<0.00001**	
Frequency					
<3 sessions/week	9	2.25 [0.36, 4.15]	71	0.02*	0.50
≥3 sessions/week	29	2.96 [2.22, 3.69]	79	<0.00001**	
Weekly duration					
<150 min/week	16	2.96 [1.98, 3.93]	61	<0.00001**	0.77
≥150 min/week	22	2.76 [1.87, 3.65]	81	<0.00001**	
Intervention duration					
<12 weeks	21	3.04 [1.88, 4.21]	79	<0.00001**	0.57
≥12 weeks	17	2.62 [1.77, 3.47]	75	<0.00001**	
Region					
Asia	19	3.04 [2.11, 3.97]	81	<0.00001**	0.01*
Europe	10	1.82 [0.35, 3.28]	65	0.02*	
Africa	5	4.84 [2.94, 6.73]	68	<0.00001**	
North America	3	1.43 [-0.47, 3.32]	0	0.14	
South America	0	-	-	-	
Oceania	1	1.10 [-0.32, 2.52]	-	0.13	
Economic status					
Lower-middle income	5	4.84 [2.94, 6.73]	68	<0.00001**	<0.0001**
Upper-middle income	15	3.63 [2.63, 4.63]	77	<0.00001**	
High income	18	1.31 [0.49, 2.14]	54	0.002**	
Weight status					
Overweight	3	2.44 [-1.10, 5.98]	81	0.18	0.90
Obesity	21	2.67 [1.76, 3.59]	81	<0.00001**	

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Sex					
Boys	9	3.69 [2.76, 4.61]	20	<0.00001**	0.93
Girls	5	3.57 [1.33, 5.81]	91	0.002**	
VO₂peak					
Type of exercise					
Aerobic	19	2.61 [1.58, 3.65]	67	<0.00001**	0.77
Anaerobic	13	3.02 [1.54, 4.51]	76	<0.0001**	
Resistance	4	2.59 [-1.63, 6.81]	80	0.23	
Combined aerobic and resistance	8	2.03 [0.85, 3.21]	0	0.0008**	
Exercise intensity					
Moderate-to-low	16	2.91 [1.66, 4.15]	69	<0.00001**	0.49
High	28	2.37 [1.49, 3.25]	62	<0.00001**	
Duration per session					
<50 min	28	2.12 [1.39, 2.86]	59	<0.00001**	0.13
≥50 min	16	3.46 [1.89, 5.03]	66	<0.0001**	
Frequency					
<3 sessions/week	5	0.92 [-0.65, 2.48]	11	0.25	0.03*
≥3 sessions/week	39	2.79 [2.03, 3.55]	67	<0.00001**	
Weekly duration					
<150 min/week	26	2.21 [1.41, 3.02]	59	<0.00001**	0.21
≥150 min/week	18	3.25 [1.85, 4.65]	72	<0.00001**	
Intervention duration					
<12 weeks	6	0.33 [-2.16, 2.81]	57	0.80	0.06
≥12 weeks	38	2.81 [2.06, 3.56]	66	<0.00001**	
Region					
Asia	7	3.72 [2.08, 5.36]	54	<0.00001**	<0.0001**
Europe	6	1.65 [-0.47, 3.77]	57	0.13	
Africa	4	0.57 [-0.08, 1.22]	0	0.08	
North America	16	2.98 [1.58, 4.38]	72	<0.0001**	
South America	7	3.62 [2.40, 4.85]	3	<0.00001**	
Oceania	4	1.11 [-1.41, 3.63]	19	0.39	
Economic status					

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Lower-middle income	4	0.57 [-0.08, 1.22]	0	0.08	<0.00001**
Upper-middle income	13	3.71 [2.56, 4.86]	39	<0.00001**	
High income	27	2.48 [1.48, 3.48]	64	<0.00001**	
Weight status					
Overweight	6	2.57 [1.33, 3.80]	0	<0.0001**	0.49
Obesity	27	3.14 [2.09, 4.18]	74	<0.00001**	
Sex					
Boys	8	5.70 [4.22, 7.19]	37	<0.00001**	<0.00001**
Girls	10	1.14 [0.26, 2.03]	43	0.01*	
Metabolic status					
MHO	3	1.11 [-0.30, 2.51]	24	0.12	0.002**
MUO	5	4.48 [2.82, 6.15]	15	<0.00001**	
HRmax					
Type of exercise					
Aerobic	12	-0.25 [-1.63, 1.13]	51	0.73	<0.0001**
Anaerobic	10	-1.57 [-2.82, -0.33]	39	0.01*	
Resistance	0	-	-	-	
Combined aerobic and resistance	1	11.50 [5.79, 17.21]	-	<0.0001**	
Exercise intensity					
Moderate-to-low	9	0.18 [-1.60, 1.96]	59	0.84	0.33
High	14	-0.96 [-2.45, 0.53]	66	0.21	
Duration per session					
<50 min	16	-0.79 [-1.92, 0.33]	49	0.17	0.48
≥50 min	7	0.36 [-2.60, 3.33]	79	0.81	
Frequency					
<3 sessions/week	3	0.45 [-4.12, 5.02]	0	0.85	0.68
≥3 sessions/week	20	-0.55 [-1.72, 0.62]	67	0.36	
Weekly duration					
<150 min/week	17	-0.77 [-1.86, 0.31]	46	0.16	0.50
≥150 min/week	6	0.42 [-2.87, 3.71]	83	0.80	
Intervention duration					
<12 weeks	4	0.92 [-5.13, 6.97]	51	0.77	0.62

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
≥12 weeks	19	-0.64 [-1.76, 0.48]	65	0.26	
Region					
Asia	6	2.10 [-1.93, 6.12]	84	0.31	0.08
Europe	7	0.34 [-1.60, 2.28]	0	0.73	
Africa	9	-1.67 [-2.53, -0.81]	17	0.0001**	
North America	0	-	-	-	
South America	1	-0.50 [-1.96, 0.96]	-	0.50	
Oceania	0	-	-	-	
Economic status					
Lower-middle income	9	-1.67 [-2.53, -0.81]	17	0.0001**	0.03*
Upper-middle income	9	0.61 [-1.68, 2.90]	76	0.60	
High income	5	1.97 [-1.31, 5.25]	12	0.24	
Weight status					
Overweight	3	-0.49 [-1.87, 0.88]	0	0.48	0.61
Obesity	12	0.04 [-1.49, 1.57]	38	0.96	
Sex					
Boys	4	-0.90 [-5.36, 3.57]	77	0.69	0.77
Girls	9	-1.58 [-2.33, -0.82]	1	<0.0001**	
HRrest					
Type of exercise					
Aerobic	13	-2.19 [-3.20, -1.17]	29	<0.0001**	0.07
Anaerobic	6	-2.82 [-4.74, -0.91]	62	0.004**	
Resistance	0	-	-	-	
Combined aerobic and resistance	6	-5.51 [-8.19, -2.83]	59	<0.0001**	
Exercise intensity					
Moderate-to-low	16	-2.69 [-3.97, -1.40]	53	<0.0001**	0.55
High	9	-3.29 [-4.79, -1.80]	59	<0.0001**	
Duration per session					
<50 min	11	-1.85 [-2.92, -0.78]	38	0.0007**	0.02*
≥50 min	14	-3.88 [-5.20, -2.55]	47	<0.00001**	
Frequency					
<3 sessions/week	5	-4.49 [-5.85, -3.13]	0	<0.00001**	0.02*

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
≥3 sessions/week	20	-2.48 [-3.52, -1.44]	56	<0.00001**	
Weekly duration					
<150 min/week	14	-2.59 [-3.69, -1.49]	54	<0.00001**	0.34
≥150 min/week	11	-3.66 [-5.57, -1.74]	52	0.0002**	
Intervention duration					
<12 weeks	7	-2.44 [-4.10, -0.77]	36	0.004**	0.50
≥12 weeks	18	-3.14 [-4.29, -1.99]	60	<0.00001**	
Region					
Asia	10	-3.03 [-4.47, -1.58]	74	<0.0001**	0.80
Europe	7	-4.09 [-7.69, -0.48]	58	0.03*	
Africa	5	-2.58 [-3.69, -1.46]	0	<0.00001**	
North America	3	-3.64 [-6.59, -0.68]	0	0.02*	
South America	0	-	-	-	
Oceania	0	-	-	-	
Economic status					
Lower-middle income	6	-2.25 [-3.40, -1.10]	7	0.0001**	0.42
Upper-middle income	10	-3.15 [-4.62, -1.68]	67	<0.0001**	
High income	9	-3.77 [-6.08, -1.46]	56	0.001**	
Weight status					
Overweight	1	-7.40 [-13.97, -0.83]	-	0.03*	0.16
Obesity	17	-2.63 [-3.50, -1.77]	47	<0.00001**	
Sex					
Boys	6	-4.73 [-6.12, -3.35]	0	<0.00001**	0.23
Girls	8	-3.47 [-5.00, -1.95]	54	<0.00001**	
SBP					
Type of exercise					
Aerobic	45	-4.26 [-6.13, -2.39]	94	<0.00001**	0.66
Anaerobic	16	-2.88 [-4.52, -1.24]	18	0.0006**	
Resistance	2	-1.10 [-8.54, 6.33]	67	0.77	
Combined aerobic and resistance	13	-3.62 [-5.56, -1.69]	44	0.0002**	
Exercise intensity					
Moderate-to-low	48	-4.79 [-6.57, -3.00]	93	<0.00001**	0.007**

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
High	28	-1.96 [-3.01, -0.92]	16	0.0002**	
Duration per session					
<50 min	35	-2.25 [-3.49, -1.02]	52	0.0003**	0.008**
≥50 min	41	-5.21 [-7.02, -3.40]	92	<0.00001**	
Frequency					
<3 sessions/week	17	-1.72 [-3.01, -0.42]	10	0.009**	0.01*
≥3 sessions/week	59	-4.43 [-6.05, -2.80]	92	<0.00001**	
Weekly duration					
<150 min/week	36	-2.24 [-3.25, -1.23]	32	<0.0001**	0.006**
≥150 min/week	40	-5.38 [-7.35, -3.40]	93	<0.00001**	
Intervention duration					
<12 weeks	16	-4.26 [-6.84, -1.67]	65	0.001**	0.78
≥12 weeks	60	-3.83 [-5.45, -2.21]	93	<0.00001**	
Region					
Asia	32	-5.42 [-7.39, -3.46]	92	<0.00001**	0.010*
Europe	15	-4.82 [-7.11, -2.54]	45	<0.0001**	
Africa	9	-2.19 [-3.83, -0.55]	0	0.009**	
North America	12	-1.28 [-3.61, 1.05]	78	0.28	
South America	8	-1.36 [-3.61, 0.88]	29	0.23	
Oceania	0	-	-	-	
Economic status					
Lower-middle income	10	-2.16 [-3.68, -0.65]	0	0.005**	0.05
Upper-middle income	30	-5.29 [-7.34, -3.24]	93	<0.00001**	
High income	36	-2.96 [-4.44, -1.47]	68	<0.0001**	
Weight status					
Overweight	10	-2.43 [-5.04, 0.18]	43	0.07	0.18
Obesity	45	-4.56 [-6.28, -2.85]	92	<0.00001**	
Sex					
Boys	12	-4.21 [-6.74, -1.67]	48	0.001**	0.46
Girls	16	-5.54 [-8.06, -3.02]	96	<0.0001**	
DBP					
Type of exercise					

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Aerobic	41	-2.04 [-3.39, -0.69]	91	0.003**	0.66
Anaerobic	16	-1.01 [-2.78, 0.75]	53	0.26	
Resistance	2	-0.16 [-3.34, 3.02]	0	0.92	
Combined aerobic and resistance	12	-1.52 [-2.68, -0.35]	0	0.01*	
Exercise intensity					
Moderate-to-low	43	-2.07 [-3.38, -0.77]	90	0.002**	0.19
High	28	-0.98 [-1.98, 0.02]	29	0.05	
Duration per session					
<50 min	35	-0.85 [-1.62, -0.09]	25	0.03*	0.07
≥50 min	36	-2.38 [-3.87, -0.89]	91	0.002**	
Frequency					
<3 sessions/week	17	-0.57 [-2.00, 0.85]	33	0.43	0.13
≥3 sessions/week	54	-1.98 [-3.12, -0.85]	89	0.0006**	
Weekly duration					
<150 min/week	36	-0.99 [-1.75, -0.24]	18	0.010*	0.12
≥150 min/week	35	-2.32 [-3.84, -0.80]	92	0.003**	
Intervention duration					
<12 weeks	13	-2.99 [-4.33, -1.66]	8	<0.0001**	0.09
≥12 weeks	58	-1.47 [-2.58, -0.37]	88	0.009**	
Region					
Asia	29	-2.46 [-4.09, -0.83]	92	0.003**	0.08
Europe	13	-2.10 [-3.81, -0.39]	34	0.02*	
Africa	9	-0.36 [-1.47, 0.76]	0	0.53	
North America	12	-0.35 [-1.17, 0.46]	0	0.39	
South America	8	-0.00 [-2.42, 2.42]	41	1.00	
Oceania	0	-	-	-	
Economic status					
Lower-middle income	10	-0.61 [-1.69, 0.46]	0	0.26	0.11
Upper-middle income	29	-2.64 [-4.29, -0.99]	92	0.002**	
High income	32	-0.78 [-1.72, 0.16]	37	0.10	
Weight status					
Overweight	10	0.00 [-1.76, 1.77]	0	1.00	0.09

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Obesity	41	-1.92 [-3.25, -0.60]	91	0.004**	
Sex					
Boys	12	-1.88 [-3.36, -0.39]	16	0.01*	0.78
Girls	15	-2.28 [-4.69, 0.12]	96	0.06	
TC					
Type of exercise					
Aerobic	52	-0.38 [-0.48, -0.28]	86	<0.00001**	0.07
Anaerobic	11	-0.45 [-0.59, -0.30]	0	<0.00001**	
Resistance	4	-0.41 [-0.98, 0.17]	70	0.17	
Combined aerobic and resistance	22	-0.20 [-0.33, -0.07]	42	0.003**	
Exercise intensity					
Moderate-to-low	58	-0.35 [-0.44, -0.27]	82	<0.00001**	0.83
High	31	-0.33 [-0.53, -0.13]	79	0.0009**	
Duration per session					
<50 min	30	-0.36 [-0.51, -0.20]	86	<0.0001**	0.95
≥50 min	59	-0.35 [-0.44, -0.26]	76	<0.00001**	
Frequency					
<3 sessions/week	15	-0.17 [-0.27, -0.08]	0	0.0003**	0.0007**
≥3 sessions/week	74	-0.39 [-0.48, -0.31]	82	<0.00001**	
Weekly duration					
<150 min/week	28	-0.19 [-0.28, -0.10]	18	<0.0001**	0.0010**
≥150 min/week	61	-0.41 [-0.51, -0.32]	84	<0.00001**	
Intervention duration					
<12 weeks	25	-0.34 [-0.52, -0.15]	67	0.0003**	0.83
≥12 weeks	64	-0.36 [-0.44, -0.27]	83	<0.00001**	
Region					
Asia	53	-0.45 [-0.55, -0.35]	84	<0.00001**	<0.0001**
Europe	8	-0.26 [-0.45, -0.07]	31	0.007**	
Africa	3	-0.45 [-1.03, 0.13]	94	0.13	
North America	11	-0.09 [-0.20, 0.03]	12	0.14	
South America	10	-0.23 [-0.41, -0.05]	0	0.01*	
Oceania	4	-0.02 [-0.31, 0.27]	0	0.89	

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Economic status					
Lower-middle income	3	-0.45 [-1.03, 0.13]	94	0.13	<0.0001**
Upper-middle income	54	-0.46 [-0.55, -0.36]	83	<0.00001**	
High income	32	-0.14 [-0.24, -0.05]	27	0.003**	
Weight status					
Overweight	14	-0.34 [-0.71, 0.02]	89	0.07	0.74
Obesity	56	-0.41 [-0.49, -0.32]	79	<0.00001**	
Sex					
Boys	18	-0.71 [-1.01, -0.41]	83	<0.00001**	0.01*
Girls	13	-0.25 [-0.44, -0.06]	84	0.01*	
Metabolic status					
MHO	10	-0.12 [-0.27, 0.04]	17	0.14	0.35
MUO	14	-0.24 [-0.44, -0.03]	72	0.02*	
TG					
Type of exercise					
Aerobic	56	-0.23 [-0.30, -0.16]	94	<0.00001**	0.36
Anaerobic	11	-0.30 [-0.52, -0.07]	82	0.01*	
Resistance	3	-0.35 [-0.85, 0.15]	67	0.17	
Combined aerobic and resistance	22	-0.16 [-0.22, -0.09]	58	<0.0001**	
Exercise intensity					
Moderate-to-low	61	-0.24 [-0.31, -0.18]	93	<0.00001**	0.27
High	31	-0.19 [-0.27, -0.10]	69	<0.00001**	
Duration per session					
<50 min	30	-0.11 [-0.17, -0.05]	74	0.0003**	0.002**
≥50 min	62	-0.27 [-0.35, -0.19]	93	<0.00001**	
Frequency					
<3 sessions/week	18	-0.18 [-0.27, -0.08]	80	0.0004**	0.27
≥3 sessions/week	74	-0.24 [-0.30, -0.18]	92	<0.00001**	
Weekly duration					
<150 min/week	30	-0.15 [-0.23, -0.07]	78	0.0002**	0.05
≥150 min/week	62	-0.26 [-0.33, -0.19]	93	<0.00001**	
Intervention duration					

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
<12 weeks	24	-0.38 [-0.55, -0.20]	84	<0.0001**	0.04*
≥12 weeks	68	-0.18 [-0.24, -0.13]	91	<0.00001**	
Region					
Asia	52	-0.29 [-0.36, -0.22]	94	<0.00001**	<0.0001**
Europe	12	-0.08 [-0.13, -0.03]	0	0.002**	
Africa	3	-0.13 [-0.54, 0.27]	98	0.51	
North America	11	-0.06 [-0.13, 0.01]	0	0.09	
South America	11	-0.23 [-0.48, 0.02]	83	0.07	
Oceania	3	-0.26 [-0.54, 0.02]	0	0.07	
Economic status					
Lower-middle income	3	-0.13 [-0.54, 0.27]	98	0.51	0.0002**
Upper-middle income	54	-0.30 [-0.37, -0.23]	88	<0.00001**	
High income	35	-0.10 [-0.16, -0.04]	68	0.002**	
Weight status					
Overweight	14	-0.21 [-0.30, -0.13]	19	<0.00001**	0.33
Obesity	56	-0.27 [-0.34, -0.20]	93	<0.00001**	
Sex					
Boys	18	-0.44 [-0.61, -0.27]	86	<0.00001**	0.02*
Girls	12	-0.16 [-0.33, 0.01]	94	0.06	
HDL-C					
Type of exercise					
Aerobic	51	0.08 [0.05, 0.12]	80	<0.00001**	0.79
Anaerobic	11	0.06 [-0.01, 0.12]	31	0.07	
Resistance	4	0.10 [0.02, 0.17]	0	0.02*	
Combined aerobic and resistance	22	0.07 [0.02, 0.11]	38	0.003**	
Exercise intensity					
Moderate-to-low	56	0.08 [0.05, 0.12]	79	<0.00001**	0.65
High	32	0.07 [0.04, 0.10]	18	<0.00001**	
Duration per session					
<50 min	31	0.06 [0.02, 0.11]	79	0.004**	0.43
≥50 min	57	0.09 [0.05, 0.12]	65	<0.00001**	
Frequency					

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
<3 sessions/week	18	0.05 [0.01, 0.10]	28	0.03*	0.25
≥3 sessions/week	70	0.08 [0.06, 0.11]	76	<0.00001**	
Weekly duration					
<150 min/week	32	0.06 [0.02, 0.10]	64	0.005**	0.26
≥150 min/week	56	0.09 [0.06, 0.12]	75	<0.00001**	
Intervention duration					
<12 weeks	24	0.04 [0.00, 0.08]	43	0.03*	0.06
≥12 weeks	64	0.09 [0.06, 0.12]	75	<0.00001**	
Region					
Asia	48	0.09 [0.05, 0.13]	77	<0.00001**	0.67
Europe	11	0.07 [0.02, 0.12]	10	0.004**	
Africa	3	0.11 [0.06, 0.17]	65	<0.0001**	
North America	11	0.04 [-0.05, 0.14]	81	0.34	
South America	11	0.07 [-0.01, 0.15]	45	0.07	
Oceania	4	0.03 [-0.07, 0.13]	0	0.52	
Economic status					
Lower-middle income	3	0.11 [0.06, 0.17]	65	<0.0001**	0.13
Upper-middle income	50	0.09 [0.05, 0.13]	78	<0.00001**	
High income	35	0.05 [0.01, 0.09]	53	0.01*	
Weight status					
Overweight	13	0.03 [-0.04, 0.09]	60	0.42	0.12
Obesity	54	0.09 [0.05, 0.12]	74	<0.00001**	
Sex					
Boys	19	0.07 [-0.01, 0.14]	79	0.07	0.63
Girls	13	0.04 [-0.01, 0.10]	70	0.10	
LDL-C					
Type of exercise					
Aerobic	50	-0.28 [-0.38, -0.19]	84	<0.00001**	0.12
Anaerobic	11	-0.40 [-0.53, -0.27]	3	<0.00001**	
Resistance	4	-0.35 [-0.68, -0.01]	52	0.04*	
Combined aerobic and resistance	22	-0.19 [-0.31, -0.07]	56	0.002**	
Exercise intensity					

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Moderate-to-low	56	-0.28 [-0.37, -0.20]	80	<0.00001**	0.74
High	31	-0.26 [-0.38, -0.13]	71	<0.0001**	
Duration per session					
<50 min	30	-0.24 [-0.36, -0.12]	80	<0.0001**	0.52
≥50 min	57	-0.29 [-0.38, -0.20]	76	<0.00001**	
Frequency					
<3 sessions/week	17	-0.10 [-0.19, -0.01]	15	0.03*	0.0003**
≥3 sessions/week	70	-0.33 [-0.41, -0.25]	80	<0.00001**	
Weekly duration					
<150 min/week	31	-0.19 [-0.28, -0.10]	53	<0.0001**	0.04*
≥150 min/week	56	-0.33 [-0.42, -0.23]	81	<0.00001**	
Intervention duration					
<12 weeks	25	-0.28 [-0.43, -0.13]	71	0.0002**	0.96
≥12 weeks	62	-0.28 [-0.36, -0.19]	80	<0.00001**	
Region					
Asia	48	-0.35 [-0.45, -0.25]	83	<0.00001**	0.01*
Europe	10	-0.23 [-0.37, -0.09]	45	0.001**	
Africa	3	-0.42 [-0.84, -0.01]	89	0.04*	
North America	11	-0.10 [-0.20, 0.00]	13	0.06	
South America	11	-0.23 [-0.38, -0.07]	30	0.004**	
Oceania	4	-0.02 [-0.26, 0.22]	0	0.89	
Economic status					
Lower-middle income	3	-0.42 [-0.84, -0.01]	89	0.04*	0.0008**
Upper-middle income	50	-0.37 [-0.47, -0.27]	82	<0.00001**	
High income	34	-0.14 [-0.21, -0.07]	27	0.0002**	
Weight status					
Overweight	13	-0.16 [-0.39, 0.07]	85	0.18	0.09
Obesity	53	-0.37 [-0.46, -0.28]	78	<0.00001**	
Sex					
Boys	19	-0.52 [-0.67, -0.37]	63	<0.00001**	0.002**
Girls	13	-0.19 [-0.33, -0.05]	76	0.008**	
Metabolic status					

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
MHO	10	-0.10 [-0.21, 0.02]	0	0.10	0.43
MUO	15	-0.18 [-0.35, -0.01]	80	0.04*	
FPG					
Type of exercise					
Aerobic	49	-0.21 [-0.31, -0.11]	89	<0.0001**	0.46
Anaerobic	14	-0.19 [-0.33, -0.05]	56	0.006**	
Resistance	8	-0.06 [-0.23, 0.10]	60	0.46	
Combined aerobic and resistance	23	-0.21 [-0.34, -0.08]	82	0.001**	
Exercise intensity					
Moderate-to-low	60	-0.24 [-0.33, -0.15]	88	<0.00001**	0.10
High	34	-0.13 [-0.22, -0.05]	73	0.003**	
Duration per session					
<50 min	32	-0.12 [-0.20, -0.05]	72	0.002**	0.06
≥50 min	62	-0.24 [-0.34, -0.15]	88	<0.00001**	
Frequency					
<3 sessions/week	23	-0.06 [-0.13, 0.01]	53	0.11	0.0007**
≥3 sessions/week	71	-0.25 [-0.33, -0.16]	87	<0.00001**	
Weekly duration					
<150 min/week	38	-0.08 [-0.15, -0.02]	60	0.009**	0.001**
≥150 min/week	56	-0.28 [-0.38, -0.18]	89	<0.00001**	
Intervention duration					
<12 weeks	24	-0.20 [-0.40, 0.01]	90	0.06	0.98
≥12 weeks	70	-0.20 [-0.27, -0.13]	83	<0.00001**	
Region					
Asia	39	-0.35 [-0.48, -0.21]	89	<0.00001**	<0.00001**
Europe	8	-0.02 [-0.10, 0.07]	41	0.72	
Africa	10	-0.19 [-0.35, -0.04]	51	0.01*	
North America	24	-0.17 [-0.28, -0.06]	84	0.003**	
South America	9	-0.07 [-0.21, 0.07]	61	0.33	
Oceania	4	0.16 [0.02, 0.31]	0	0.02*	
Economic status					
Lower-middle income	10	-0.19 [-0.35, -0.04]	51	0.01*	0.02*

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Upper-middle income	39	-0.32 [-0.45, -0.19]	90	<0.00001**	
High income	45	-0.10 [-0.17, -0.03]	78	0.008**	
Weight status					
Overweight	16	-0.13 [-0.25, -0.01]	78	0.04*	0.04*
Obesity	59	-0.29 [-0.39, -0.19]	88	<0.00001**	
Sex					
Boys	19	-0.22 [-0.39, -0.05]	76	0.010*	0.45
Girls	26	-0.30 [-0.40, -0.20]	70	<0.00001**	
HbA1c					
Type of exercise					
Aerobic	8	-0.03 [-0.09, 0.02]	0	0.20	0.94
Anaerobic	2	-0.06 [-0.20, 0.09]	0	0.42	
Resistance	0	-	-	-	
Combined aerobic and resistance	4	-0.05 [-0.24, 0.14]	62	0.59	
Exercise intensity					
Moderate-to-low	8	-0.07 [-0.13, 0.00]	0	0.05	0.59
High	6	-0.04 [-0.13, 0.06]	43	0.45	
Duration per session					
<50 min	8	-0.05 [-0.10, 0.01]	0	0.08	0.80
≥50 min	6	-0.03 [-0.16, 0.11]	50	0.69	
Frequency					
<3 sessions/week	8	-0.04 [-0.09, 0.01]	0	0.15	0.92
≥3 sessions/week	6	-0.05 [-0.20, 0.10]	60	0.55	
Weekly duration					
<150 min/week	10	-0.05 [-0.10, -0.00]	0	0.05	0.61
≥150 min/week	4	0.01 [-0.22, 0.25]	68	0.91	
Intervention duration					
<12 weeks	1	-0.10 [-0.34, 0.14]	-	0.41	0.67
≥12 weeks	13	-0.05 [-0.10, 0.01]	20	0.09	
Region					
Asia	1	-0.10 [-0.29, 0.09]	-	0.29	0.56
Europe	4	0.00 [-0.06, 0.06]	0	0.97	

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Africa	0	-	-	-	
North America	1	-0.10 [-0.31, 0.11]	-	0.34	
South America	3	-0.07 [-0.17, 0.02]	0	0.14	
Oceania	5	-0.08 [-0.25, 0.09]	58	0.37	
Economic status					
Lower-middle income	0	-	-	-	0.85
Upper-middle income	4	-0.06 [-0.14, 0.02]	0	0.14	
High income	10	-0.05 [-0.12, 0.03]	37	0.23	
Weight status					
Overweight	3	-0.08 [-0.18, 0.02]	0	0.12	0.71
Obesity	7	-0.05 [-0.17, 0.06]	53	0.38	
Sex					
Boys	0	-	-	-	-
Girls	2	-0.05 [-0.16, 0.06]	0	0.33	
FINS					
Type of exercise					
Aerobic	28	-4.66 [-5.99, -3.33]	81	<0.00001**	0.26
Anaerobic	10	-3.44 [-4.06, -2.83]	0	<0.00001**	
Resistance	6	-0.28 [-6.03, 5.47]	36	0.92	
Combined aerobic and resistance	13	-4.03 [-6.77, -1.28]	84	0.004**	
Exercise intensity					
Moderate-to-low	32	-4.92 [-6.42, -3.42]	83	<0.00001**	0.02*
High	25	-2.88 [-3.64, -2.12]	34	<0.00001**	
Duration per session					
<50 min	19	-2.80 [-3.53, -2.07]	52	<0.00001**	0.02*
≥50 min	38	-4.94 [-6.54, -3.35]	78	<0.00001**	
Frequency					
<3 sessions/week	14	-4.11 [-6.87, -1.35]	75	0.004**	0.89
≥3 sessions/week	43	-3.89 [-4.82, -2.96]	77	<0.00001**	
Weekly duration					
<150 min/week	24	-3.42 [-4.57, -2.26]	68	<0.00001**	0.32
≥150 min/week	33	-4.31 [-5.66, -2.96]	80	<0.00001**	

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Intervention duration					
<12 weeks	10	-4.73 [-6.89, -2.57]	47	<0.0001**	0.44
≥12 weeks	47	-3.79 [-4.73, -2.86]	77	<0.00001**	
Region					
Asia	15	-5.66 [-7.38, -3.94]	84	<0.00001**	0.03*
Europe	5	-1.11 [-4.05, 1.84]	54	0.46	
Africa	8	-2.81 [-3.57, -2.06]	35	<0.00001**	
North America	20	-4.31 [-7.22, -1.40]	72	0.004**	
South America	7	-3.39 [-7.99, 1.20]	84	0.15	
Oceania	2	-0.81 [-6.41, 4.79]	0	0.78	
Economic status					
Lower-middle income	8	-2.81 [-3.57, -2.06]	35	<0.00001**	0.04*
Upper-middle income	17	-5.53 [-7.48, -3.59]	87	<0.00001**	
High income	32	-3.41 [-5.07, -1.75]	67	<0.0001**	
Weight status					
Overweight	9	-1.68 [-3.16, -0.20]	29	0.03*	0.0007**
Obesity	38	-4.83 [-5.91, -3.76]	76	<0.00001**	
Sex					
Boys	11	-6.64 [-9.16, -4.11]	72	<0.00001**	0.07
Girls	21	-4.11 [-5.26, -2.96]	74	<0.00001**	
Metabolic status					
MHO	8	-0.67 [-1.95, 0.60]	0	0.30	0.004**
MUO	13	-5.48 [-8.51, -2.45]	90	0.0004**	
Depression					
Type of exercise					
Aerobic	18	-0.03 [-0.16, 0.10]	13	0.66	0.55
Anaerobic	0	-	-	-	
Resistance	1	-0.28 [-0.73, 0.17]	-	0.22	
Combined aerobic and resistance	3	-0.09 [-0.38, 0.19]	0	0.52	
Exercise intensity					
Moderate-to-low	15	0.01 [-0.13, 0.16]	11	0.86	0.16
High	7	-0.15 [-0.31, 0.02]	0	0.08	

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Duration per session					
<50 min	11	-0.16 [-0.31, -0.01]	0	0.04*	0.04*
≥50 min	11	0.06 [-0.09, 0.21]	3	0.43	
Frequency					
<3 sessions/week	5	0.14 [-0.08, 0.36]	0	0.20	0.05
≥3 sessions/week	17	-0.10 [-0.22, 0.02]	1	0.09	
Weekly duration					
<150 min/week	12	0.01 [-0.14, 0.15]	0	0.94	0.23
≥150 min/week	10	-0.14 [-0.33, 0.05]	30	0.14	
Intervention duration					
<12 weeks	4	-0.12 [-0.43, 0.19]	0	0.46	0.67
≥12 weeks	18	-0.05 [-0.17, 0.08]	19	0.48	
Region					
Asia	3	-0.01 [-0.36, 0.34]	39	0.96	0.14
Europe	5	-0.05 [-0.29, 0.19]	0	0.68	
Africa	0	-	-	-	
North America	12	-0.14 [-0.29, -0.00]	0	0.05	
South America	1	0.30 [-0.16, 0.76]	-	0.20	
Oceania	1	0.43 [-0.11, 0.96]	-	0.12	
Economic status					
Lower-middle income	0	-	-	-	0.29
Upper-middle income	4	0.06 [-0.20, 0.32]	33	0.64	
High income	18	-0.09 [-0.21, 0.03]	0	0.14	
Weight status					
Overweight	5	-0.23 [-0.58, 0.11]	32	0.18	0.30
Obesity	11	-0.04 [-0.18, 0.10]	0	0.61	
Sex					
Boys	0	-	-	-	-
Girls	1	-0.55 [-1.28, 0.18]	-	0.14	
Anxiety					
Type of exercise					
Aerobic	4	-0.03 [-0.23, 0.18]	0	0.80	0.41

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Anaerobic	0	-	-	-	
Resistance	0	-	-	-	
Combined aerobic and resistance	2	-1.68 [-5.62, 2.26]	97	0.40	
Exercise intensity					
Moderate-to-low	5	-0.50 [-1.17, 0.16]	88	0.14	0.05
High	1	0.29 [-0.14, 0.72]	-	0.19	
Duration per session					
<50 min	0	-	-	-	-
≥50 min	6	-0.33 [-0.87, 0.21]	86	0.23	
Frequency					
<3 sessions/week	2	-0.07 [-0.38, 0.24]	0	0.65	0.27
≥3 sessions/week	4	-0.62 [-1.56, 0.31]	92	0.19	
Weekly duration					
<150 min/week	2	-0.07 [-0.38, 0.24]	0	0.65	0.27
≥150 min/week	4	-0.62 [-1.56, 0.31]	92	0.19	
Intervention duration					
<12 weeks	1	0.05 [-0.62, 0.73]	-	0.87	0.31
≥12 weeks	5	-0.43 [-1.06, 0.21]	89	0.19	
Region					
Asia	2	-1.82 [-5.47, 1.84]	97	0.33	0.42
Europe	1	0.29 [-0.14, 0.72]	-	0.19	
Africa	0	-	-	-	
North America	2	-0.08 [-0.41, 0.25]	0	0.63	
South America	0	-	-	-	
Oceania	1	0.03 [-0.50, 0.56]	-	0.92	
Economic status					
Lower-middle income	0	-	-	-	0.05
Upper-middle income	3	-1.02 [-2.15, 0.10]	94	0.08	
High income	3	0.16 [-0.14, 0.46]	0	0.30	
Weight status					
Overweight	0	-	-	-	-
Obesity	3	-0.04 [-0.26, 0.19]	0	0.75	

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Sex					
Boys	0	-	-	-	-
Girls	1	-3.73 [-4.97, -2.49]	-	<0.00001**	
Self-esteem					
Type of exercise					
Aerobic	8	0.18 [-0.04, 0.41]	24	0.11	0.48
Anaerobic	0	-	-	-	
Resistance	2	0.51 [-0.09, 1.12]	61	0.09	
Combined aerobic and resistance	3	0.10 [-0.20, 0.40]	0	0.53	
Exercise intensity					
Moderate-to-low	9	0.30 [0.03, 0.58]	44	0.03*	0.38
High	4	0.14 [-0.09, 0.37]	0	0.23	
Duration per session					
<50 min	7	0.21 [-0.01, 0.43]	18	0.06	0.98
≥50 min	6	0.21 [-0.08, 0.49]	33	0.16	
Frequency					
<3 sessions/week	2	0.59 [-0.19, 1.36]	65	0.14	0.28
≥3 sessions/week	11	0.15 [-0.00, 0.30]	0	0.05	
Weekly duration					
<150 min/week	5	0.26 [0.01, 0.51]	16	0.04*	0.65
≥150 min/week	8	0.18 [-0.05, 0.42]	27	0.13	
Intervention duration					
<12 weeks	2	0.68 [0.02, 1.34]	37	0.04*	0.12
≥12 weeks	11	0.15 [-0.00, 0.29]	0	0.05	
Region					
Asia	1	1.04 [0.27, 1.81]	-	0.008**	0.06
Europe	2	0.01 [-0.31, 0.33]	0	0.94	
Africa	0	-	-	-	
North America	8	0.13 [-0.05, 0.30]	0	0.16	
South America	0	-	-	-	
Oceania	2	0.53 [-0.07, 1.13]	57	0.08	
Economic status					

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Lower-middle income	0	-	-	-	-
Upper-middle income	0	-	-	-	
High income	13	0.21 [0.04, 0.37]	19	0.01*	
Weight status					
Overweight	2	0.02 [-0.25, 0.28]	0	0.91	0.16
Obesity	5	0.28 [0.01, 0.55]	17	0.04*	
Sex					
Boys	1	0.85 [0.26, 1.44]	-	0.005**	0.01*
Girls	1	0.04 [-0.23, 0.31]	-	0.77	
Self-worth					
Type of exercise					
Aerobic	9	0.27 [0.08, 0.45]	11	0.005**	0.85
Anaerobic	0	-	-	-	
Resistance	2	0.27 [-0.09, 0.63]	0	0.14	
Combined aerobic and resistance	1	0.12 [-0.35, 0.59]	-	0.61	
Exercise intensity					
Moderate-to-low	6	0.34 [0.09, 0.60]	0	0.007**	0.36
High	6	0.20 [0.00, 0.39]	9	0.04*	
Duration per session					
<50 min	11	0.24 [0.09, 0.39]	0	0.002**	0.71
≥50 min	1	0.35 [-0.22, 0.92]	-	0.23	
Frequency					
<3 sessions/week	0	-	-	-	-
≥3 sessions/week	12	0.25 [0.10, 0.39]	0	0.001**	
Weekly duration					
<150 min/week	7	0.21 [0.01, 0.42]	0	0.04*	0.55
≥150 min/week	5	0.31 [0.05, 0.58]	28	0.02*	
Intervention duration					
<12 weeks	2	0.62 [0.13, 1.11]	0	0.01*	0.12
≥12 weeks	10	0.21 [0.05, 0.36]	0	0.008**	
Region					
Asia	0	-	-	-	0.18

Health outcomes	k	MD[95%CI]	I ² (%)	P-value of Q test	Subgroup Differences
Europe	3	0.56 [0.18, 0.95]	0	0.004**	
Africa	0	-	-	-	
North America	8	0.18 [0.01, 0.34]	0	0.04*	
South America	0	-	-	-	
Oceania	1	0.35 [-0.22, 0.92]	-	0.23	
Economic status					
Lower-middle income	0	-	-	-	-
Upper-middle income	0	-	-	-	
High income	12	0.25 [0.10, 0.39]	0	0.001**	
Weight status					
Overweight	4	0.24 [-0.15, 0.64]	45	0.23	0.87
Obesity	6	0.28 [0.06, 0.50]	0	0.01*	
Sex					
Boys	1	0.35 [-0.22, 0.92]	-	0.23	-
Girls	0	-	-	-	

Notes: MD, mean difference; CI, confidence interval; I^2 , I-square; P-value, probability value. N indicated the number of the included studies while k indicated the number of intervention groups incorporated into the meta-analysis. BMI, body mass index; WC, waist circumference; BF%, percentage of body fat; VO_2 max, maximal oxygen consumption; VO_2 peak, peak oxygen uptake; HRmax, max heart rate; HRrest, resting heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FPG, fasting plasma glucose; HbA1c, hemoglobin A1c; FINS, fasting insulin; MHO, metabolically healthy obesity; MUO, metabolically unhealthy obesity.

* $P < 0.05$, ** $P < 0.01$

Figure S1. Forest plots of meta-analysis results for 20 outcome indicators in children and adolescents with overweight or obesity

Figure S1.1. Forest plot of the effect of exercise on BMI

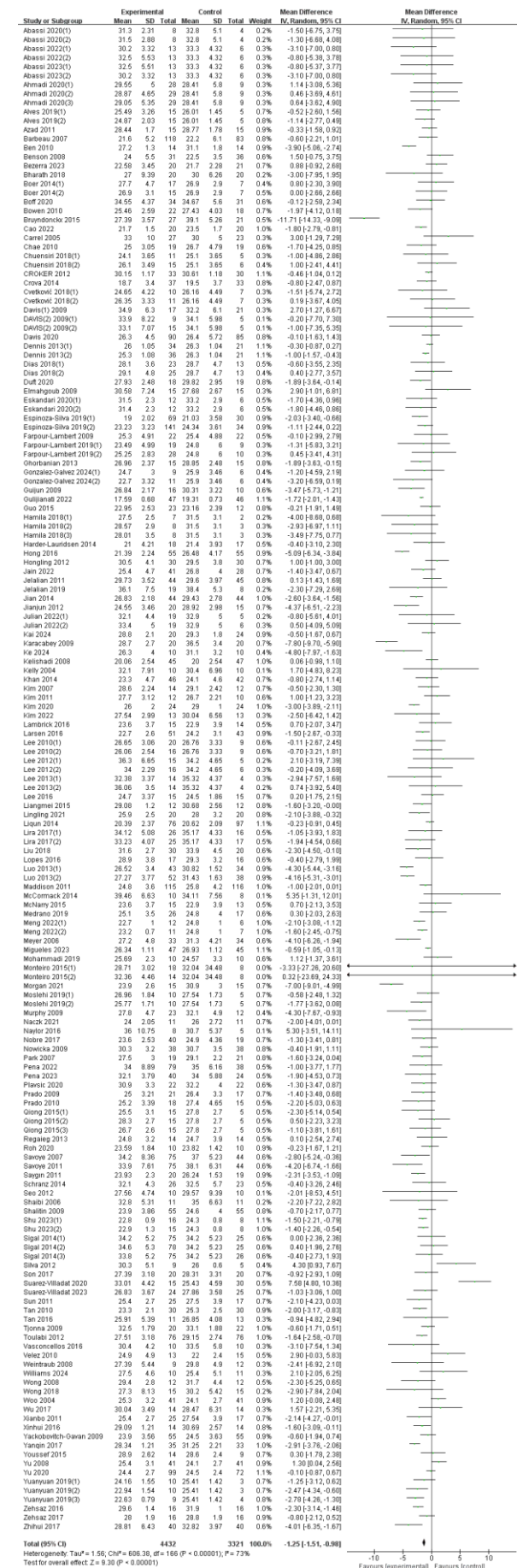


Figure S1.3. Forest plot of the effect of exercise on BF%

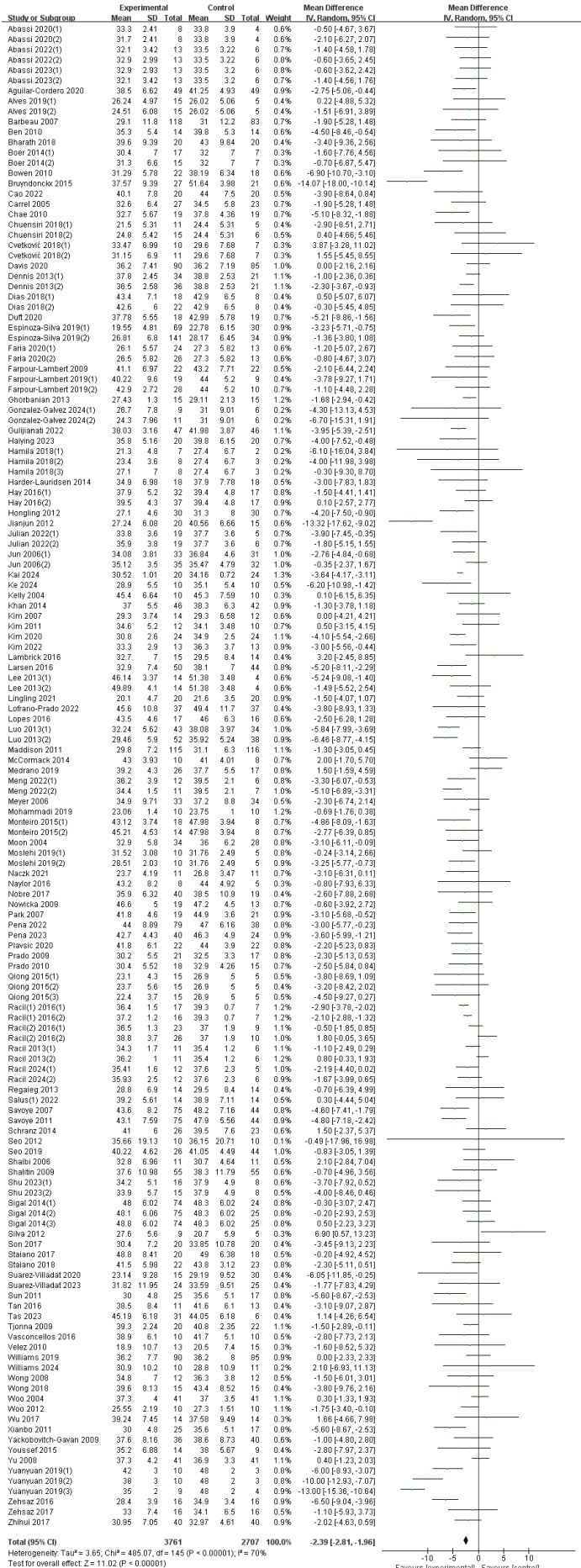


Figure S1.6. Forest plot of the effect of exercise on HRmax

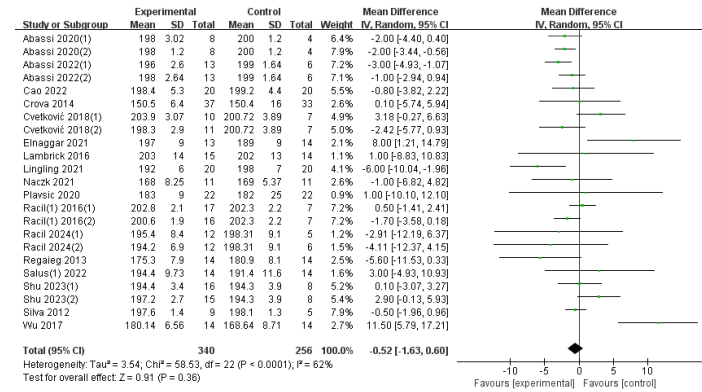


Figure S1.7. Forest plot of the effect of exercise on HRrest

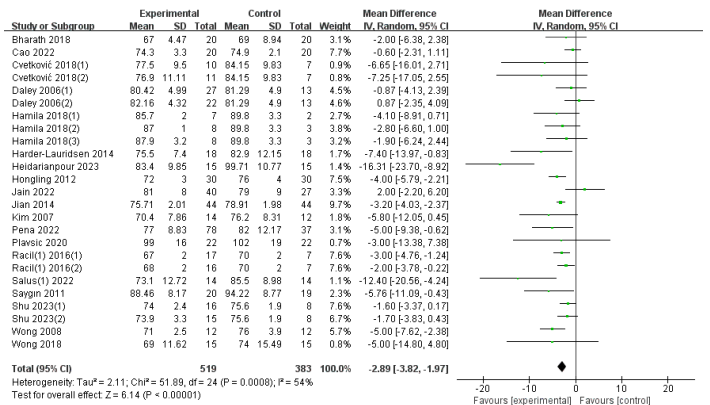


Figure S1.8. Forest plot of the effect of exercise on SBP

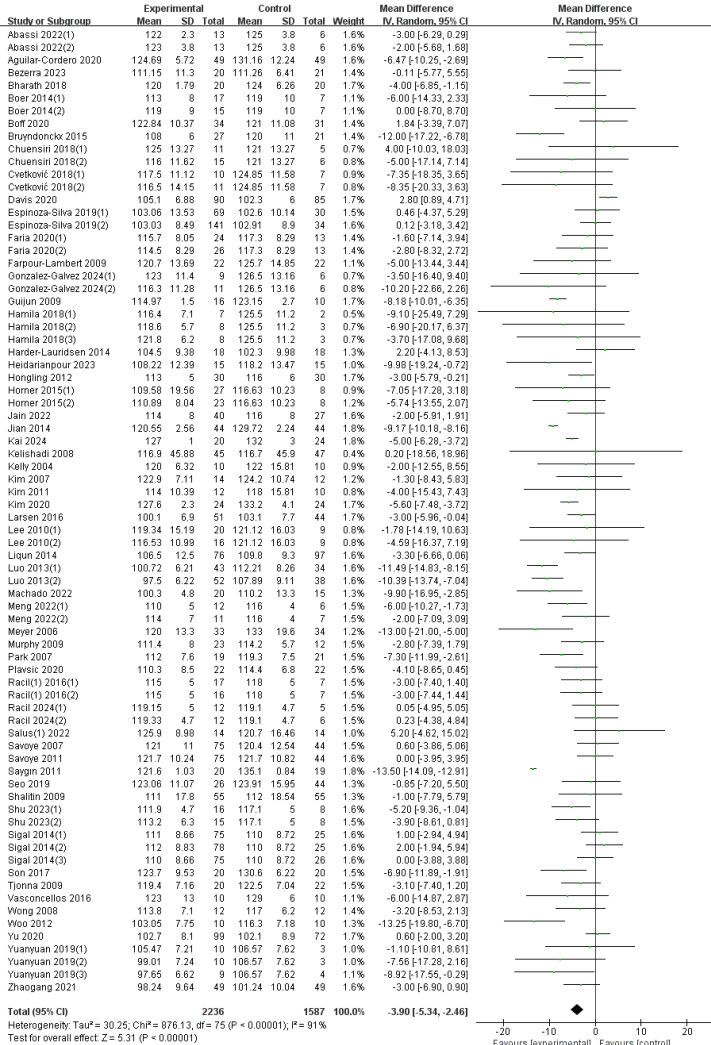


Figure S1.10. Forest plot of the effect of exercise on TC

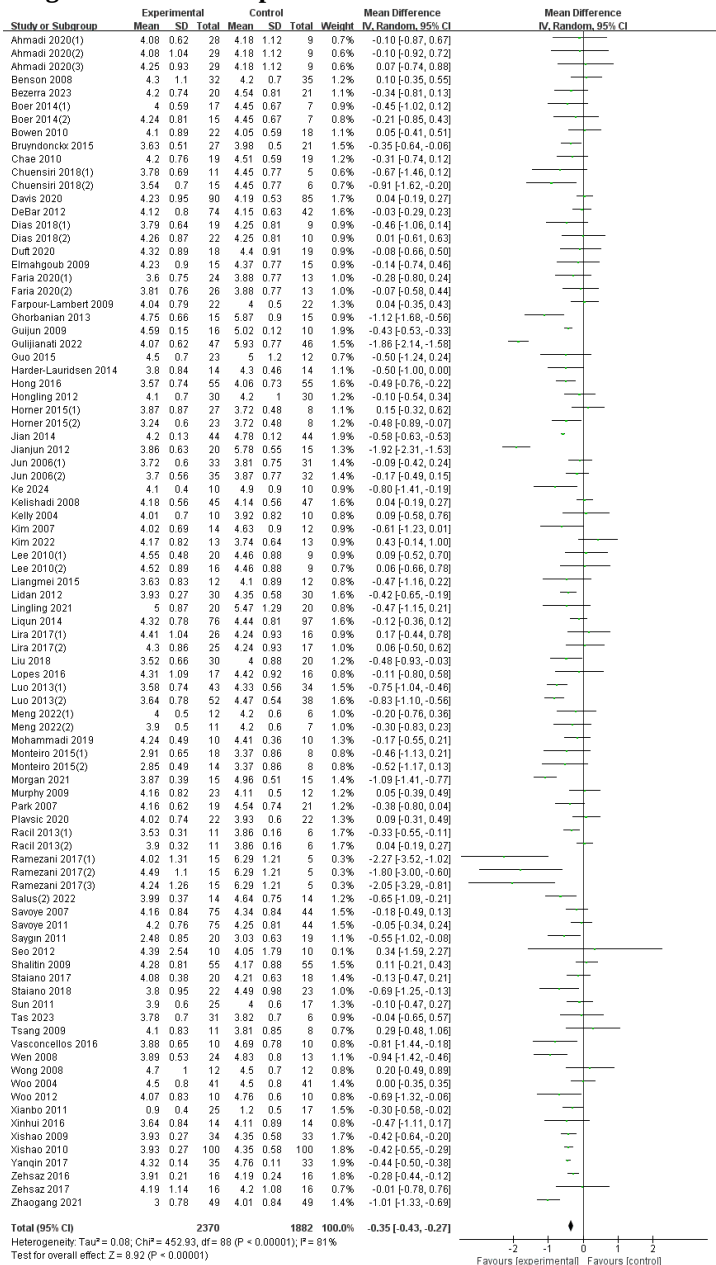


Figure S1.11. Forest plot of the effect of exercise on TG

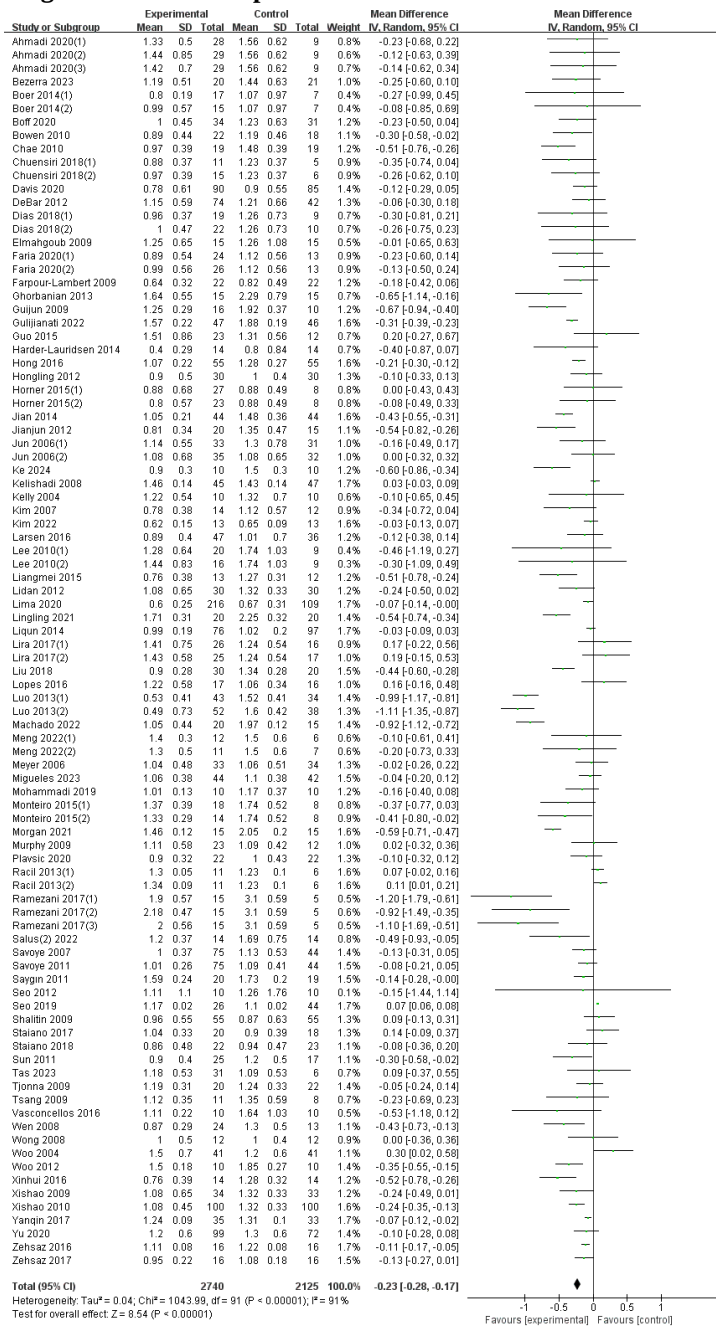


Figure S1.12. Forest plot of the effect of exercise on HDL-C

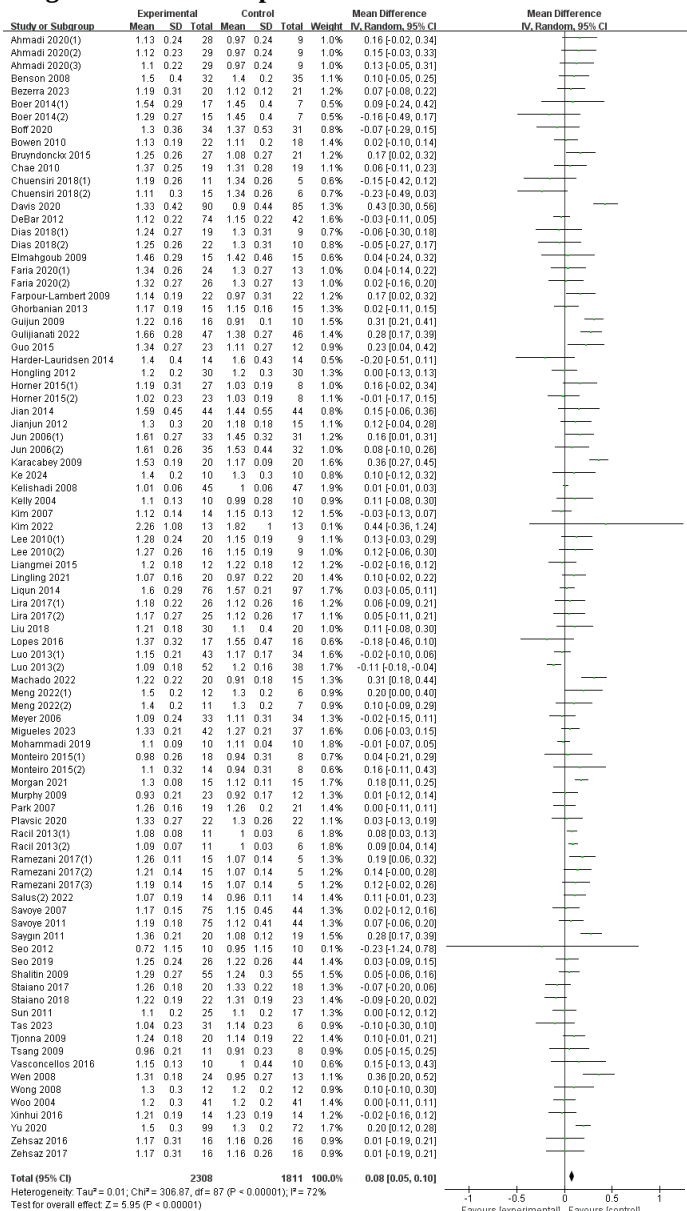


Figure S1.13. Forest plot of the effect of exercise on LDL-C

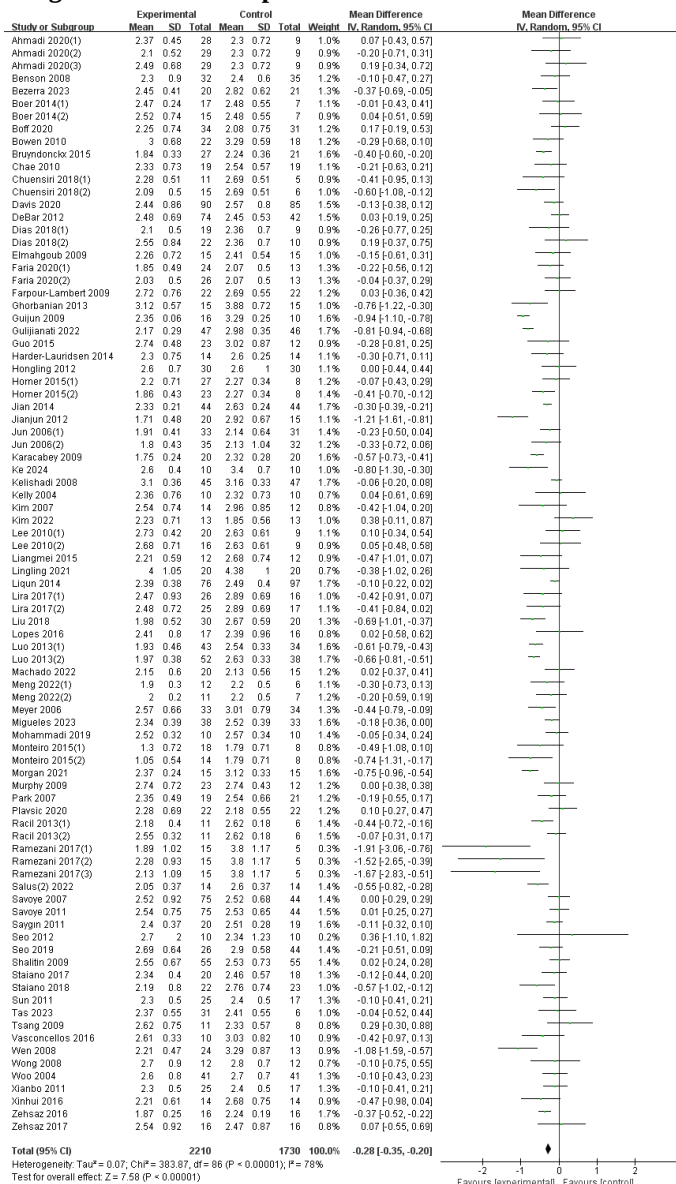


Figure S1.14. Forest plot of the effect of exercise on FPG

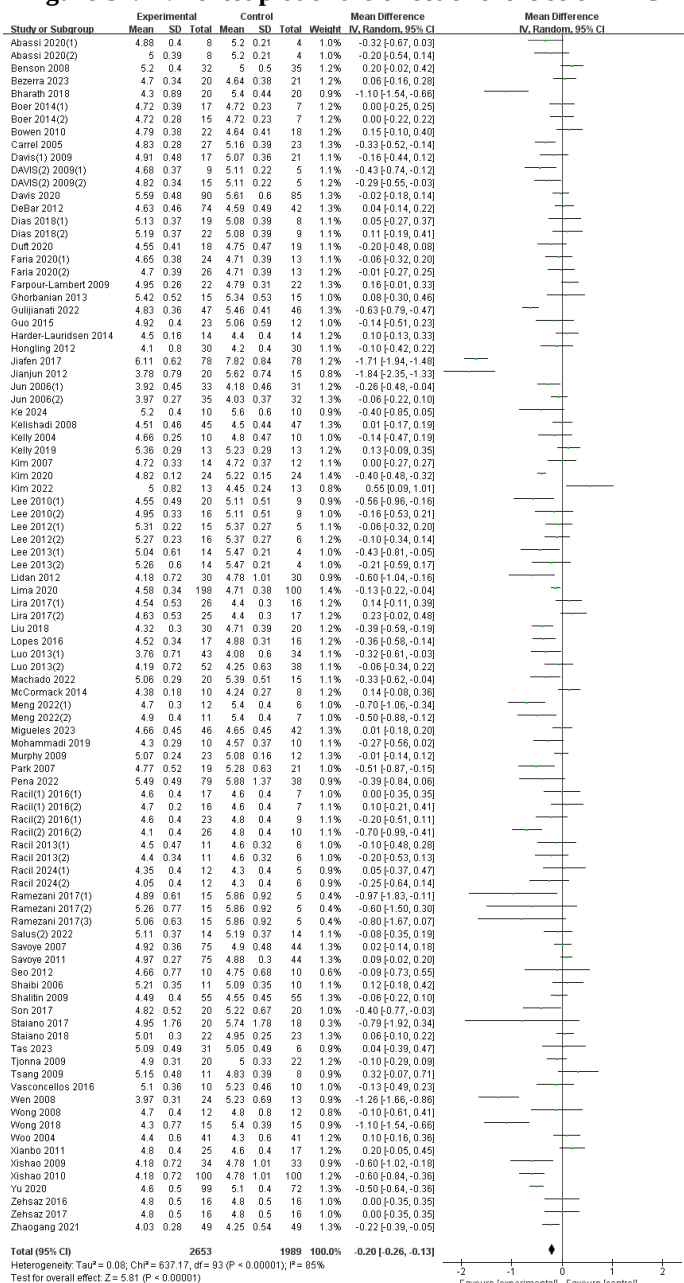


Figure S1.15. Forest plot of the effect of exercise on HbA1c

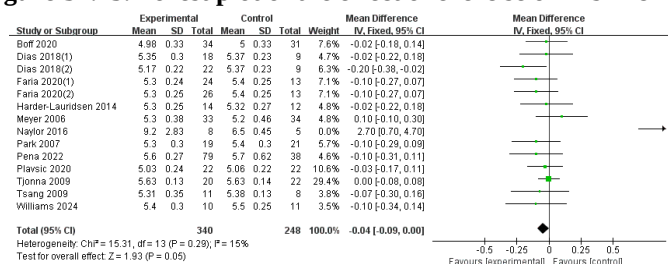


Figure S1.16. Forest plot of the effect of exercise on FINS

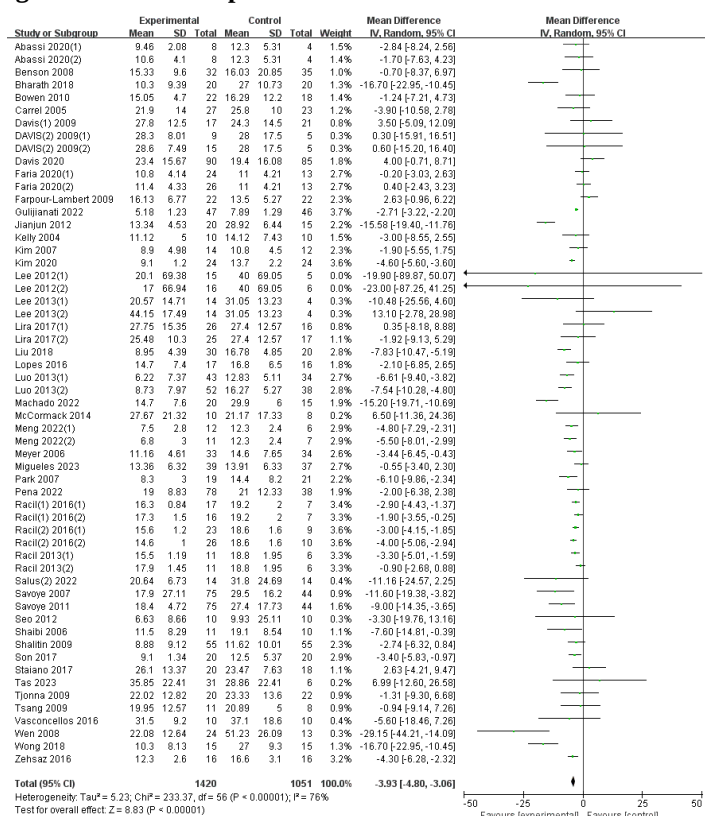


Figure S1.17. Forest plot of the effect of exercise on Depression

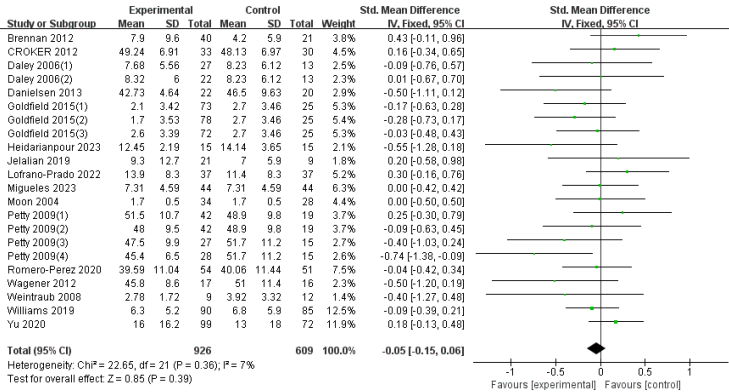


Figure S1.18. Forest plot of the effect of exercise on Anxiety

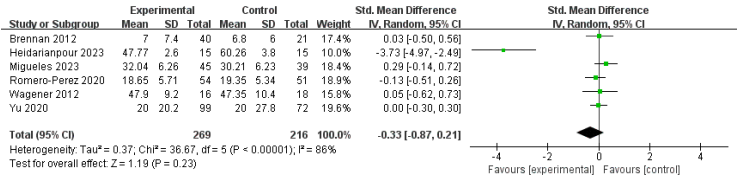


Figure S1.19. Forest plot of the effect of exercise on Self-esteem

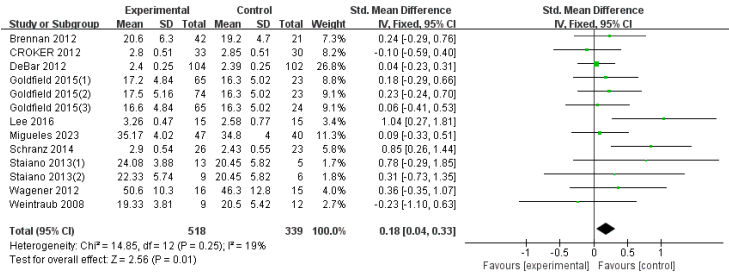


Figure S1.20. Forest plot of the effect of exercise on Self-worth

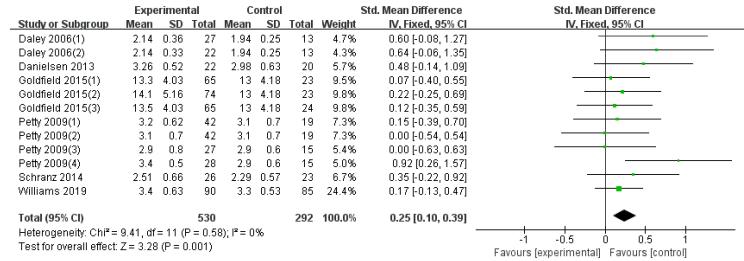
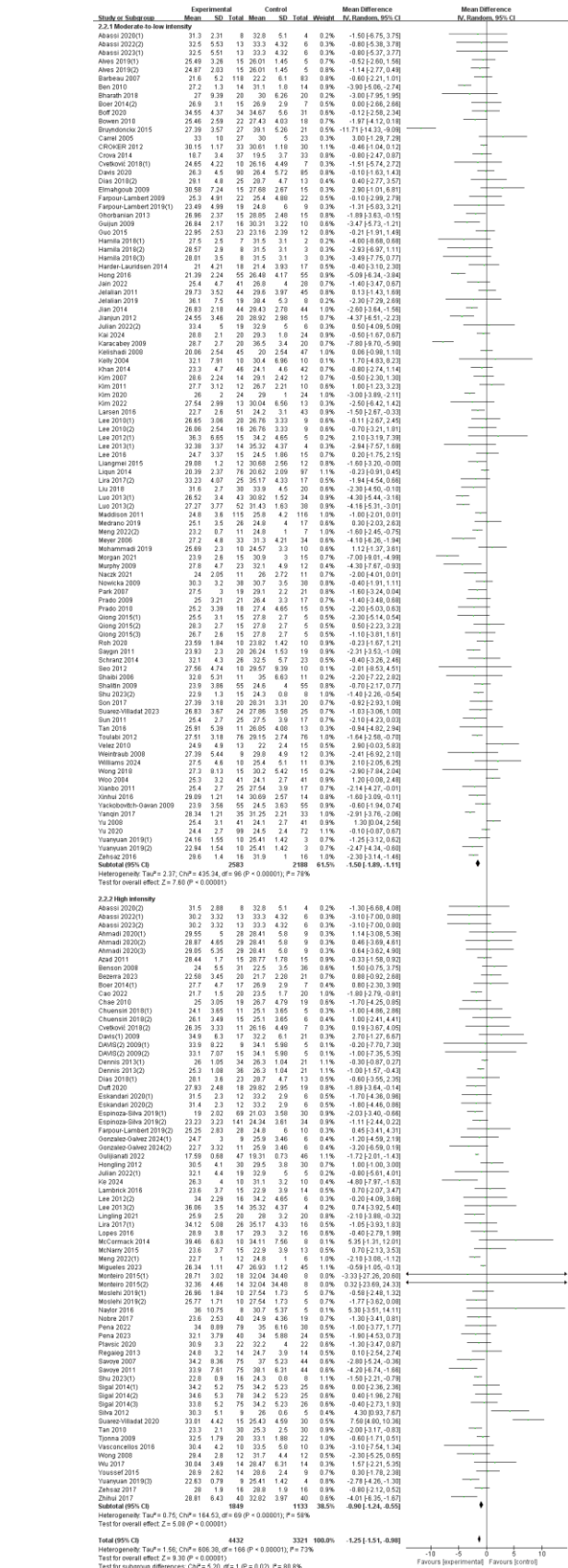
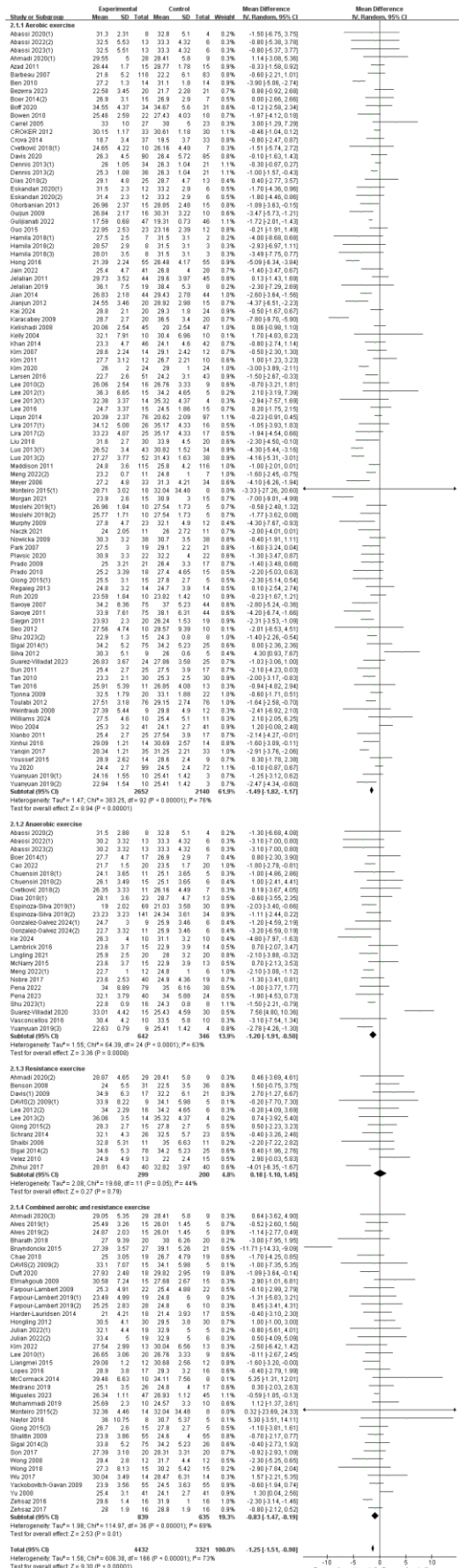


Figure S2. Forest plots of subgroup analyses for BMI in children and adolescents with overweight or obesity

Figure S2.1. Forest plot of subgroup analyses by type of exercise

Figure S2.2. Forest plot of subgroup analyses by exercise intensity



frequency

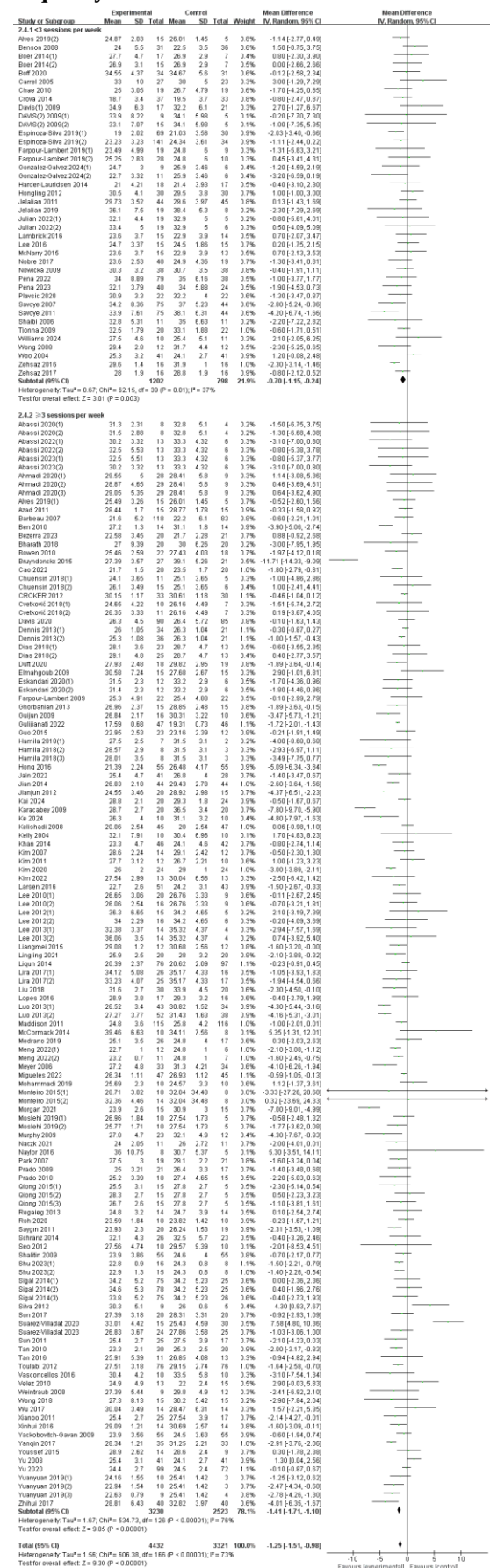


Figure S2.5. Forest plot of subgroup analyses by weekly exercise duration

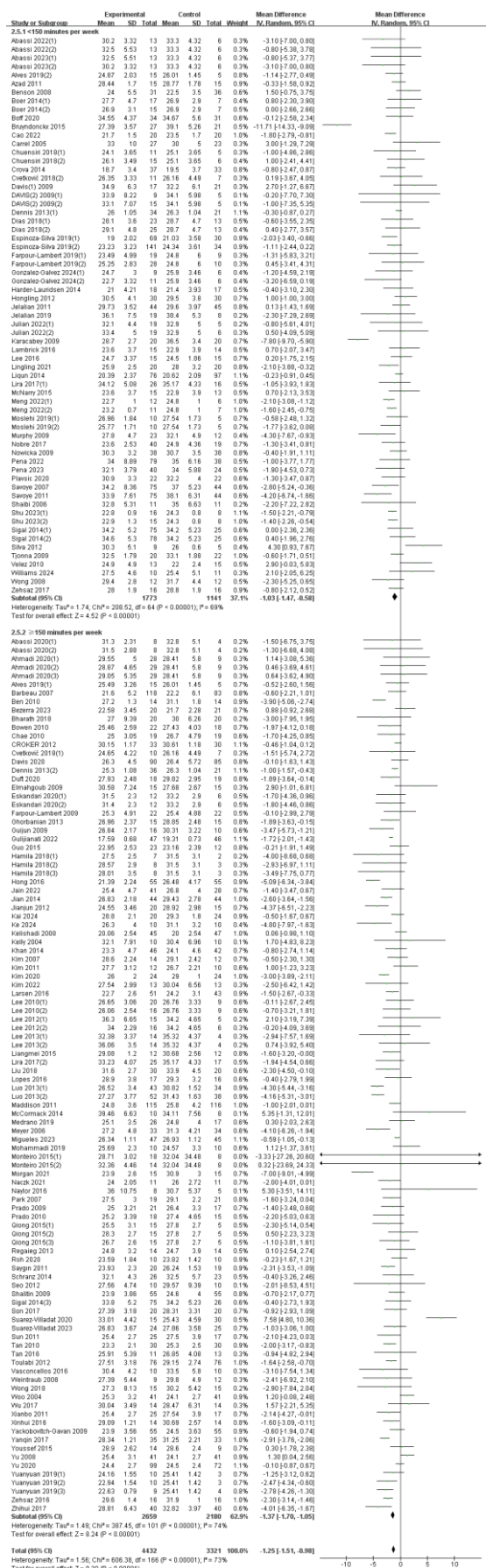


Figure S2.6. Forest plot of subgroup analyses by intervention duration

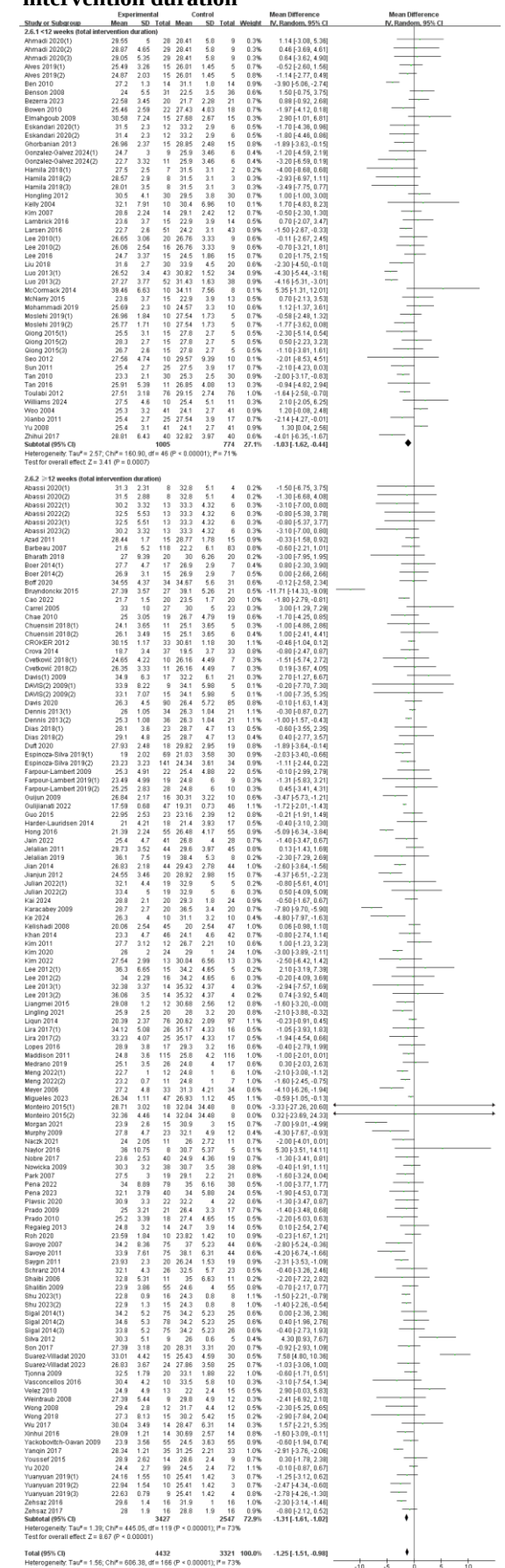


Figure S2.7. Forest plot of subgroup analyses by region

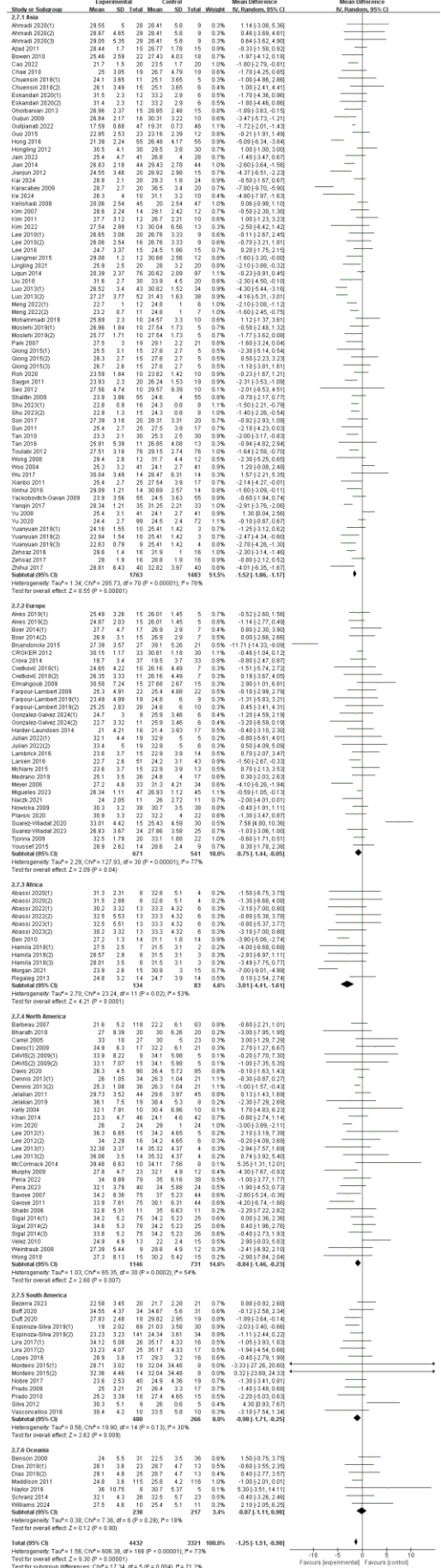


Figure S2.8. Forest plot of subgroup analyses by economic status

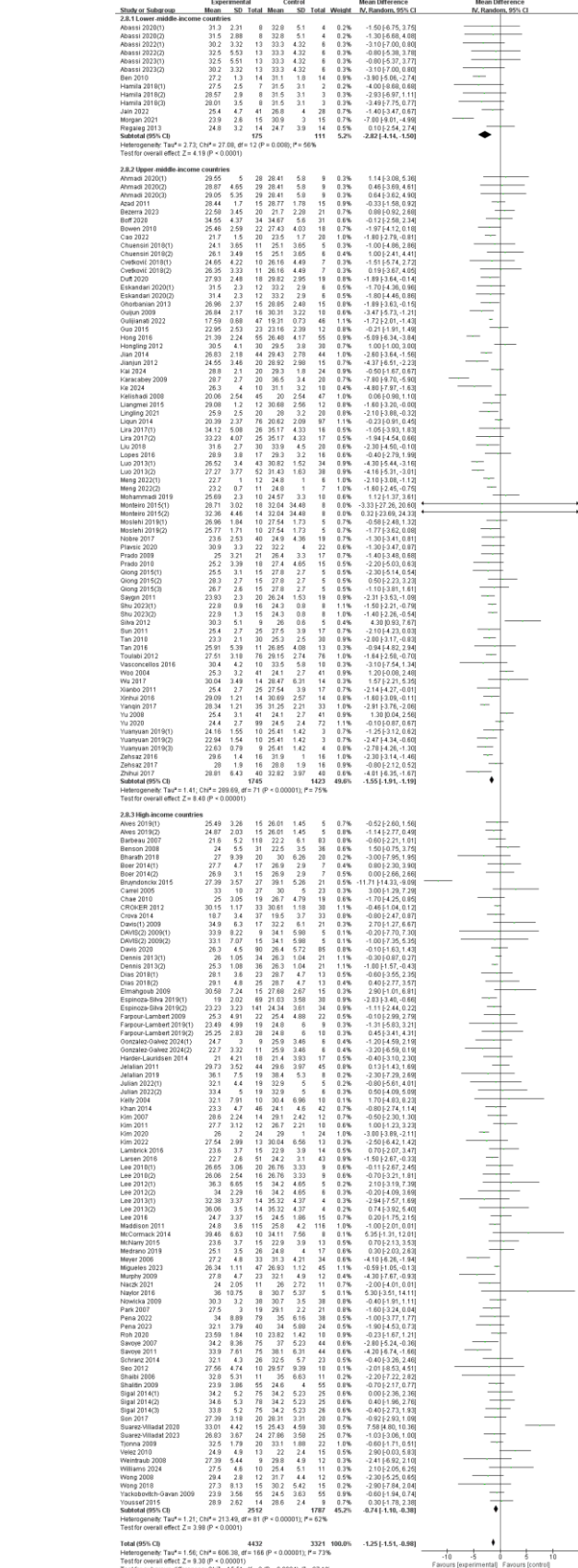


Figure S2.9. Forest plot of subgroup analyses by weight status

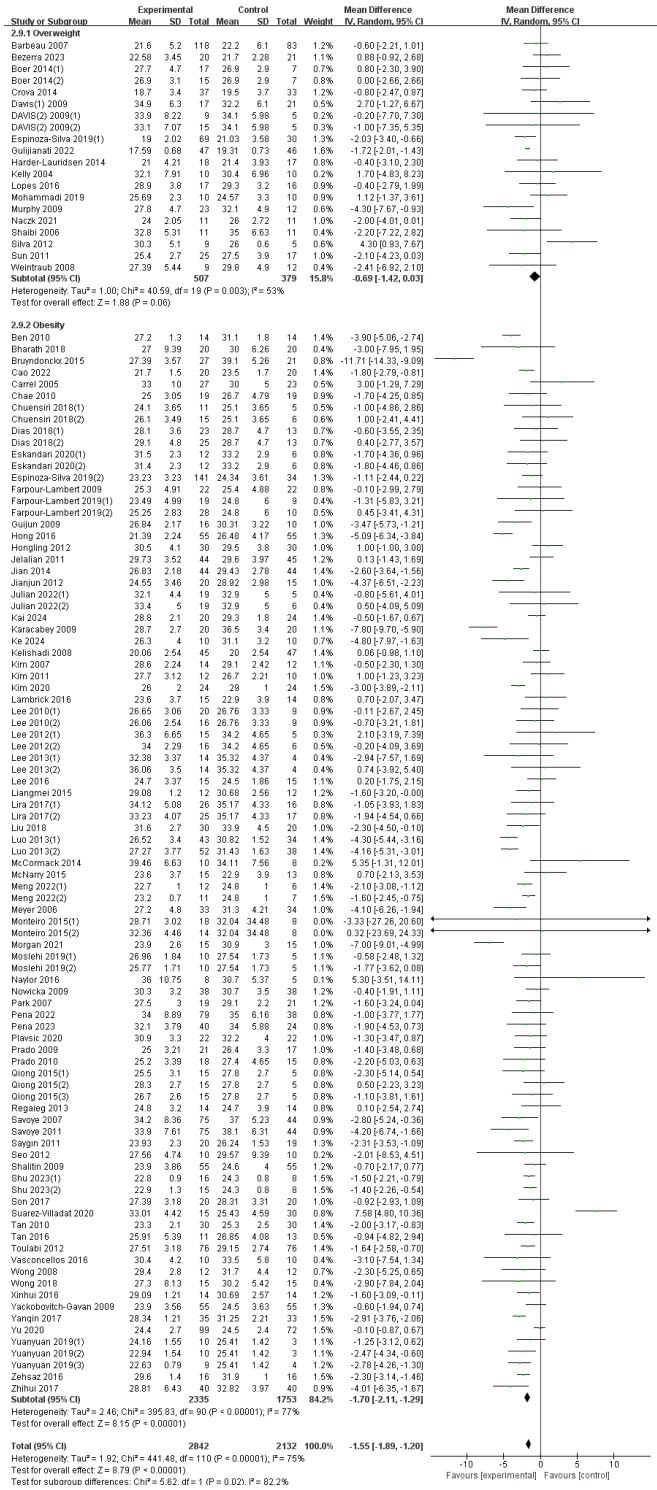


Figure S2.10. Forest plot of subgroup analyses by sex

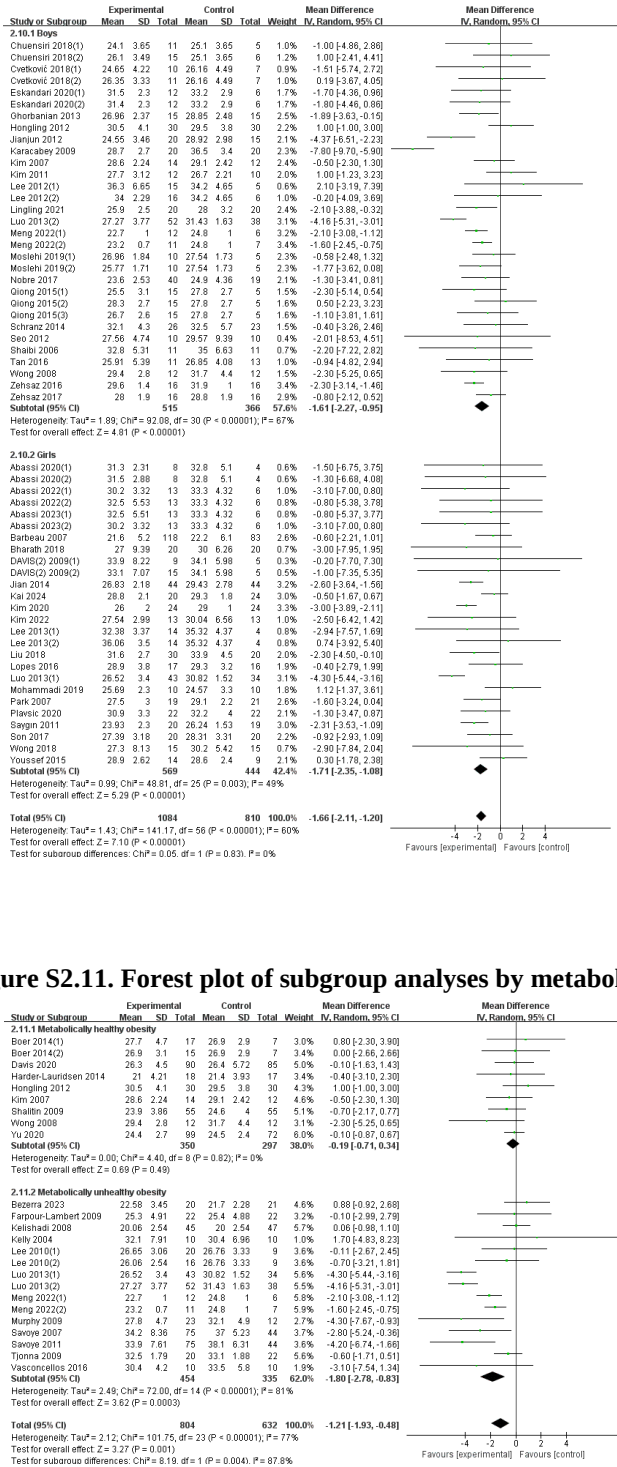


Figure S3. Forest plots of subgroup analyses for WC in children and adolescents with overweight or obesity

Figure S3.1. Forest plot of subgroup analyses by type of exercise

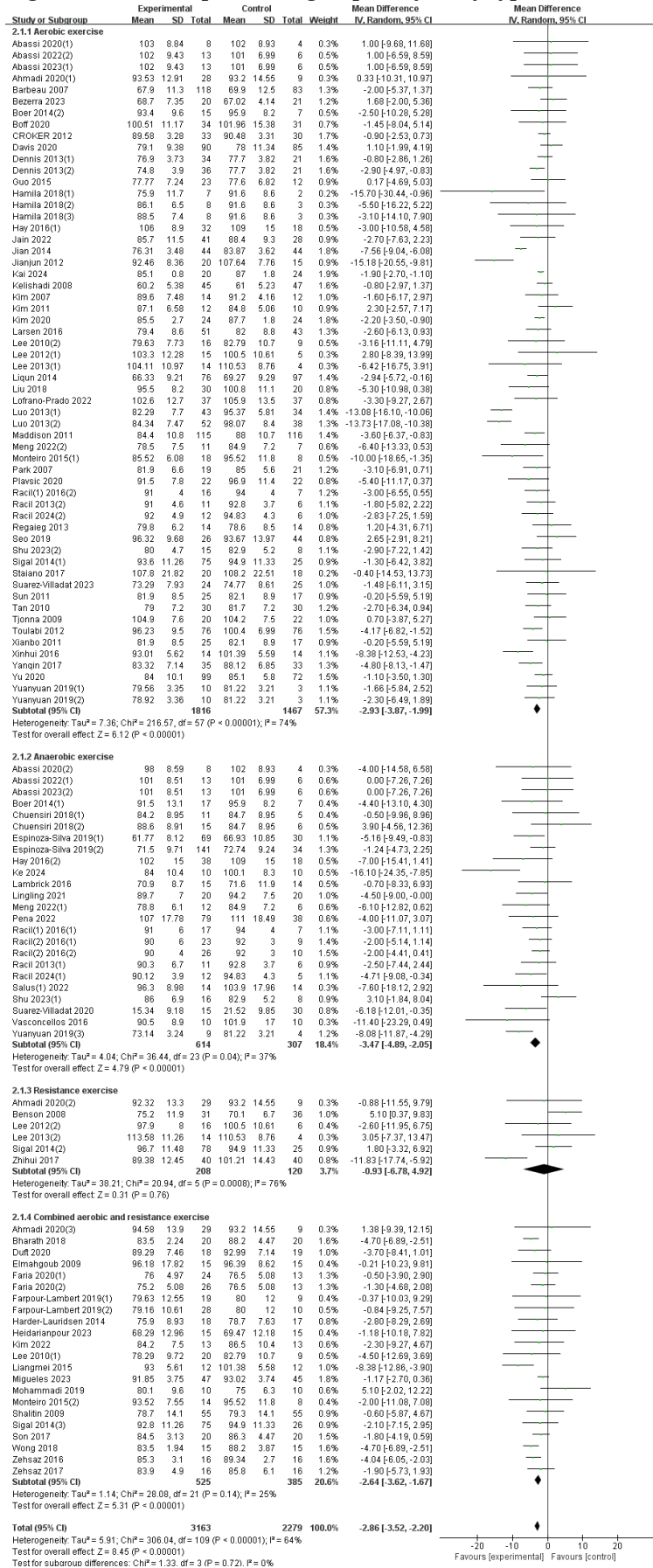


Figure S3.2. Forest plot of subgroup analyses by exercise intensity

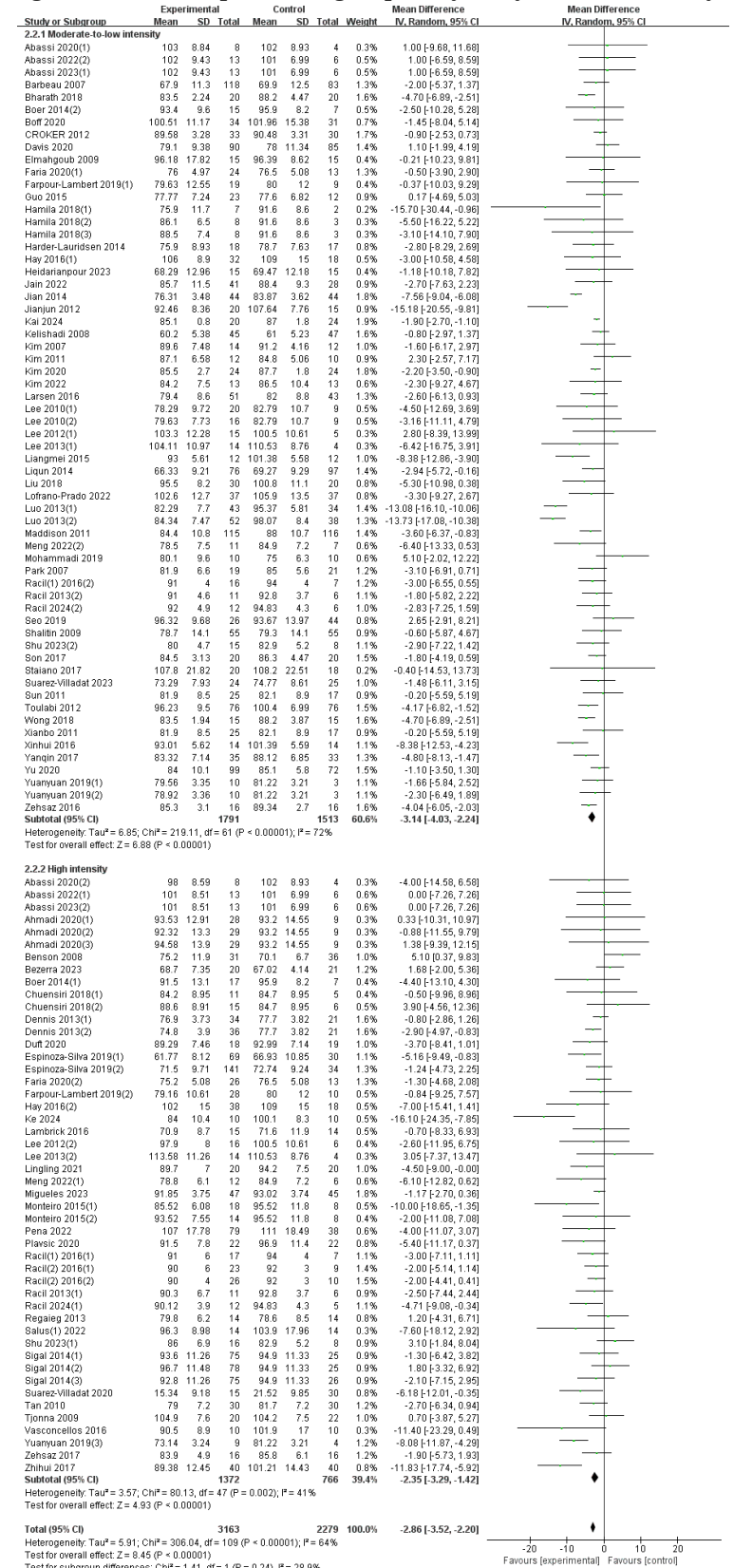


Figure S3.3. Forest plot of subgroup analyses by duration per session

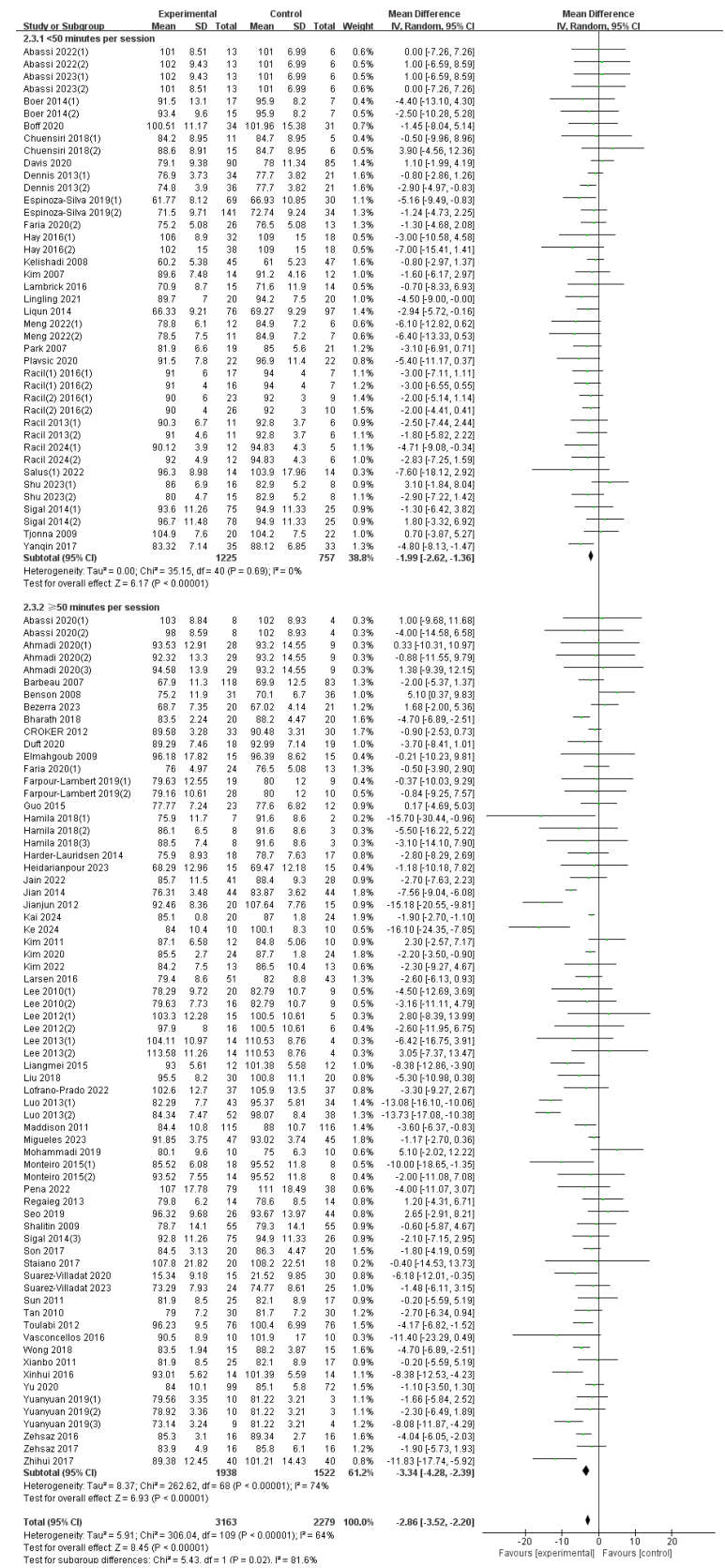


Figure S3.5. Forest plot of subgroup analyses by weekly exercise duration

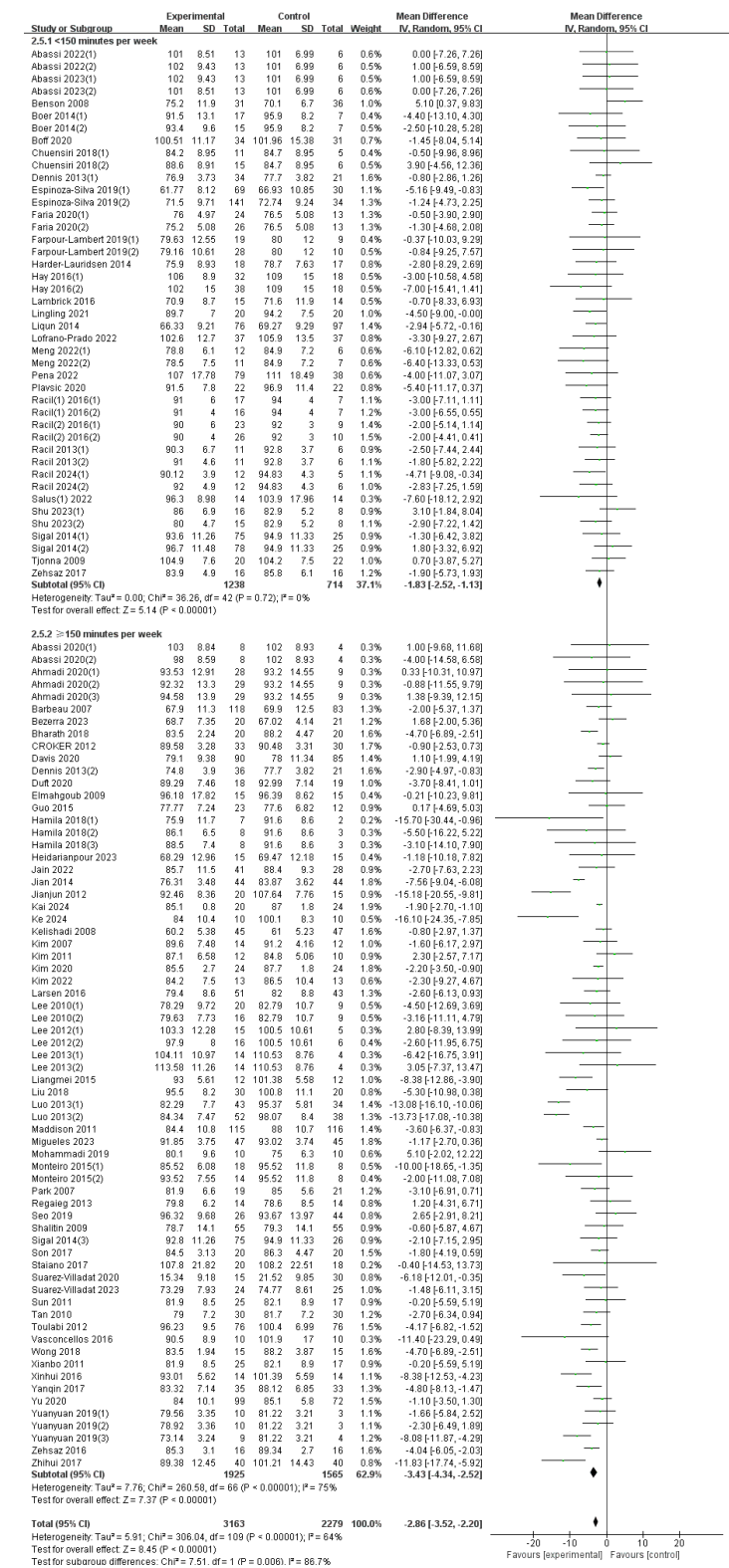


Figure S3.6. Forest plot of subgroup analyses by intervention duration

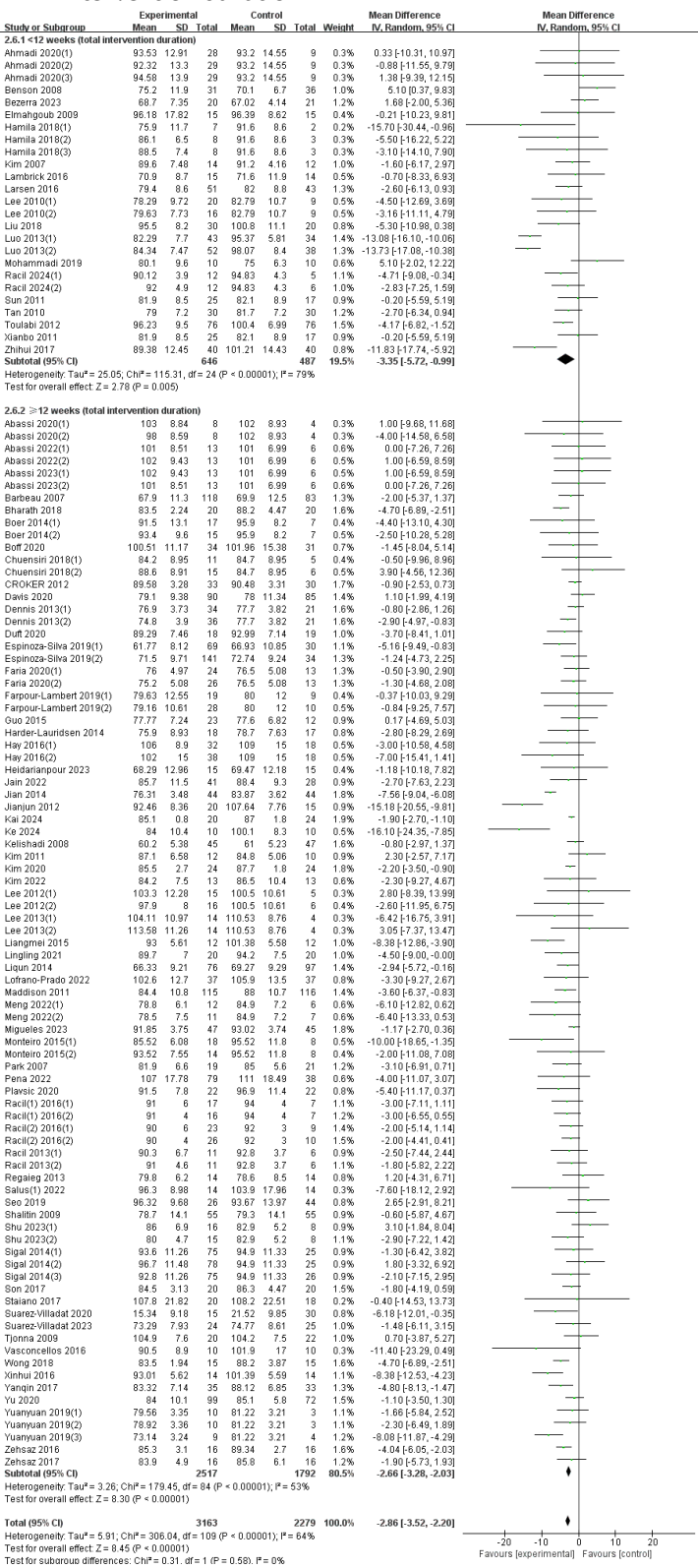


Figure S3.7. Forest plot of subgroup analyses by region

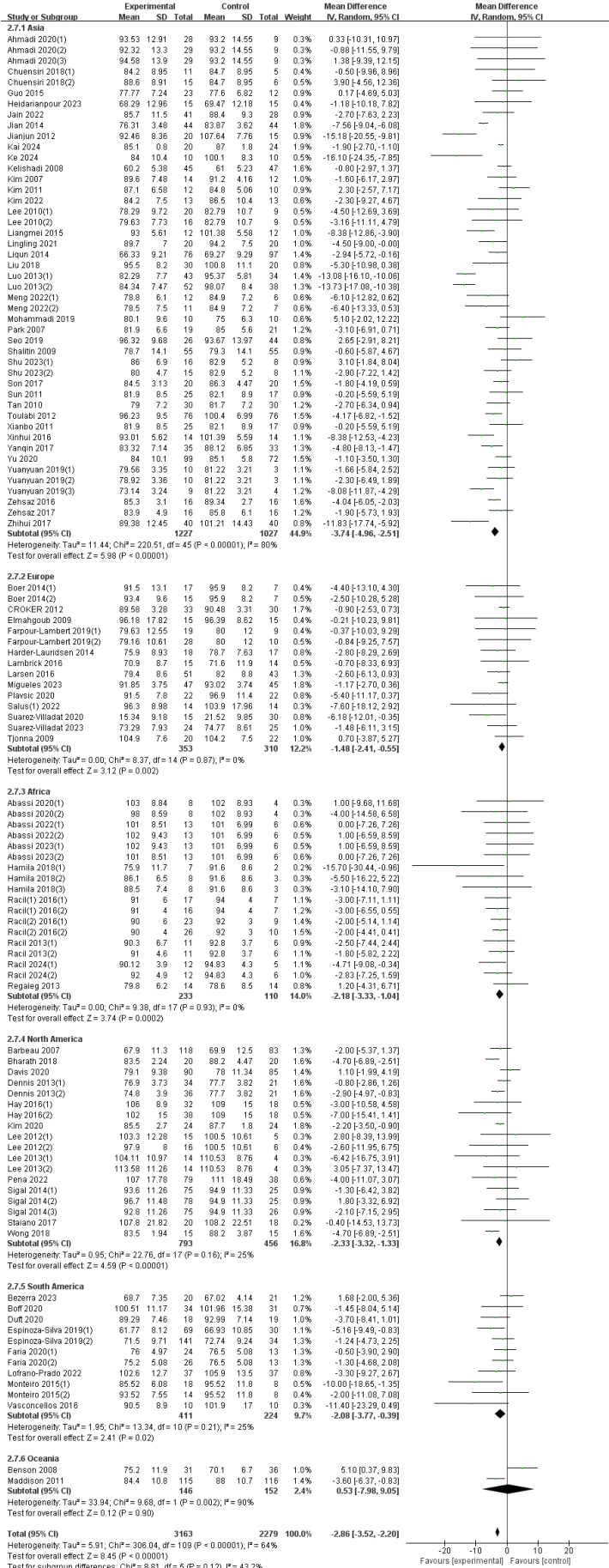


Figure S3.9. Forest plot of subgroup analyses by weight status

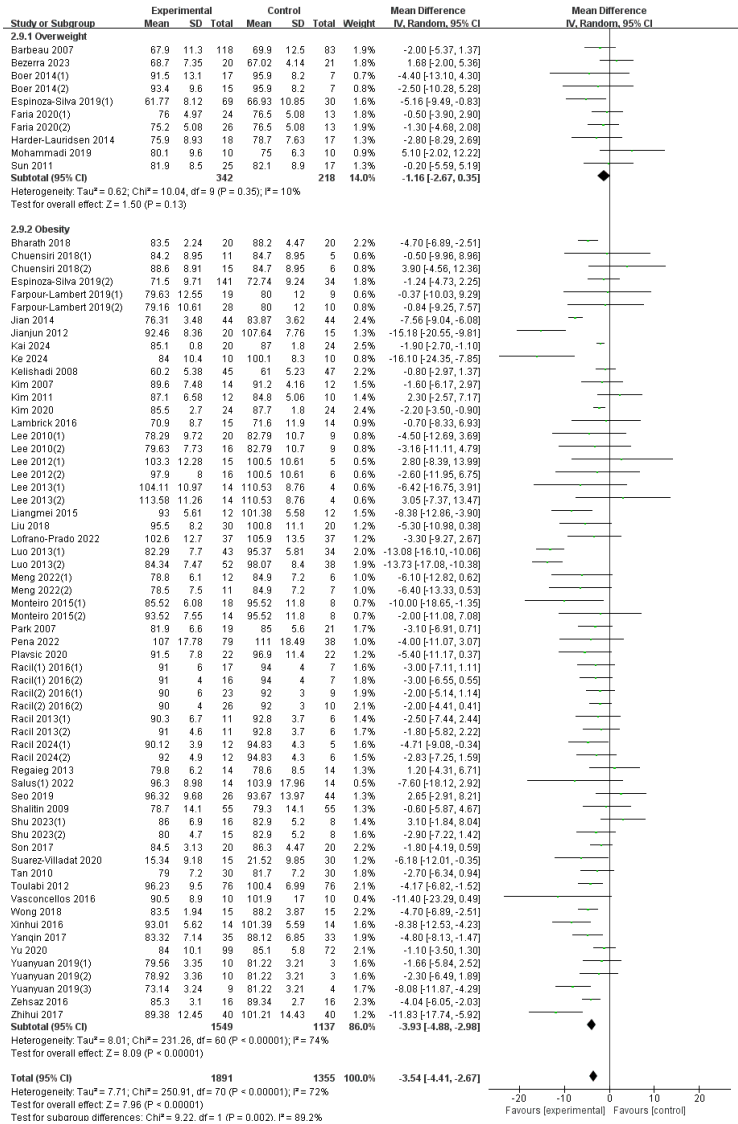


Figure S3.10. Forest plot of subgroup analyses by sex

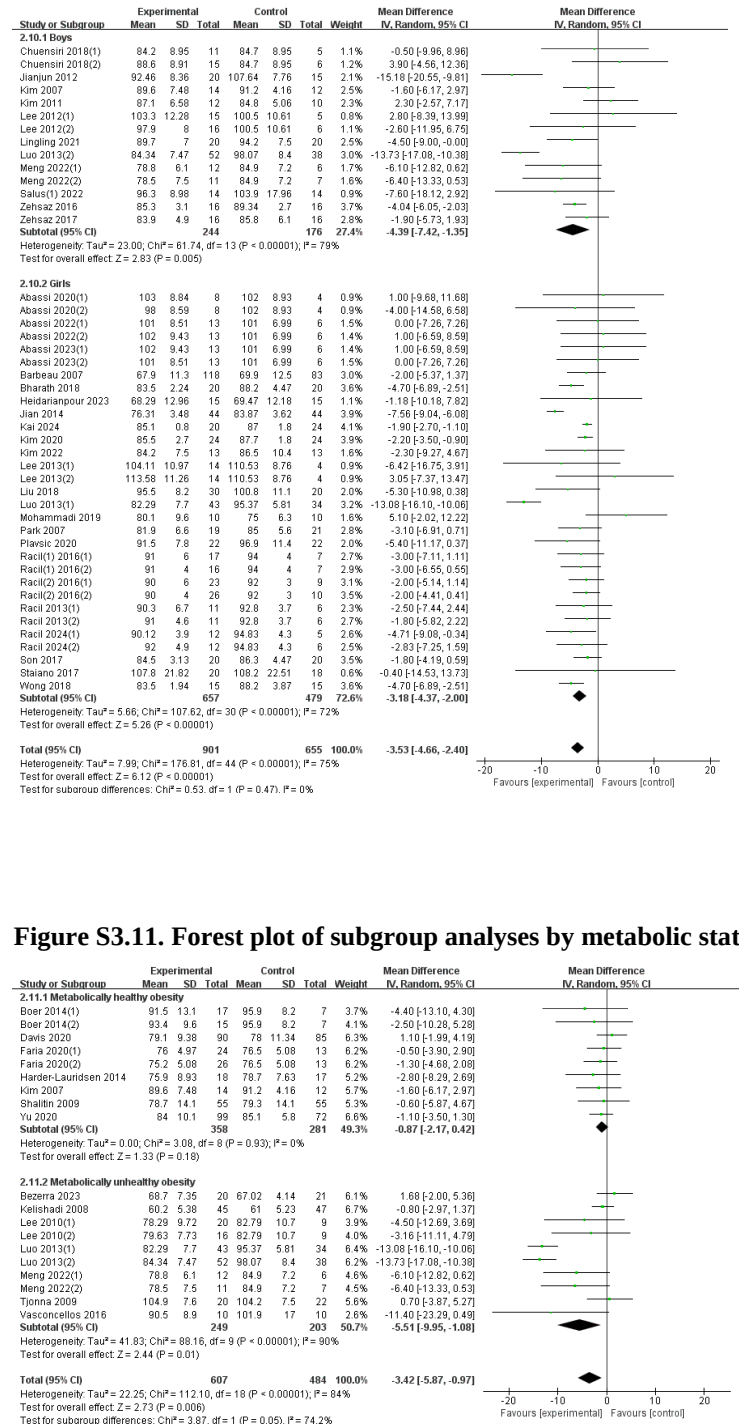


Figure S4. Forest plots of subgroup analyses for BF% in children and adolescents with overweight or obesity

Figure S4.1. Forest plot of subgroup analyses by type of exercise

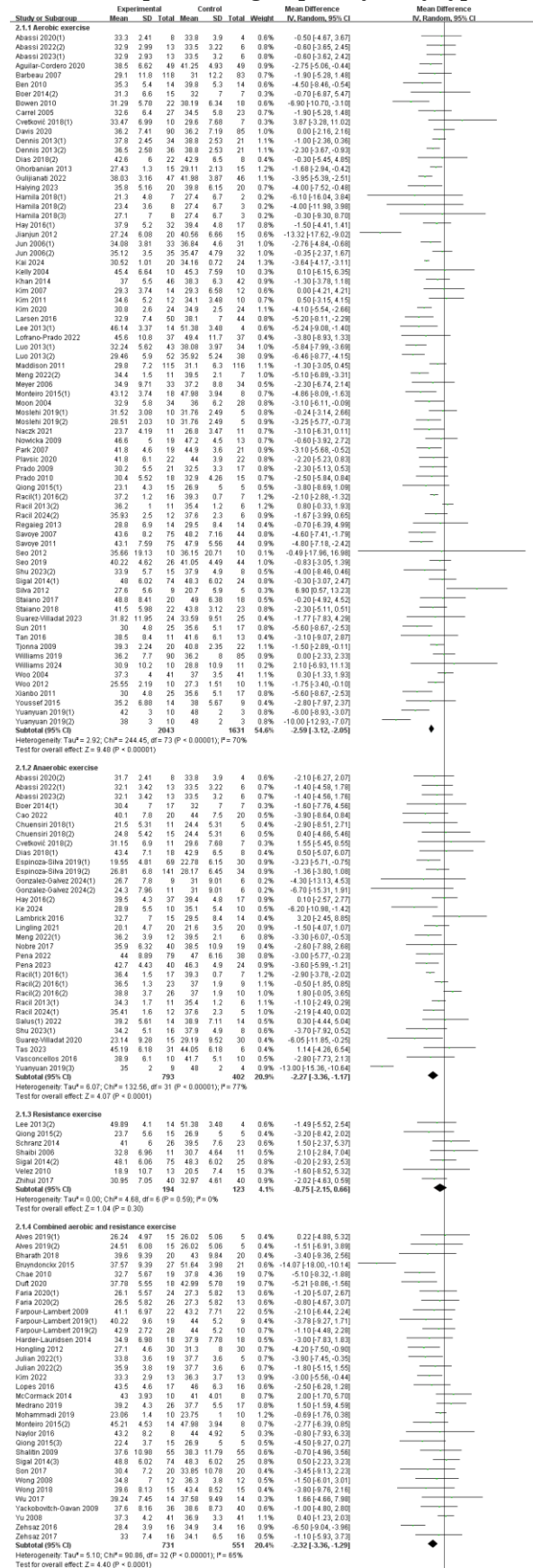


Figure S4.3. Forest plot of subgroup analyses by duration per session

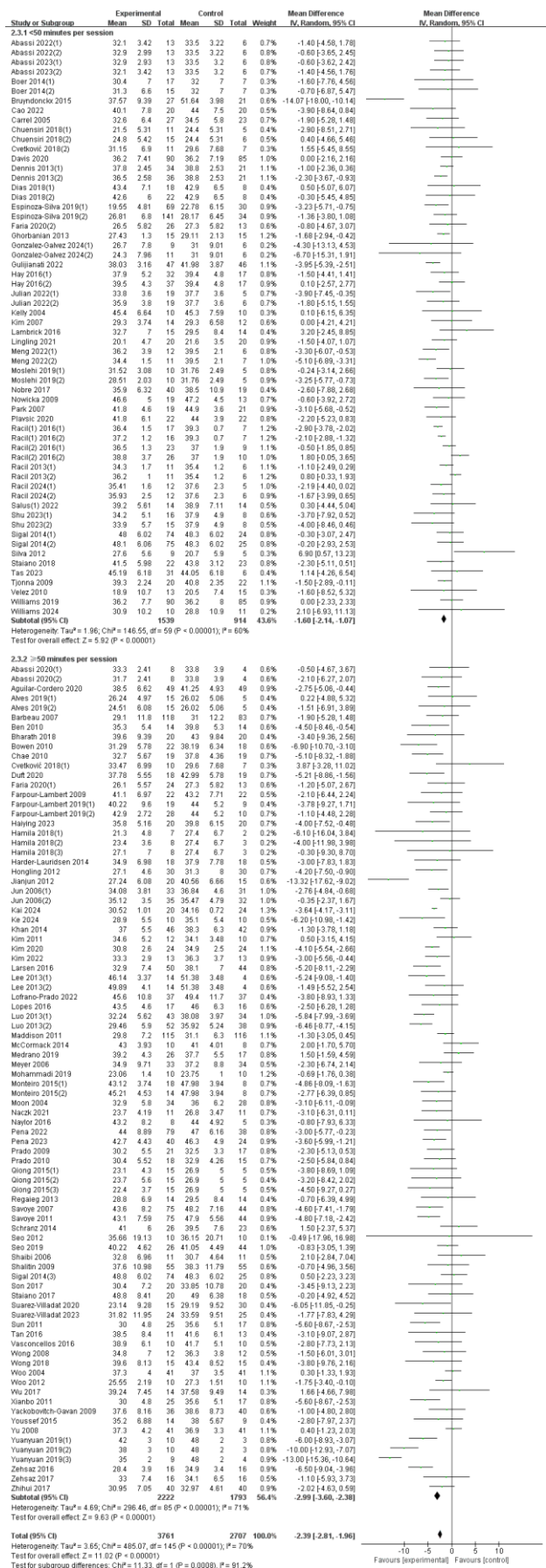


Figure S4.5. Forest plot of subgroup analyses by weekly exercise duration

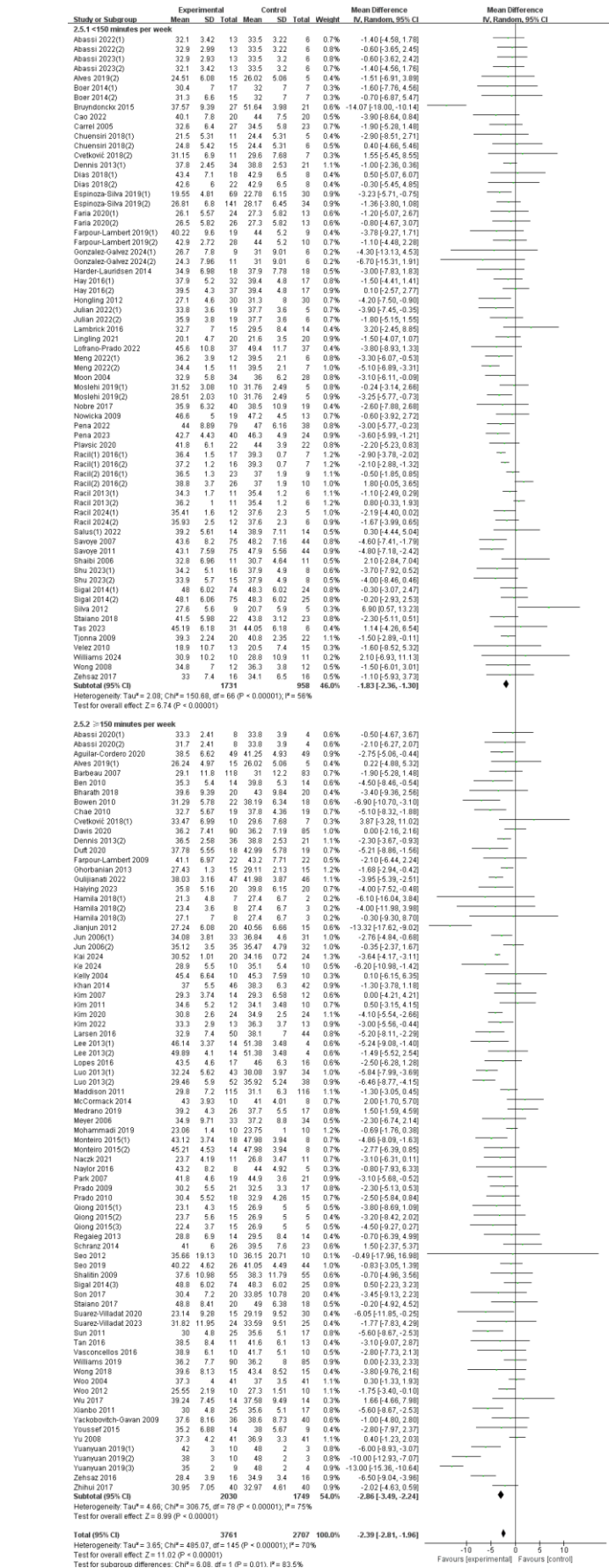


Figure S4.7. Forest plot of subgroup analyses by region

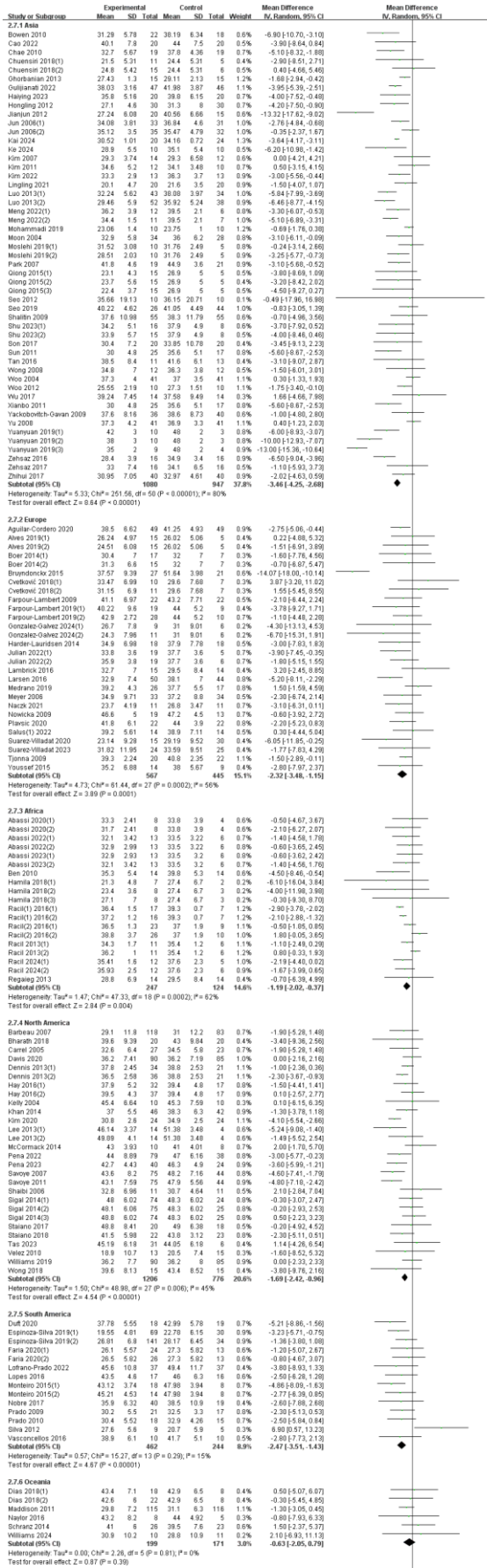


Figure S4.9. Forest plot of subgroup analyses by weight status

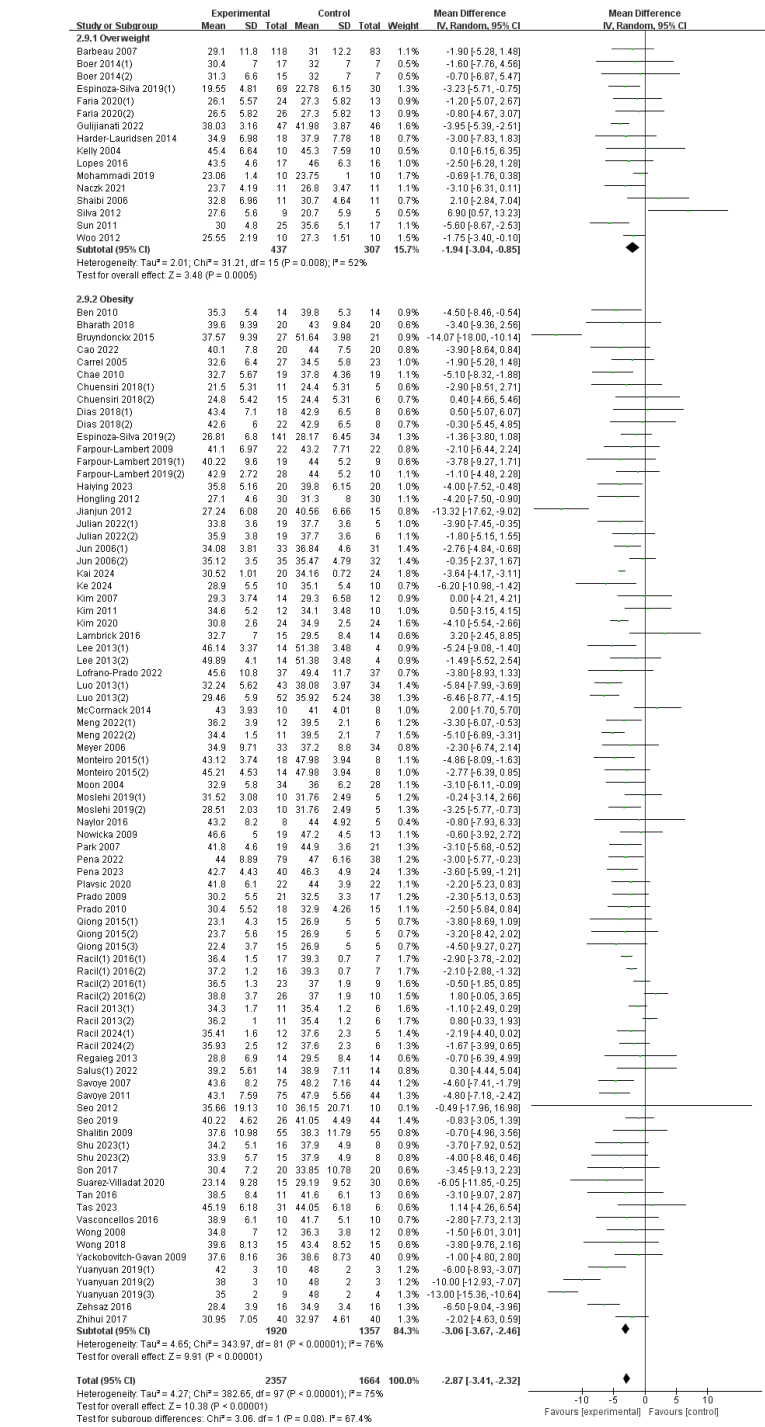


Figure S4.10. Forest plot of subgroup analyses by sex

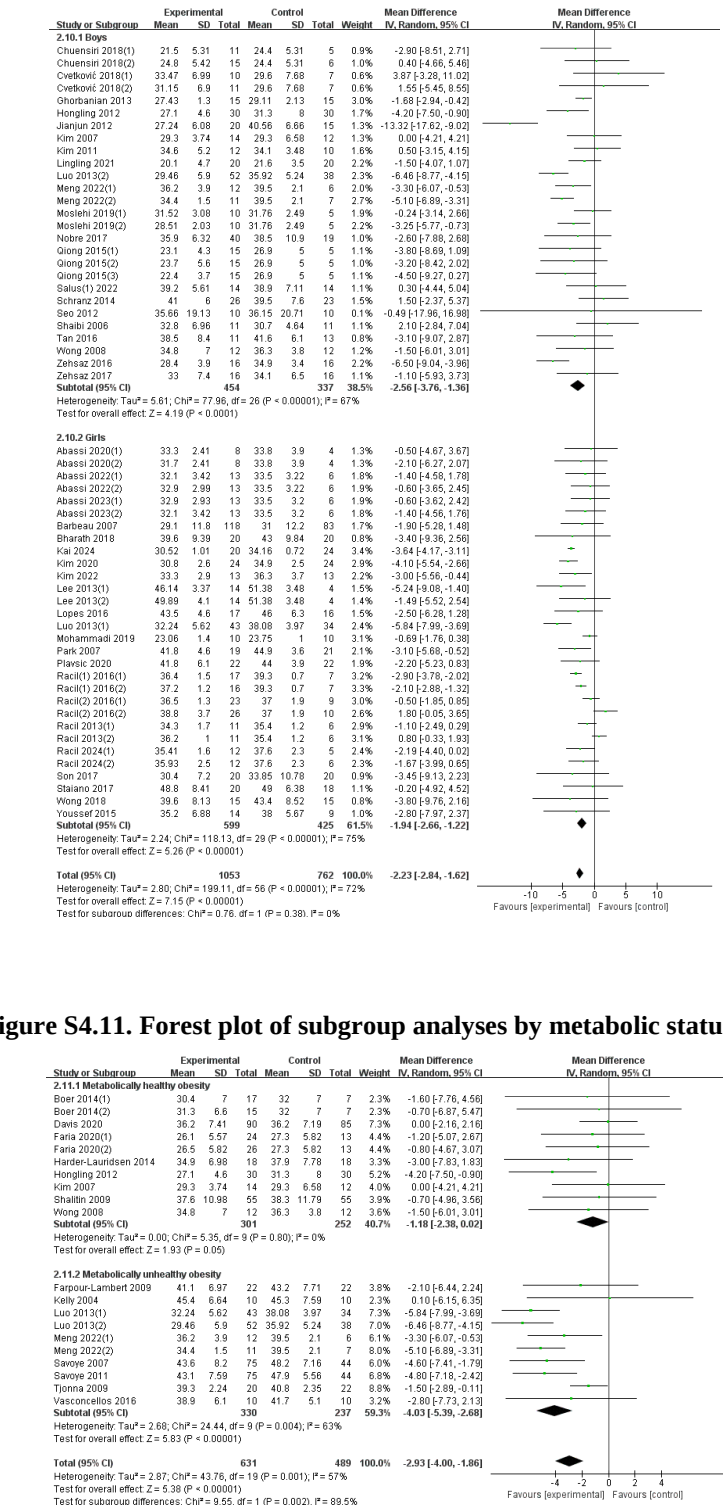


Figure S5. Forest plots of subgroup analyses for VO₂max in children and adolescents with overweight or obesity

Figure S5.1. Forest plot of subgroup analyses by type of exercise

Figure S5.2. Forest plot of subgroup analyses by exercise intensity

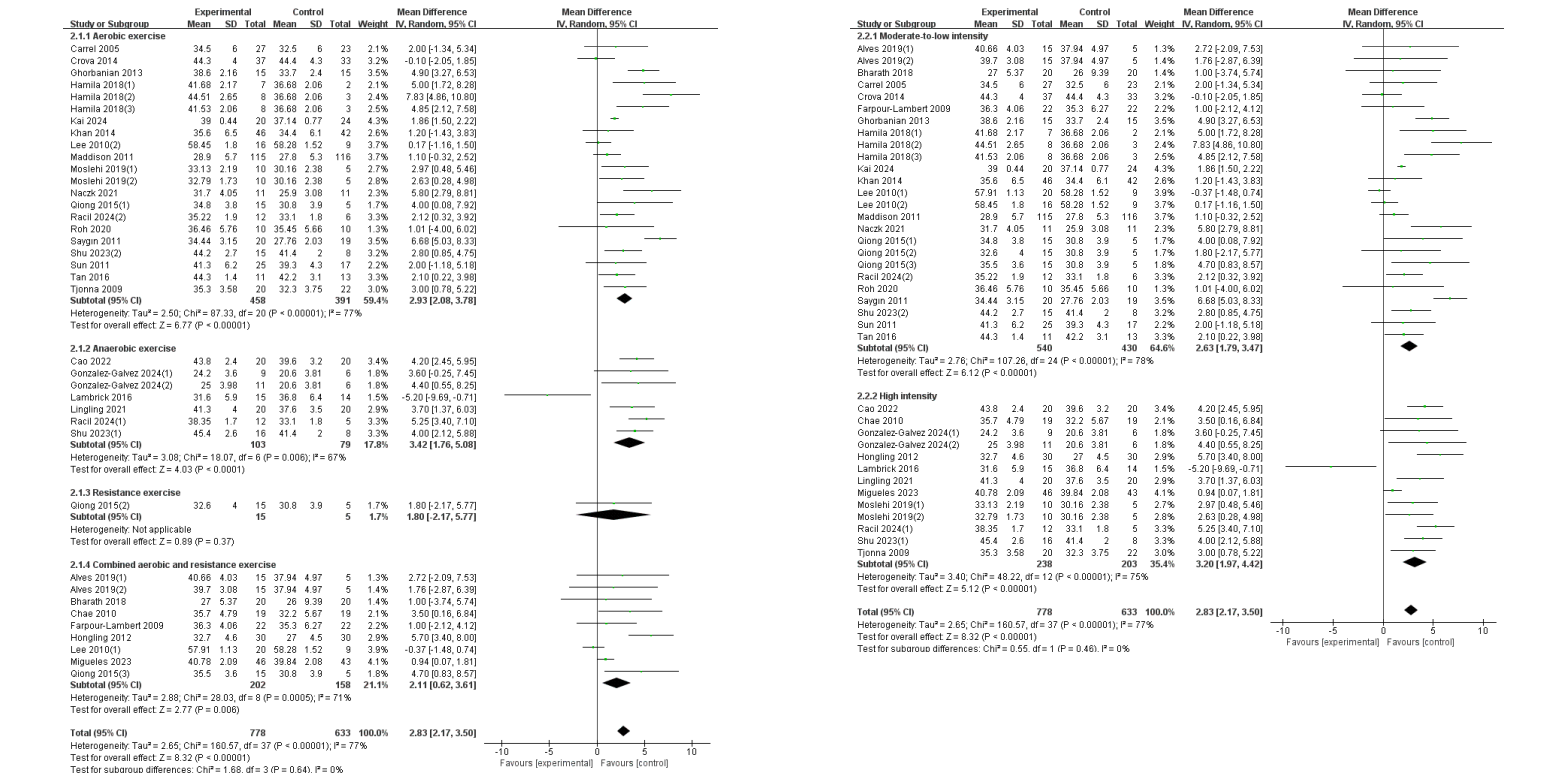


Figure S5.3. Forest plot of subgroup analyses by duration per session

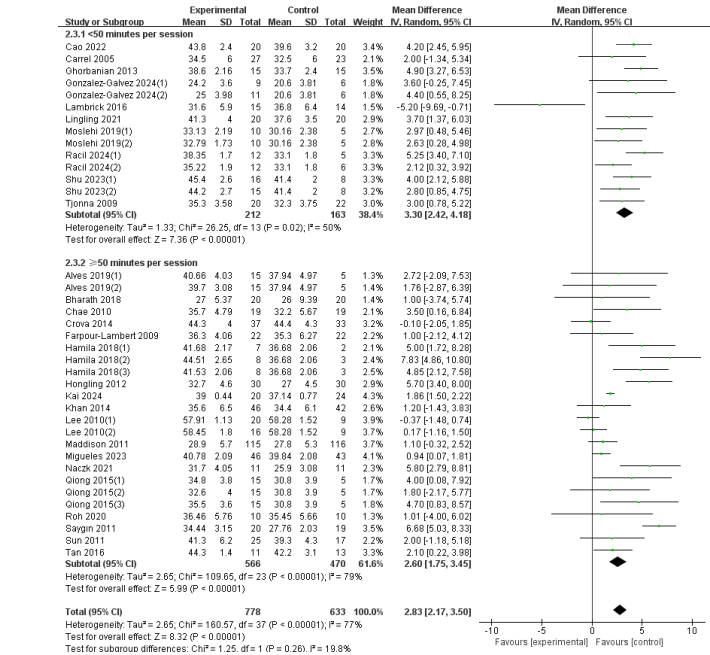


Figure S5.5. Forest plot of subgroup analyses by weekly exercise duration

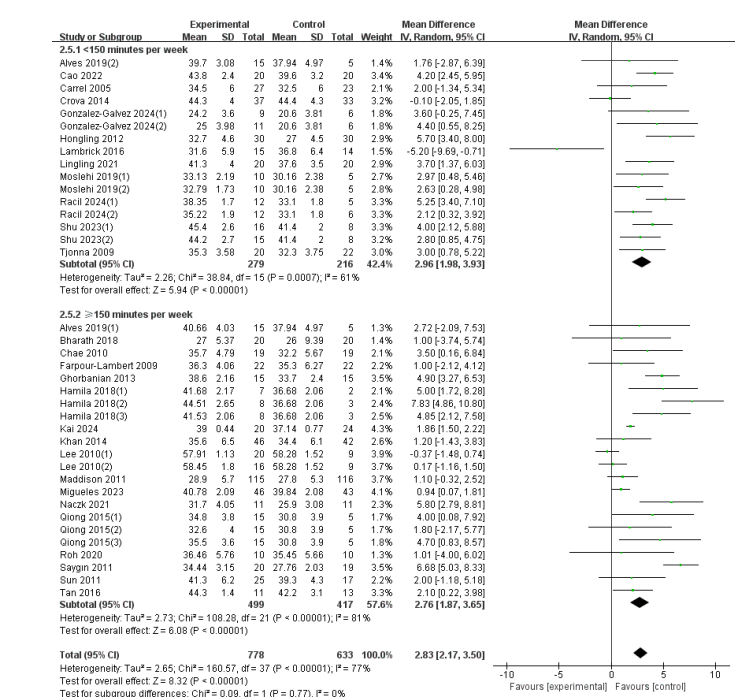


Figure S5.6. Forest plot of subgroup analyses by intervention duration

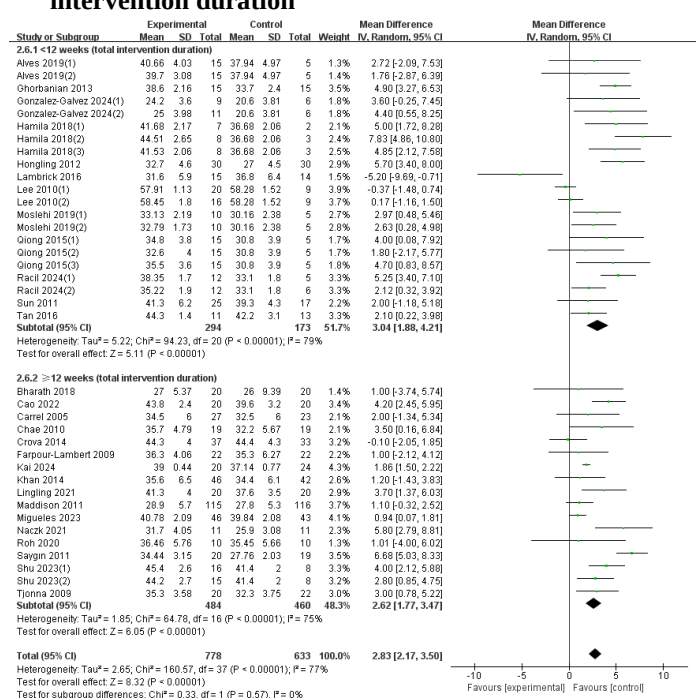


Figure S5.7. Forest plot of subgroup analyses by region

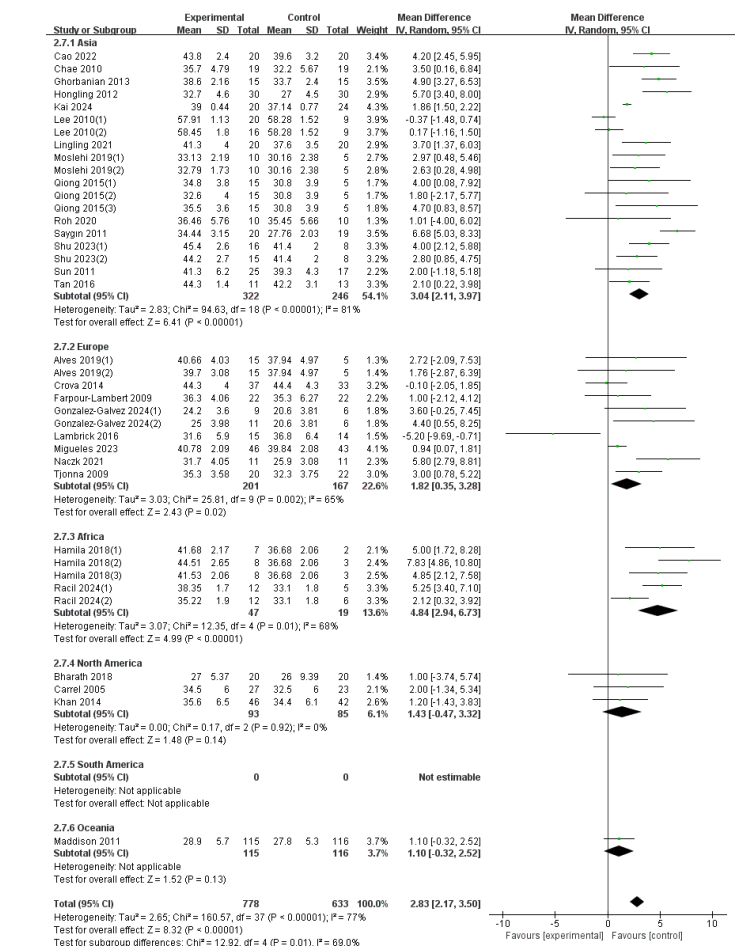


Figure S5.9. Forest plot of subgroup analyses by weight status

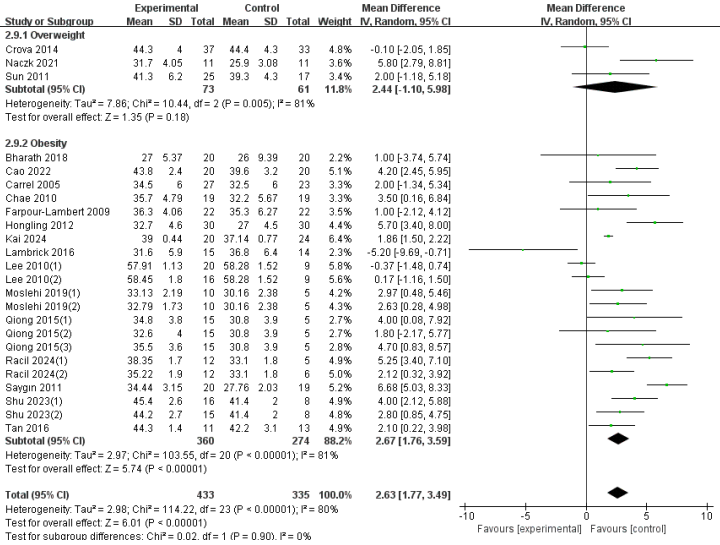


Figure S5.10. Forest plot of subgroup analyses by sex

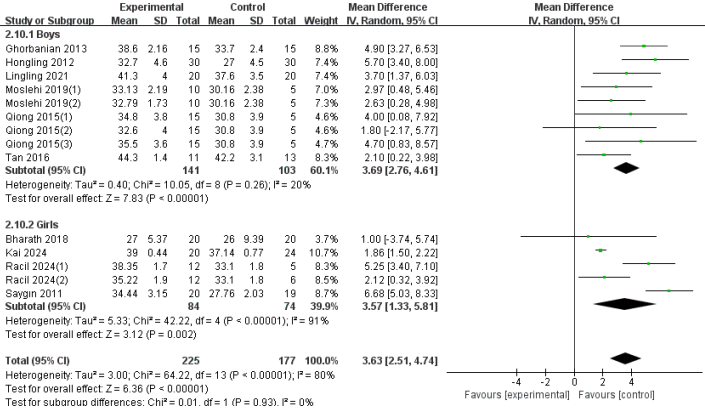


Figure S6. Forest plots of subgroup analyses for VO₂peak in children and adolescents with overweight or obesity

Figure S6.1. Forest plot of subgroup analyses by type of exercise

Figure S6.2. Forest plot of subgroup analyses by exercise intensity

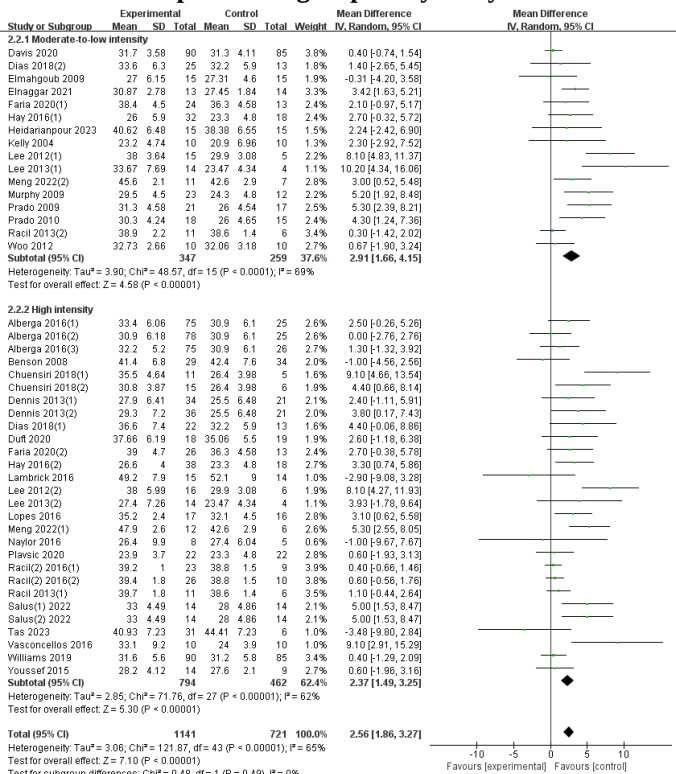
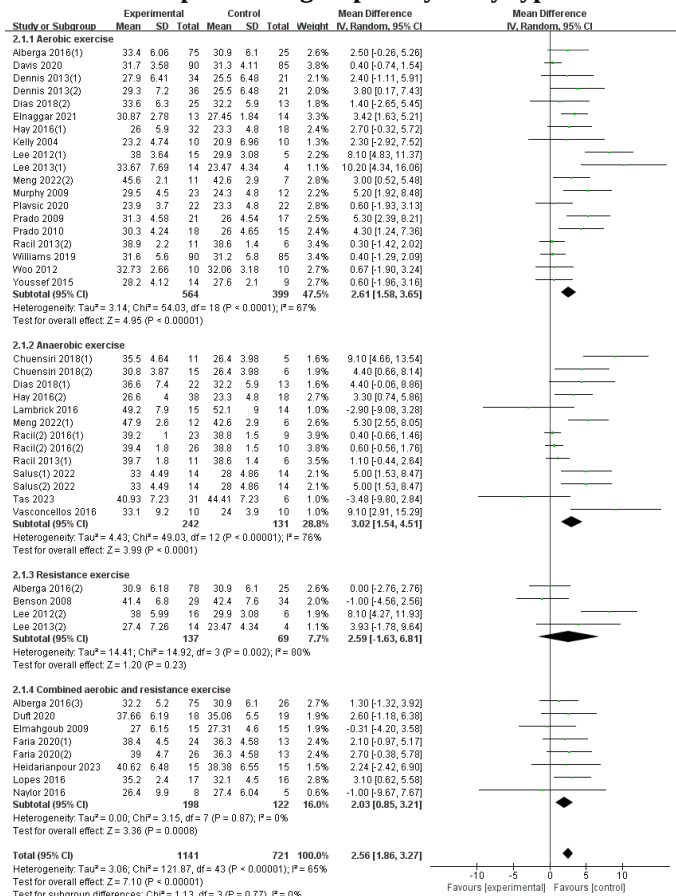


Figure S6.5. Forest plot of subgroup analyses by weekly exercise duration

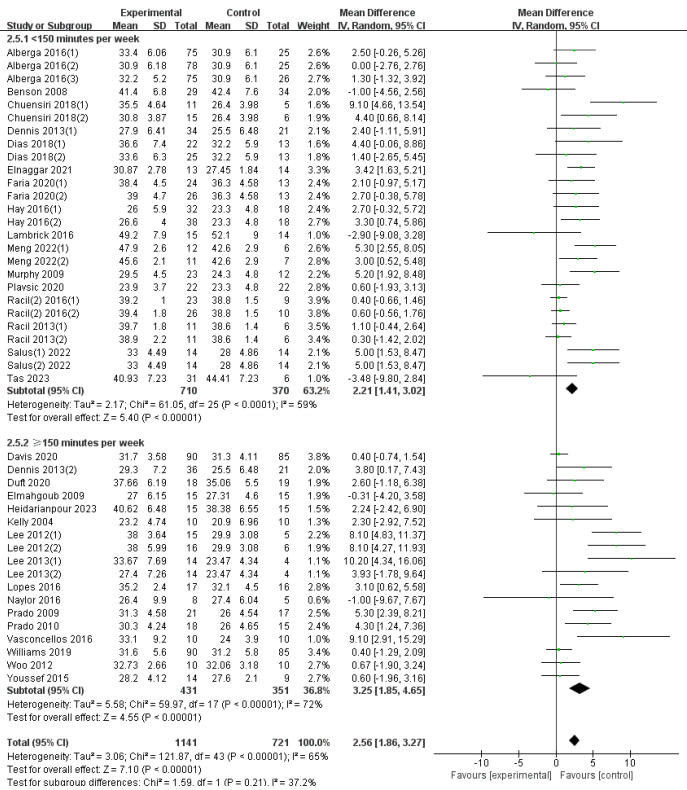


Figure S6.7. Forest plot of subgroup analyses by region

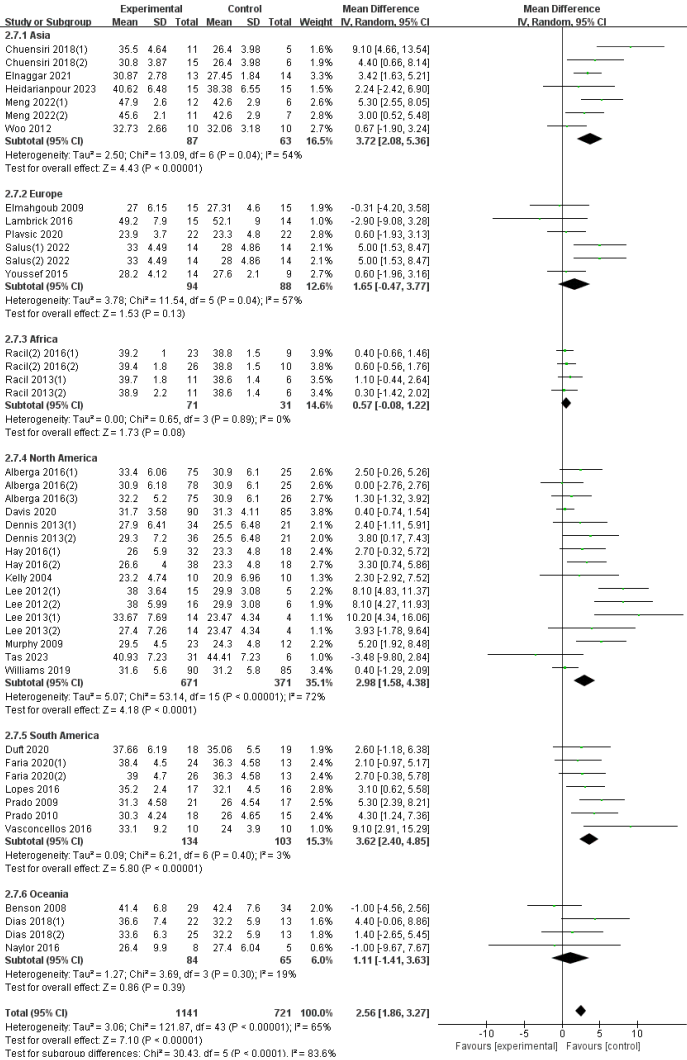


Figure S6.6. Forest plot of subgroup analyses by intervention duration

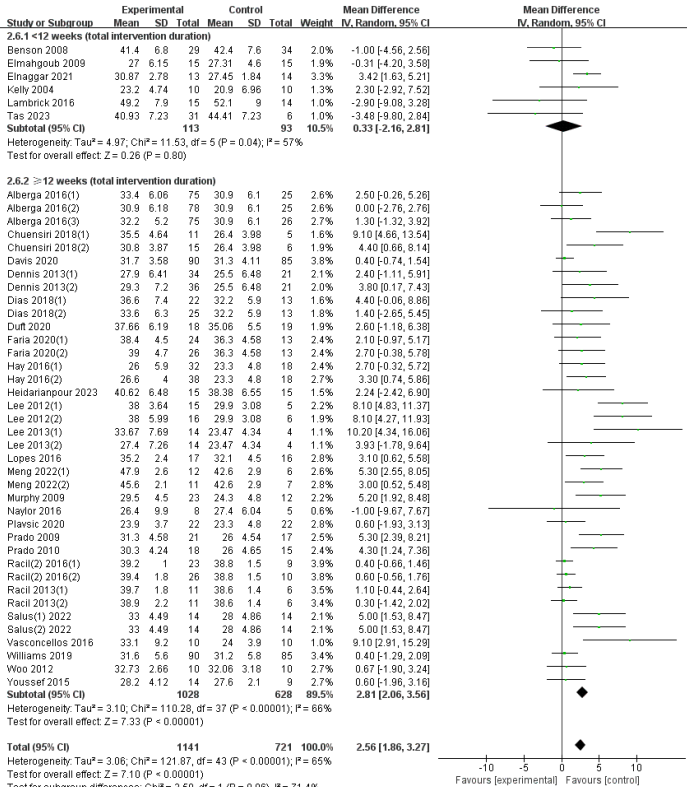


Figure S6.9. Forest plot of subgroup analyses by weight status

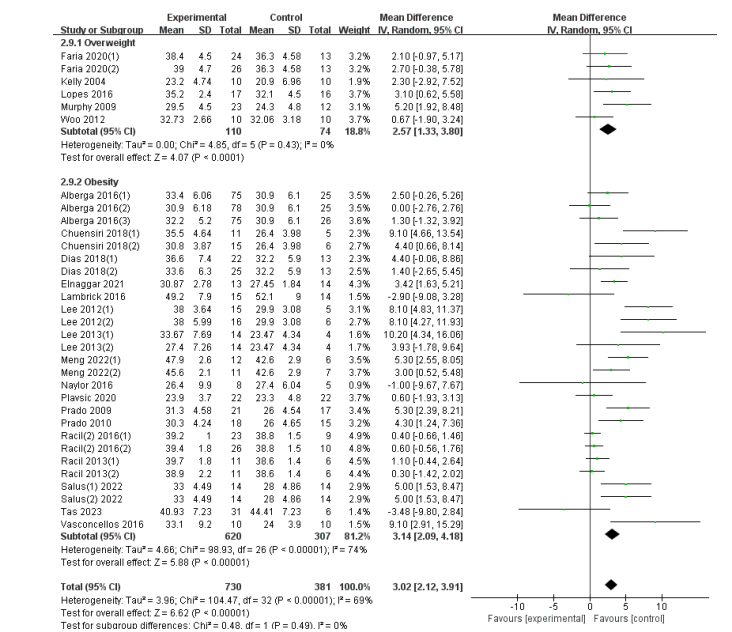


Figure S6.10. Forest plot of subgroup analyses by sex

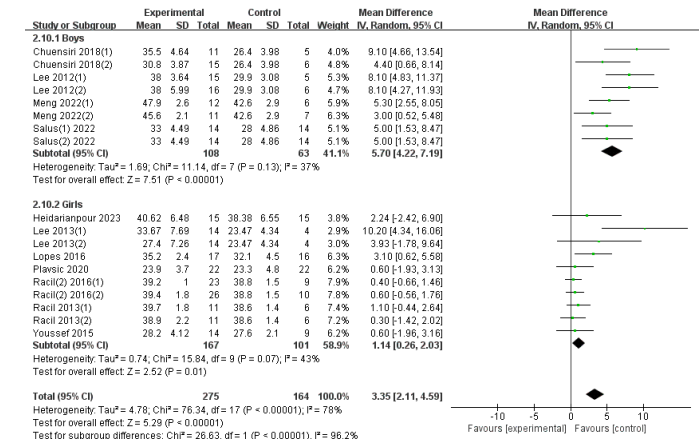


Figure S6.11. Forest plot of subgroup analyses by metabolic status

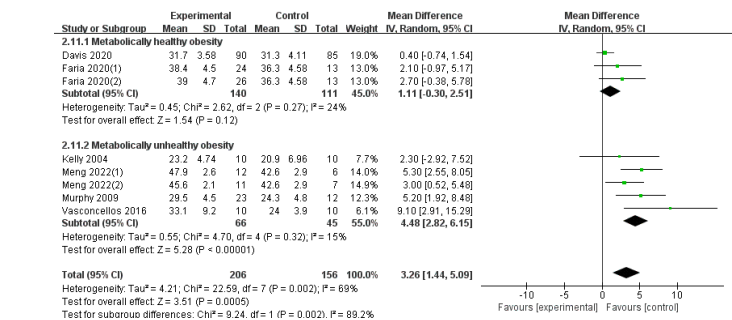


Figure S7. Forest plots of subgroup analyses for HRmax in children and adolescents with overweight or obesity

Figure S7.1. Forest plot of subgroup analyses by type of exercise

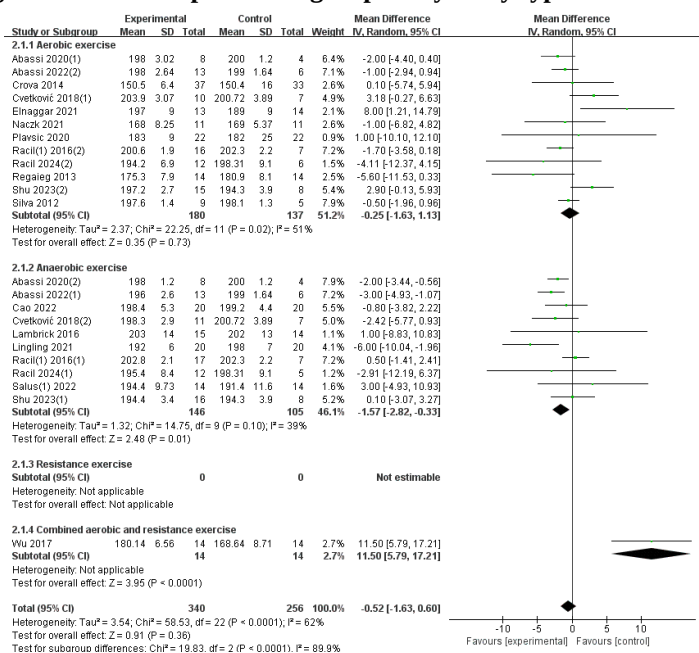


Figure S7.2. Forest plot of subgroup analyses by exercise intensity

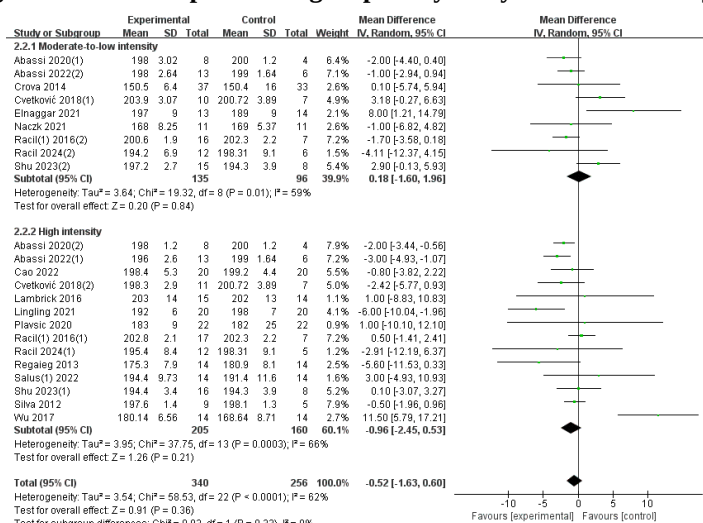


Figure S7.3. Forest plot of subgroup analyses by duration per session

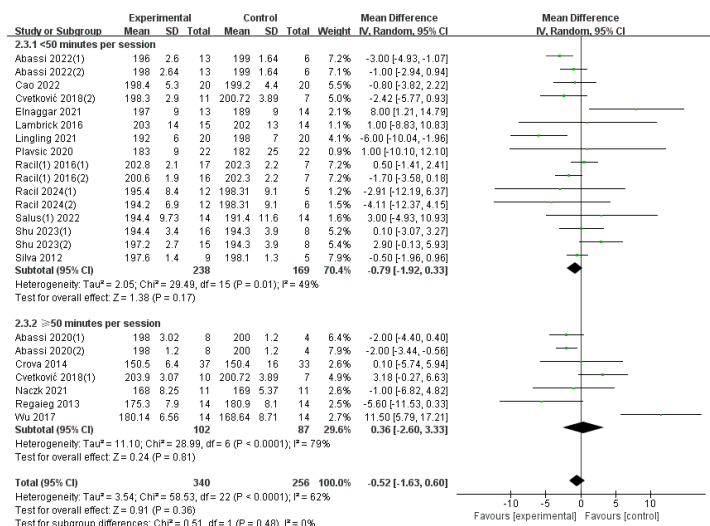


Figure S7.4. Forest plot of subgroup analyses by exercise frequency

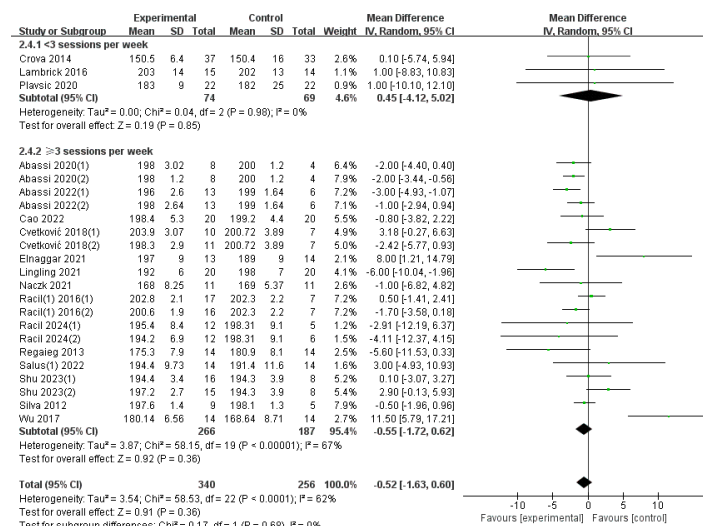


Figure S7.5. Forest plot of subgroup analyses by weekly exercise duration

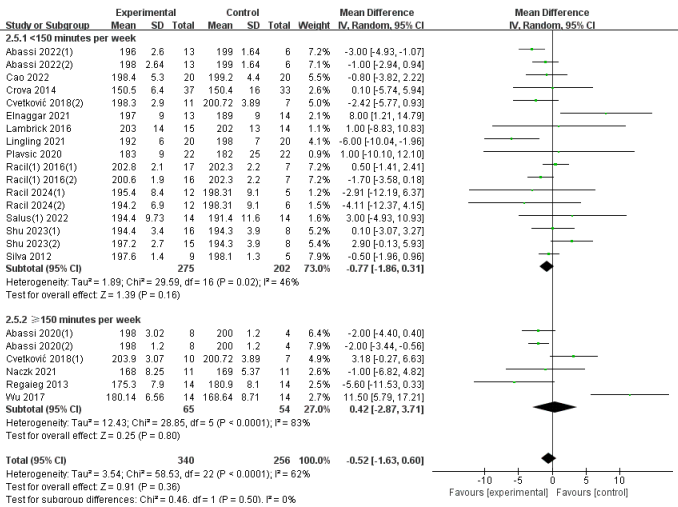


Figure S7.6. Forest plot of subgroup analyses by intervention duration

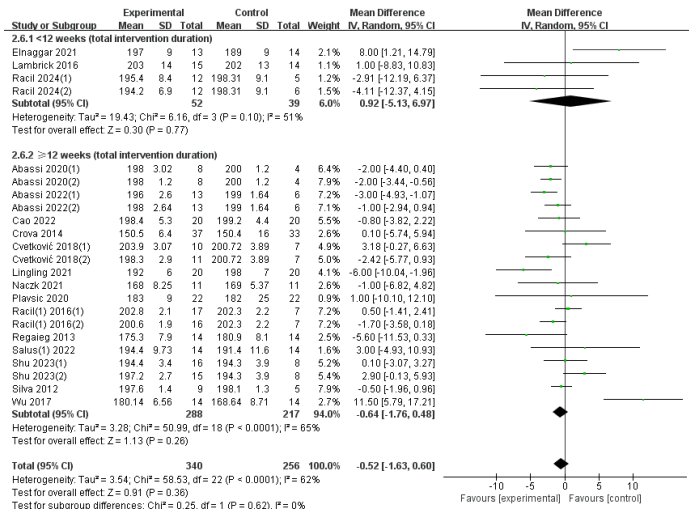


Figure S7.7. Forest plot of subgroup analyses by region

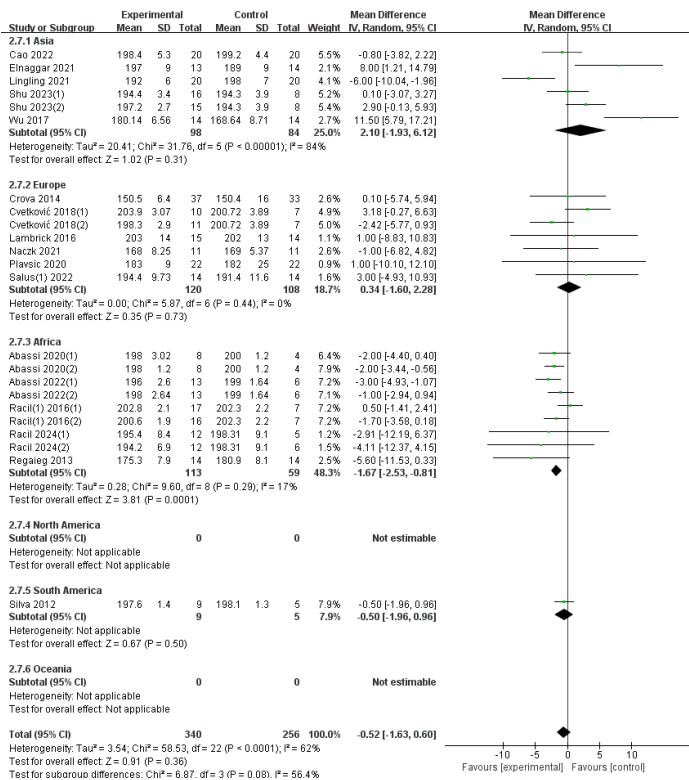


Figure S7.8. Forest plot of subgroup analyses by economic status

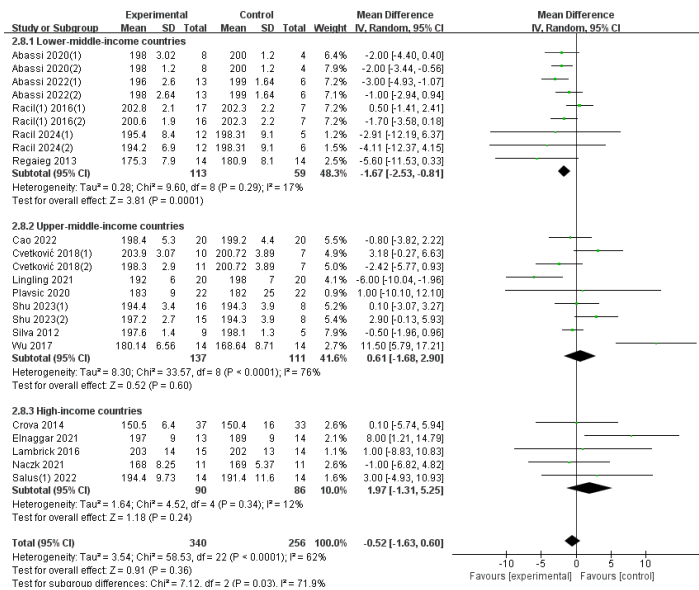


Figure S7.9. Forest plot of subgroup analyses by weight status

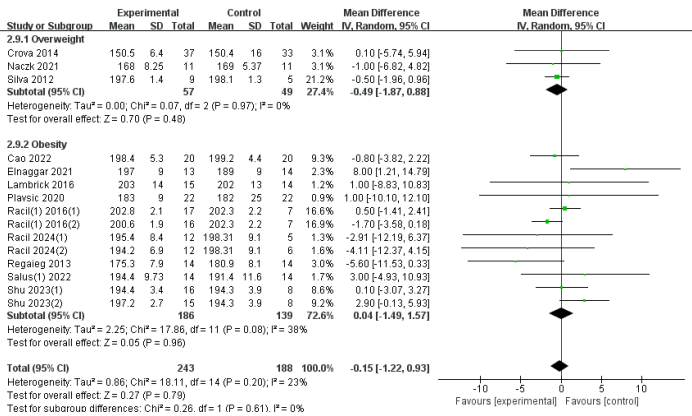


Figure S7.10. Forest plot of subgroup analyses by sex

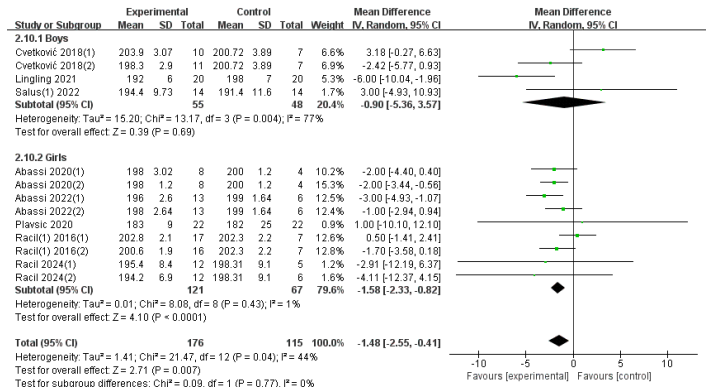


Figure S8. Forest plots of subgroup analyses for HRrest in children and adolescents with overweight or obesity

Figure S8.1. Forest plot of subgroup analyses by type of exercise

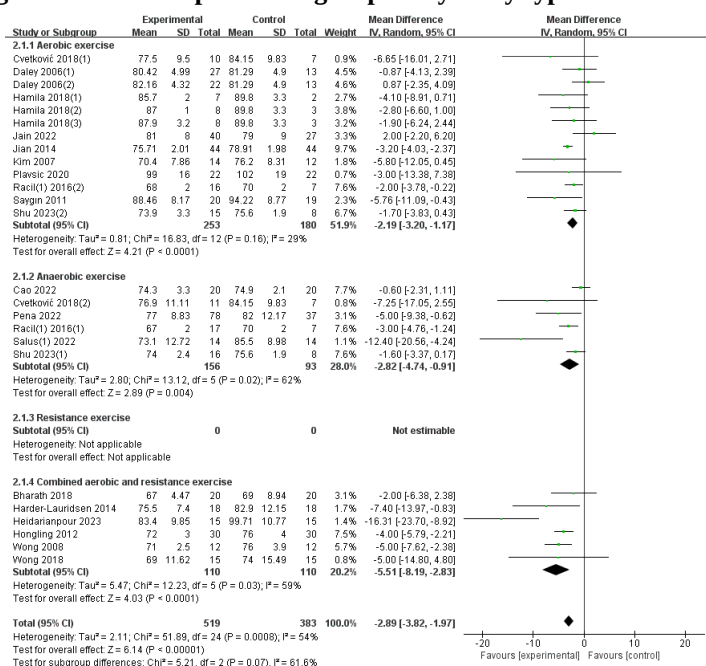


Figure S8.2. Forest plot of subgroup analyses by exercise intensity

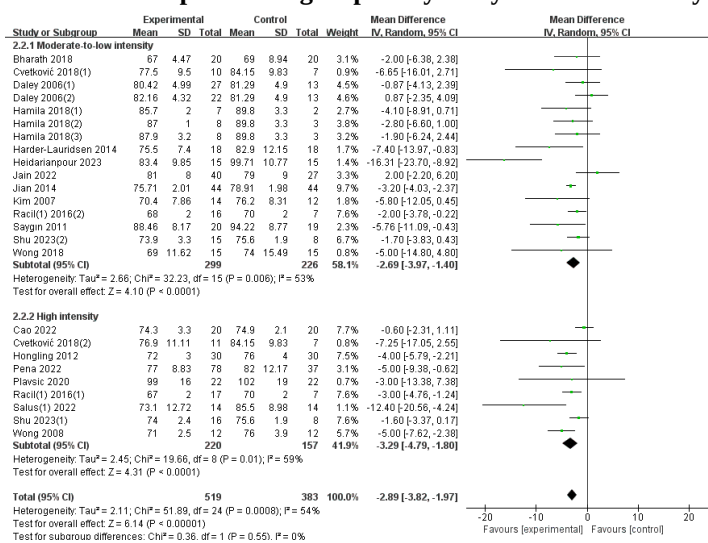


Figure S8.3. Forest plot of subgroup analyses by duration per session

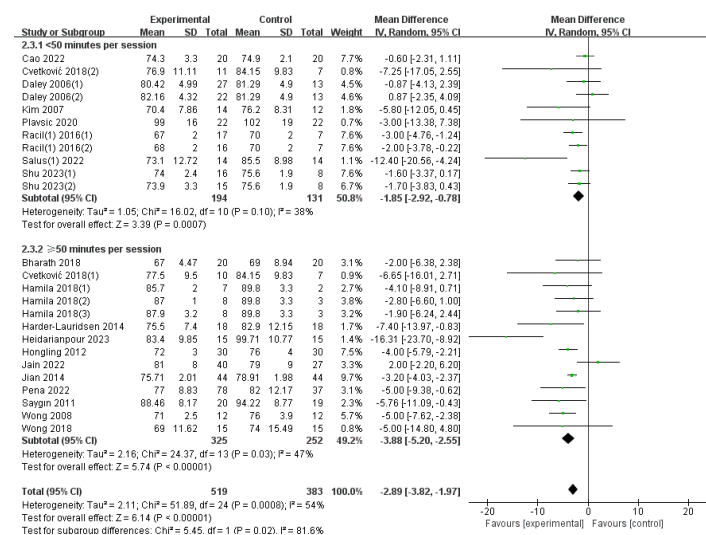


Figure S8.4. Forest plot of subgroup analyses by exercise frequency

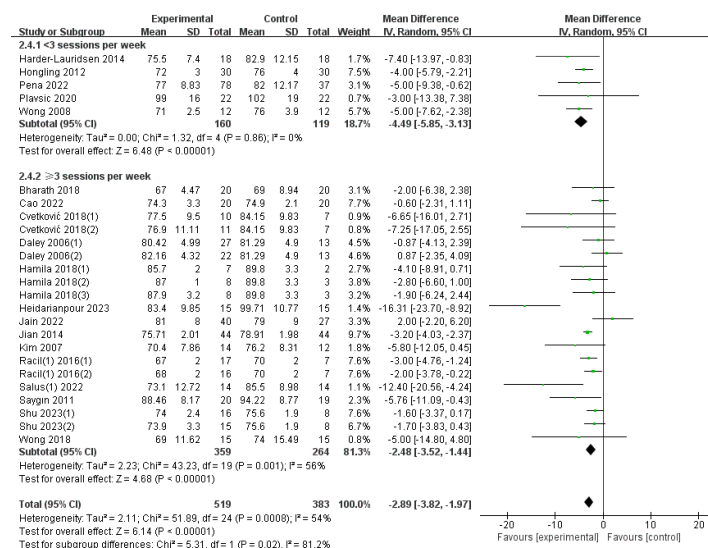


Figure S8.5. Forest plot of subgroup analyses by weekly exercise duration

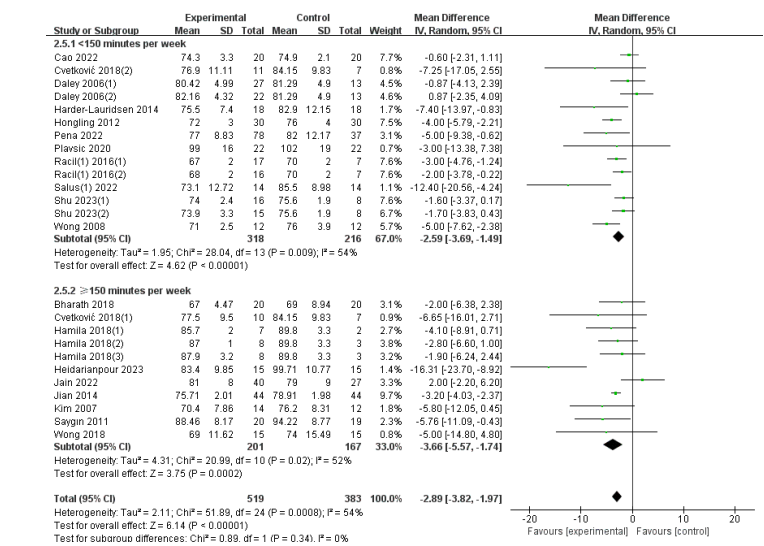


Figure S8.6. Forest plot of subgroup analyses by intervention duration

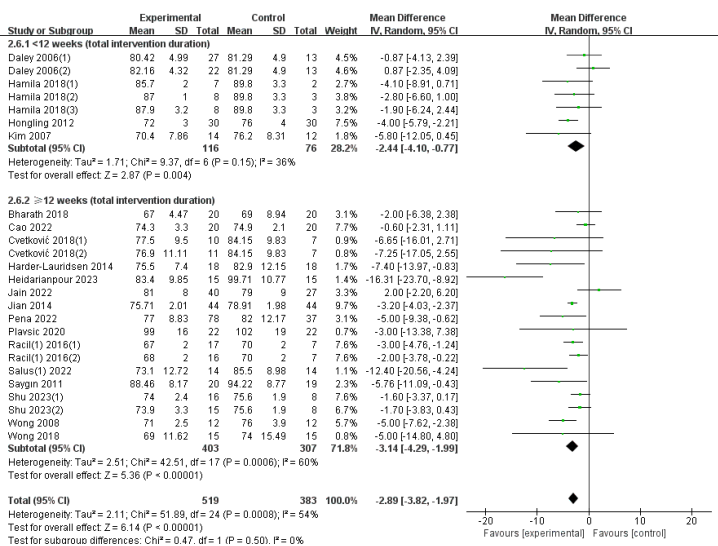


Figure S8.7. Forest plot of subgroup analyses by region

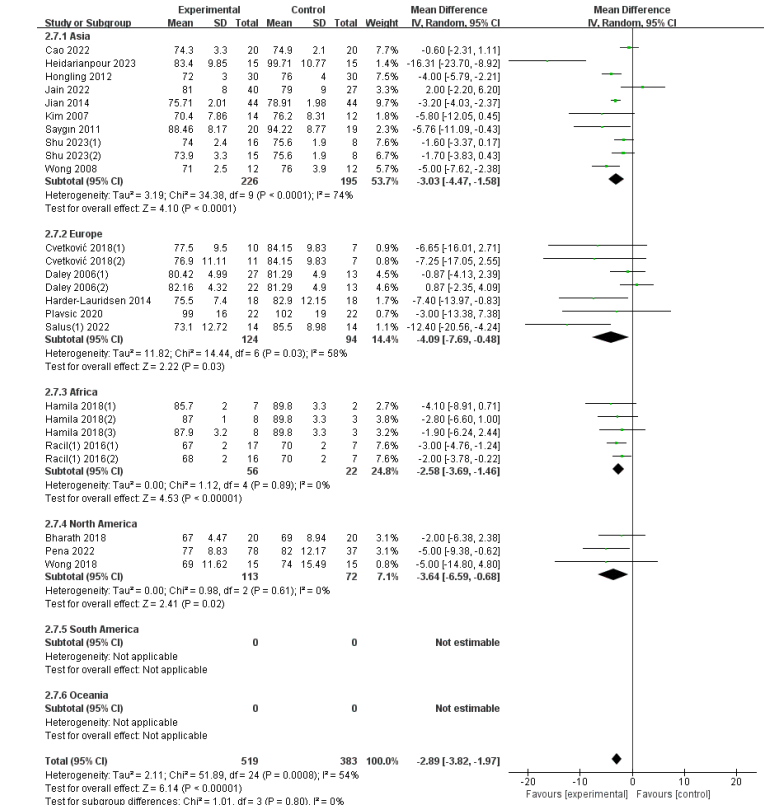


Figure S8.8. Forest plot of subgroup analyses by economic status

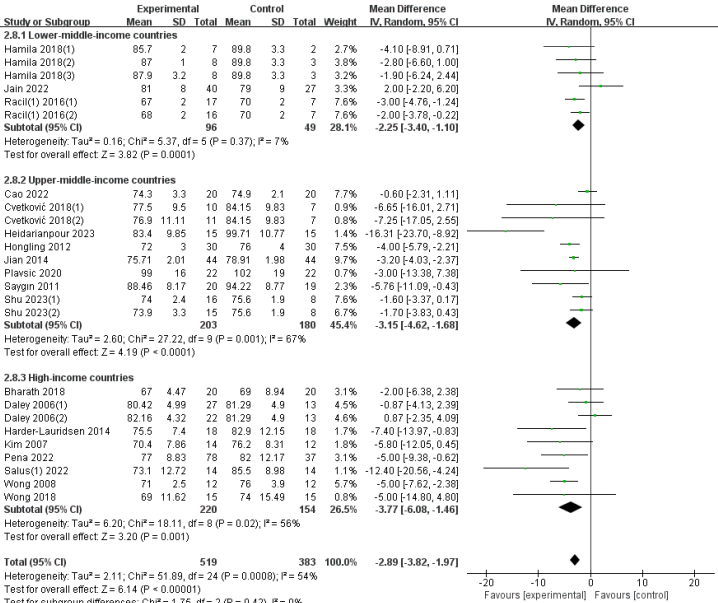


Figure S8.9. Forest plot of subgroup analyses by weight status

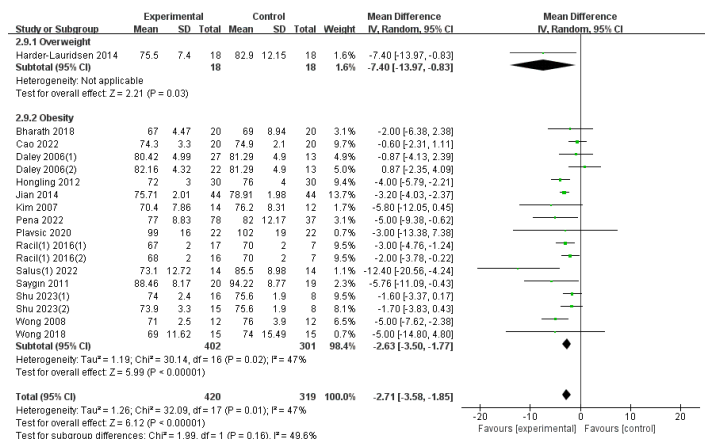


Figure S8.10. Forest plot of subgroup analyses by sex

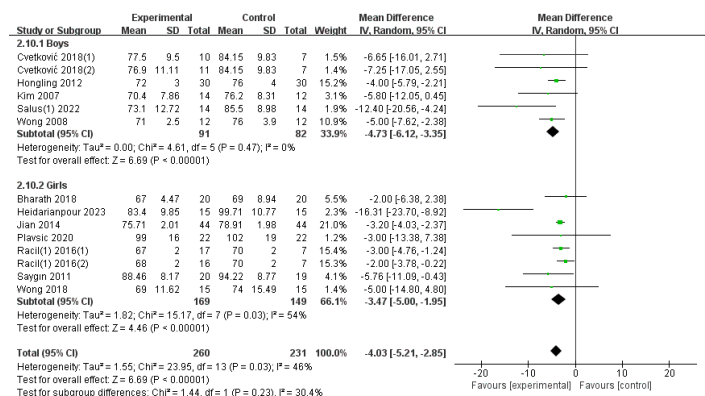


Figure S9. Forest plots of subgroup analyses for SBP in children and adolescents with overweight or obesity

Figure S9.1. Forest plot of subgroup analyses by type of exercise

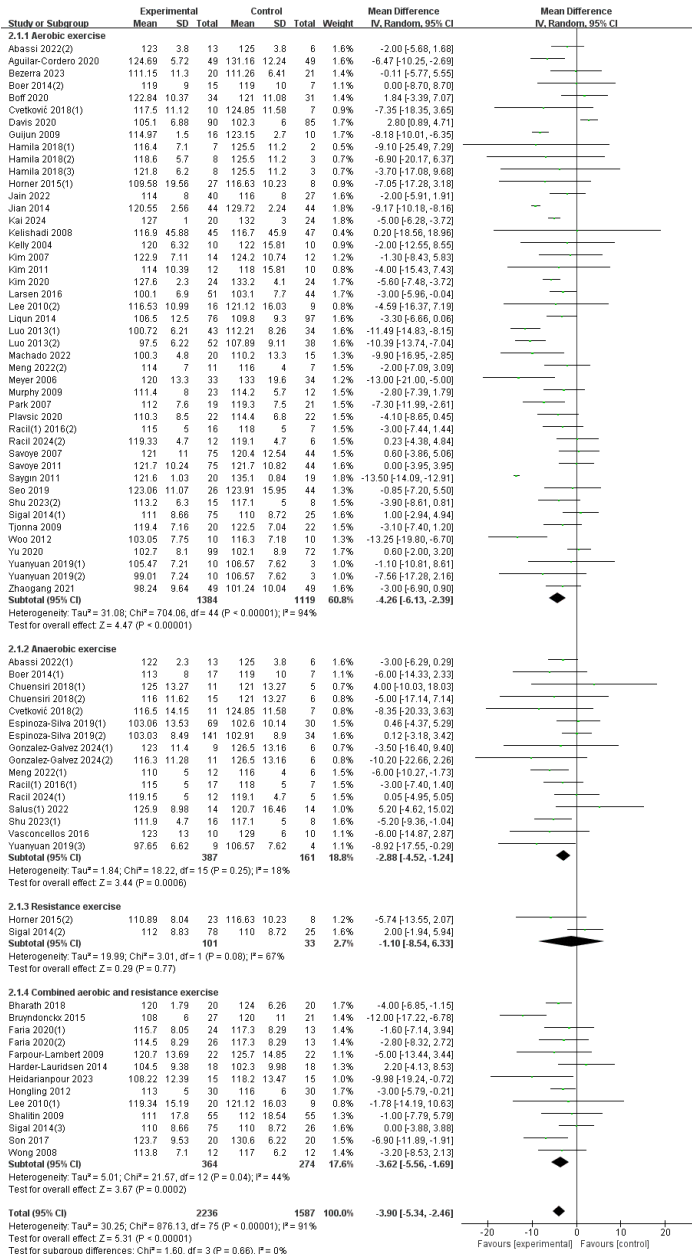


Figure S9.2. Forest plot of subgroup analyses by exercise intensity

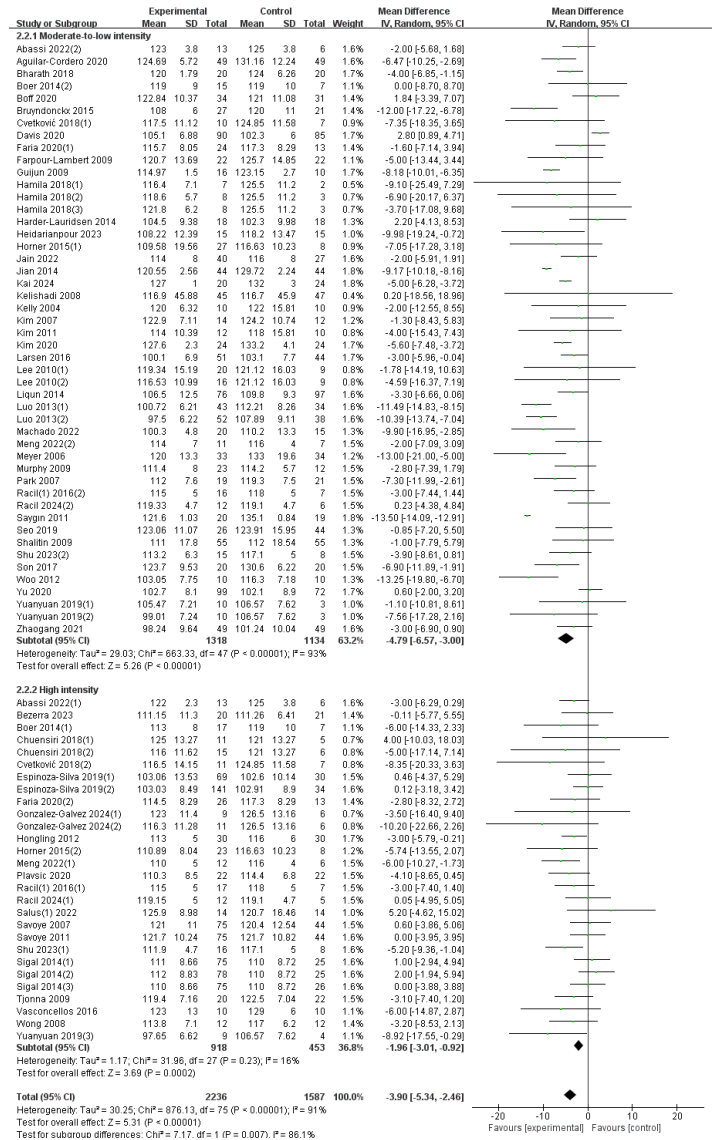


Figure S9.3. Forest plot of subgroup analyses by duration per session

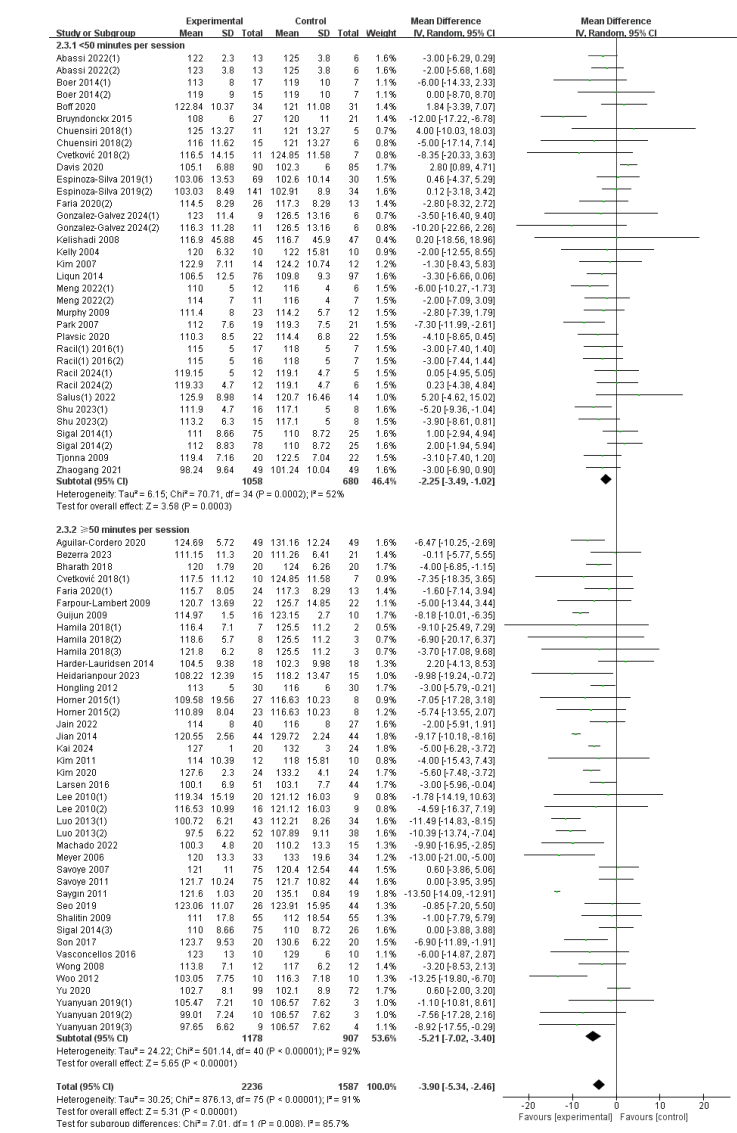


Figure S9.5. Forest plot of subgroup analyses by weekly exercise duration

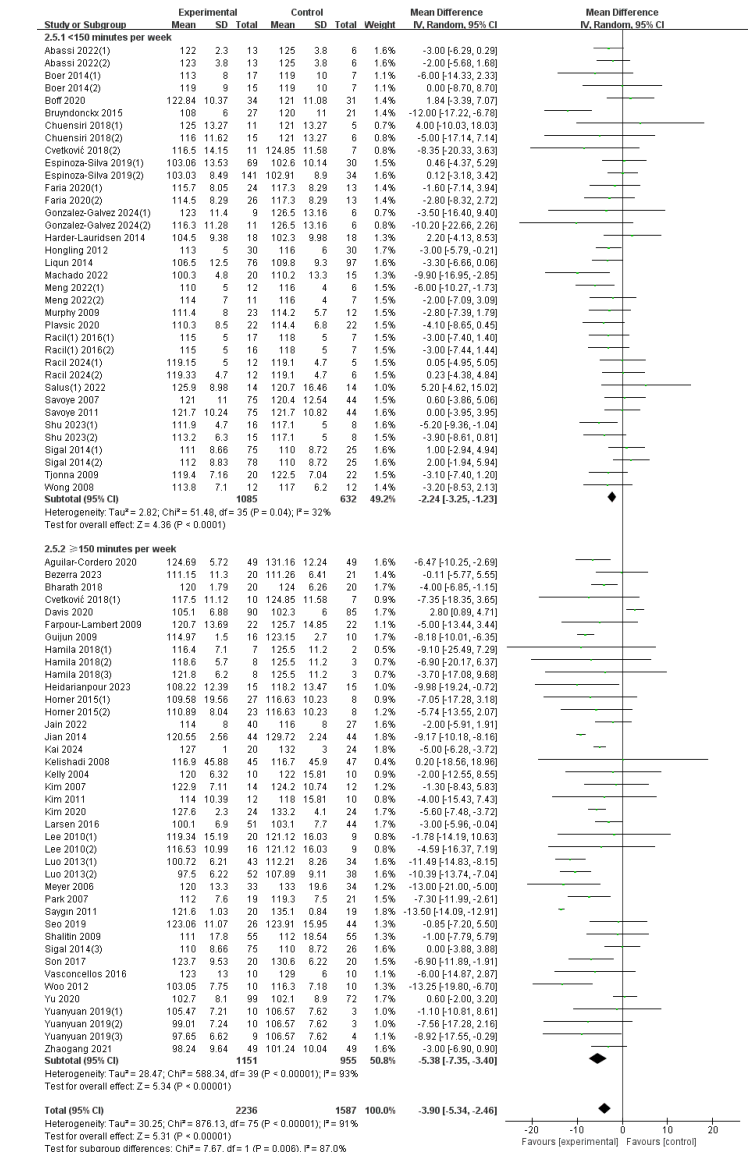


Figure S9.6. Forest plot of subgroup analyses by intervention duration

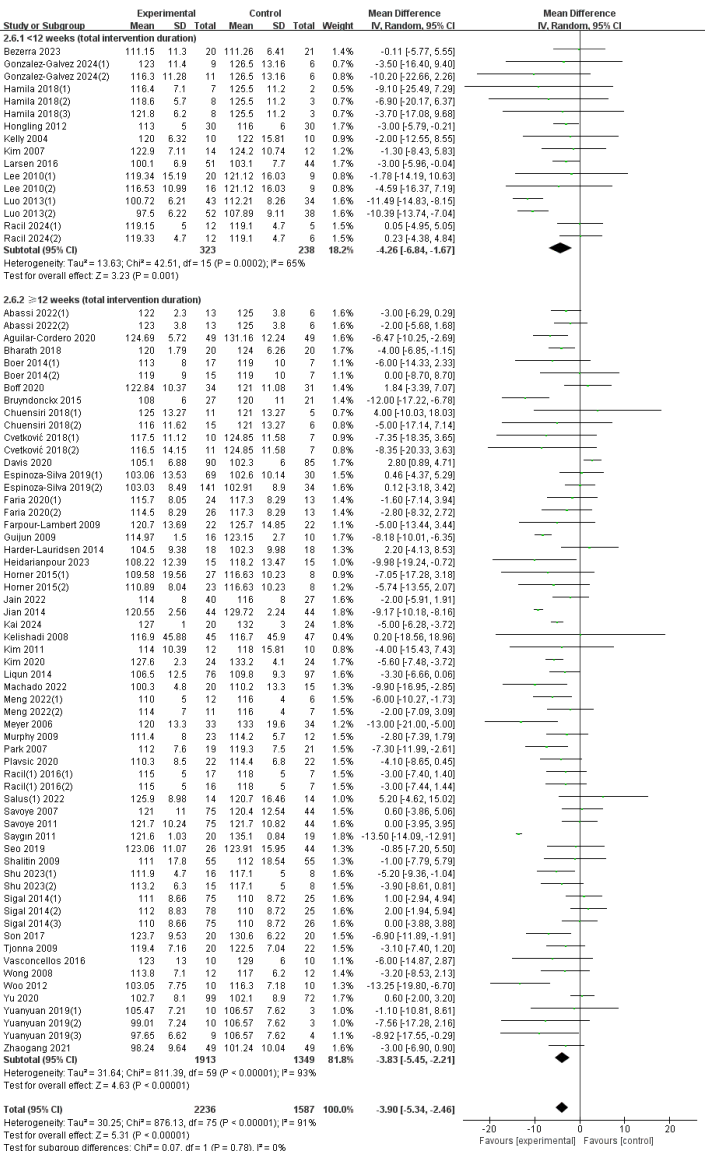


Figure S9.7. Forest plot of subgroup analyses by region

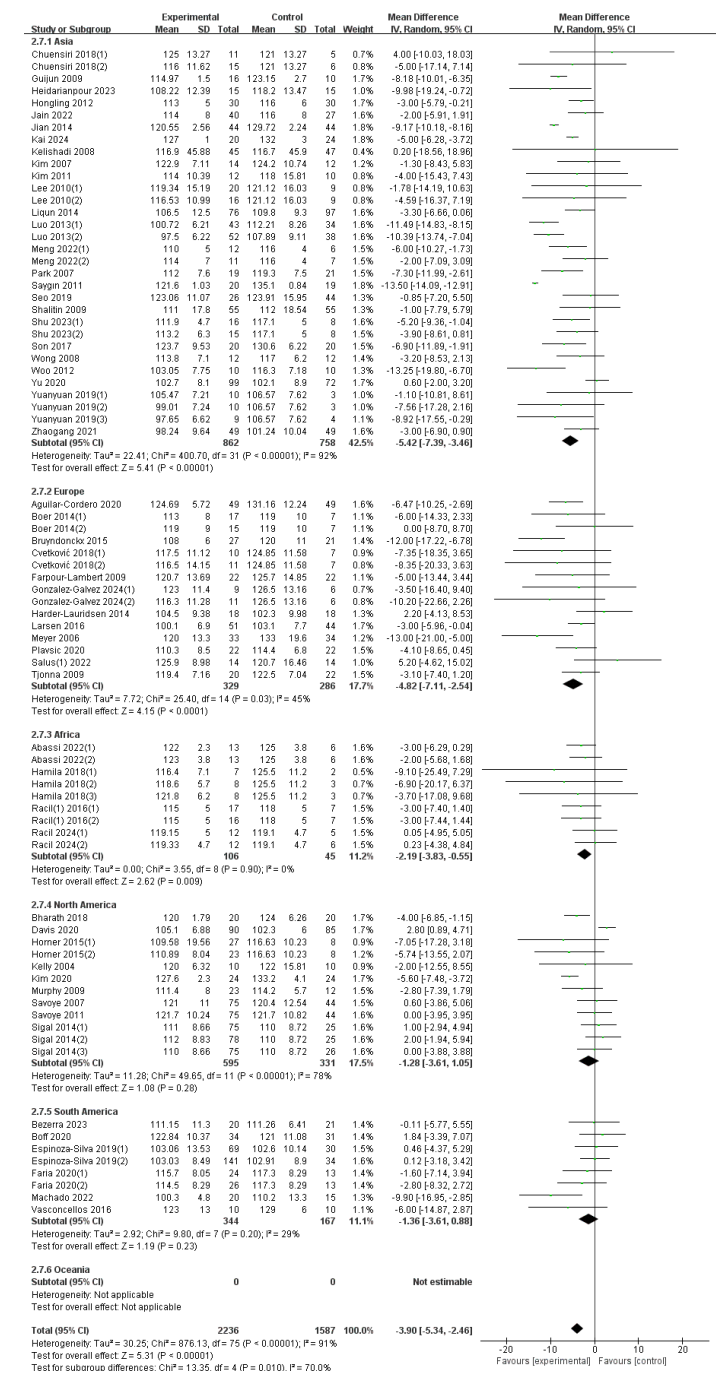


Figure S9.8. Forest plot of subgroup analyses by economic status

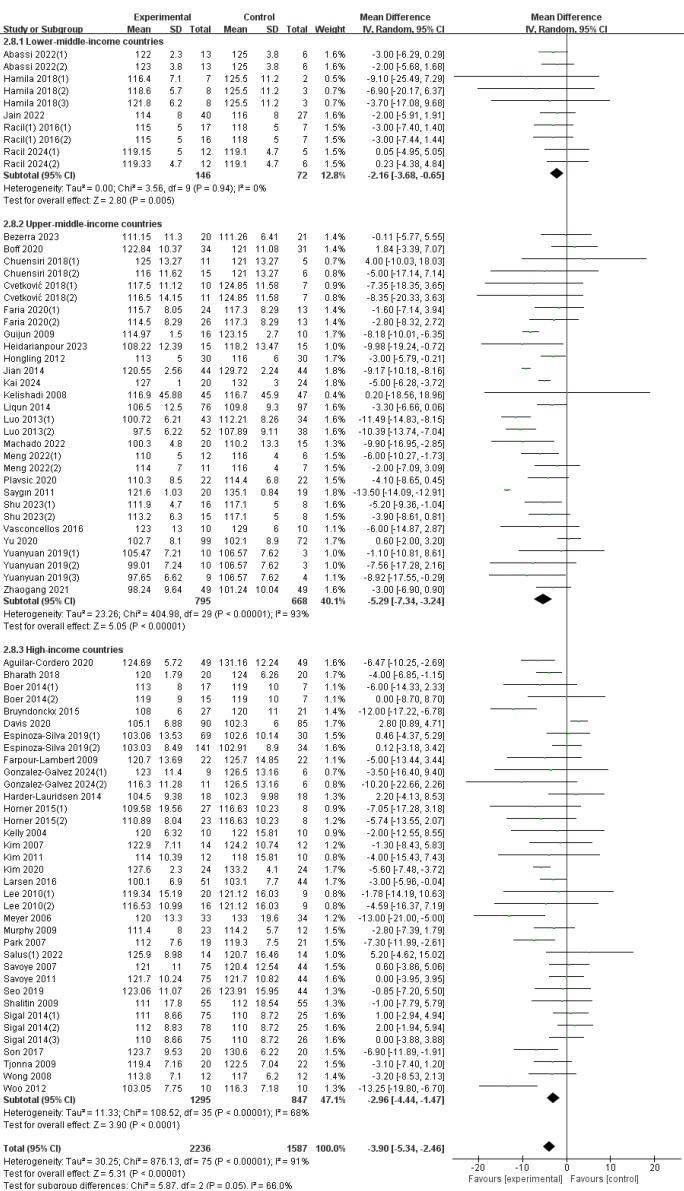


Figure S9.9. Forest plot of subgroup analyses by weight status

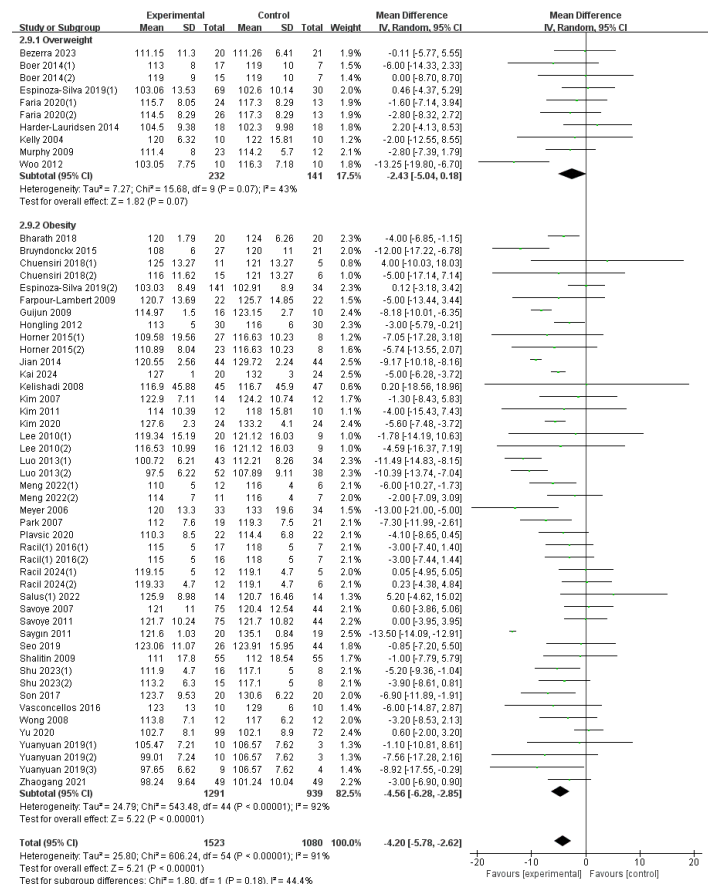


Figure S9.10. Forest plot of subgroup analyses by sex

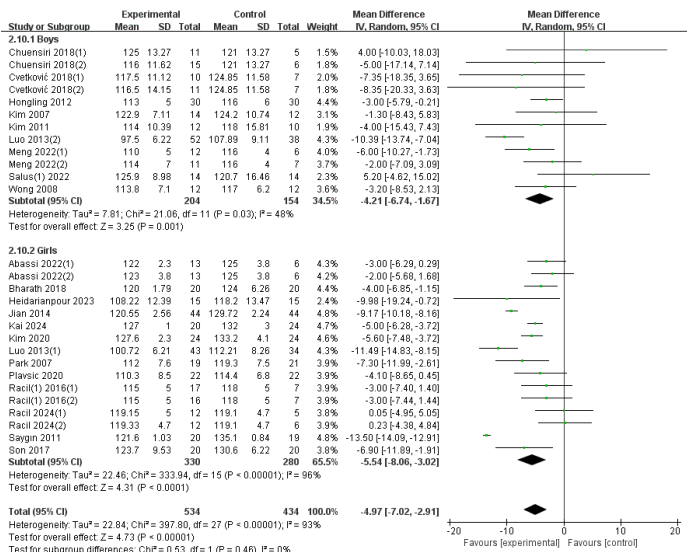


Figure S10. Forest plots of subgroup analyses for DBP in children and adolescents with overweight or obesity

Figure S10.1. Forest plot of subgroup analyses by type of exercise

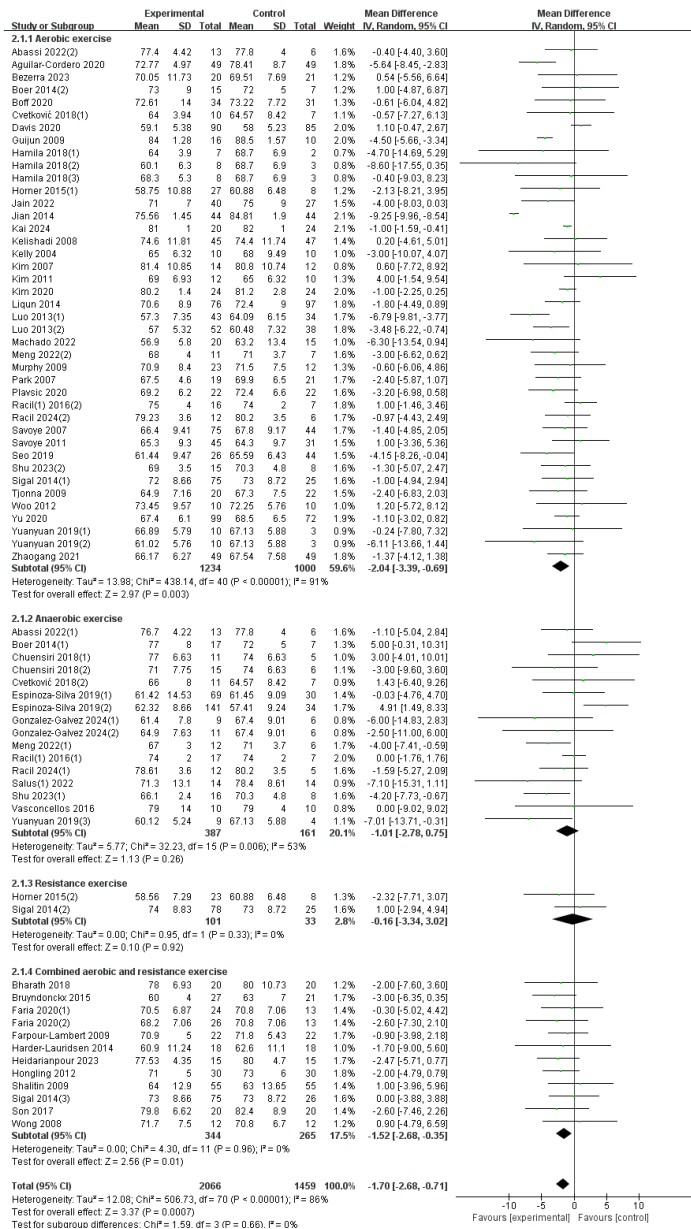


Figure S10.2. Forest plot of subgroup analyses by exercise intensity

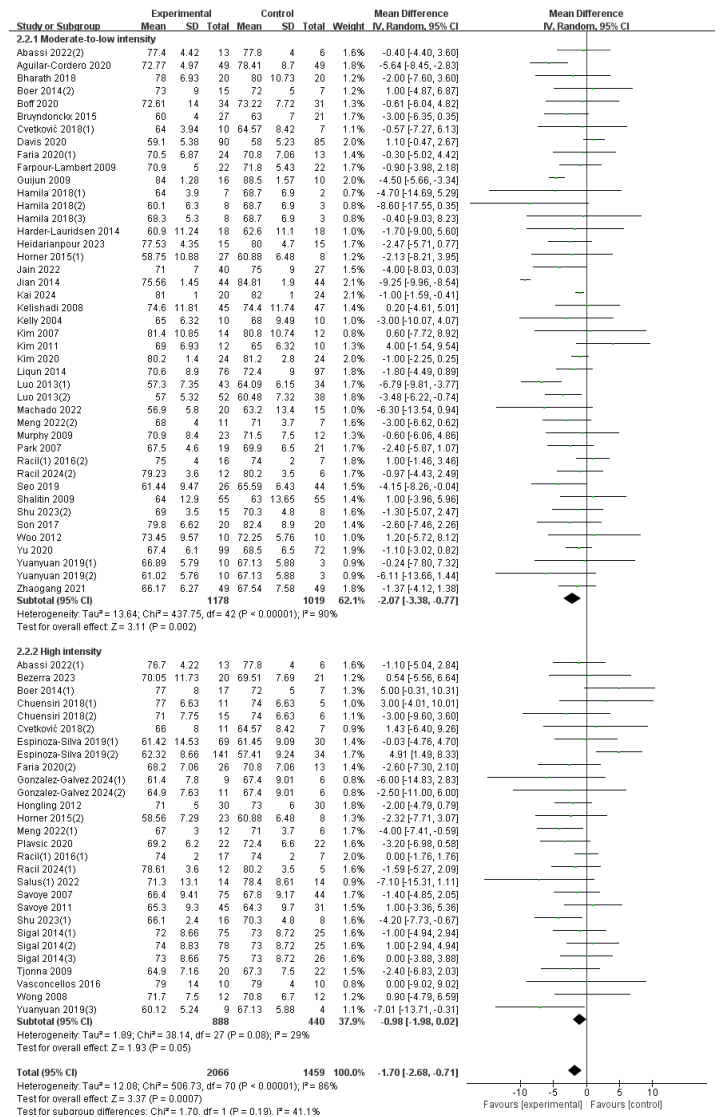


Figure S10.3. Forest plot of subgroup analyses by duration per session

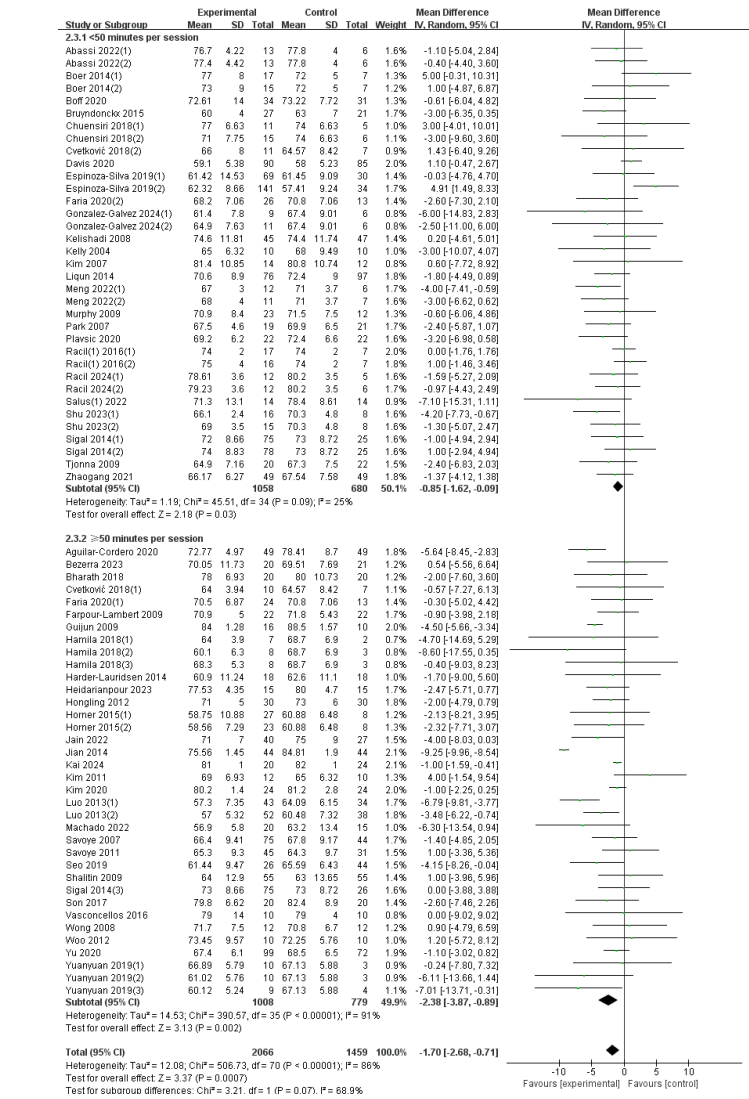


Figure S10.4. Forest plot of subgroup analyses by exercise frequency

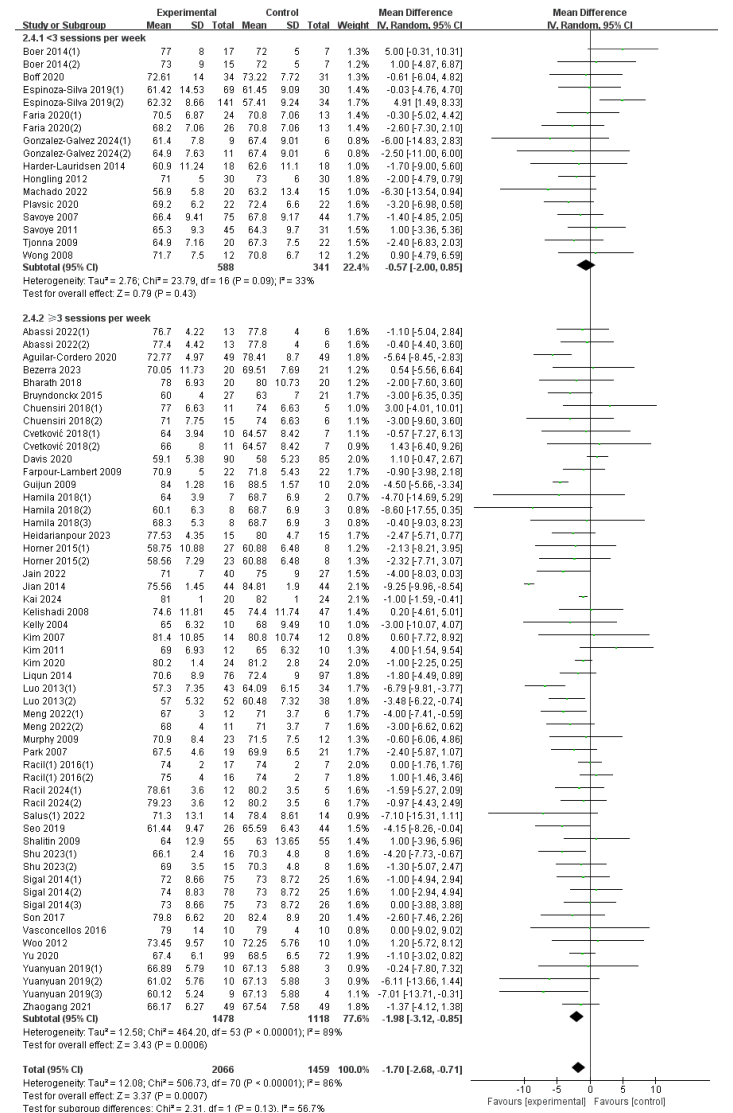


Figure S10.5. Forest plot of subgroup analyses by weekly exercise duration

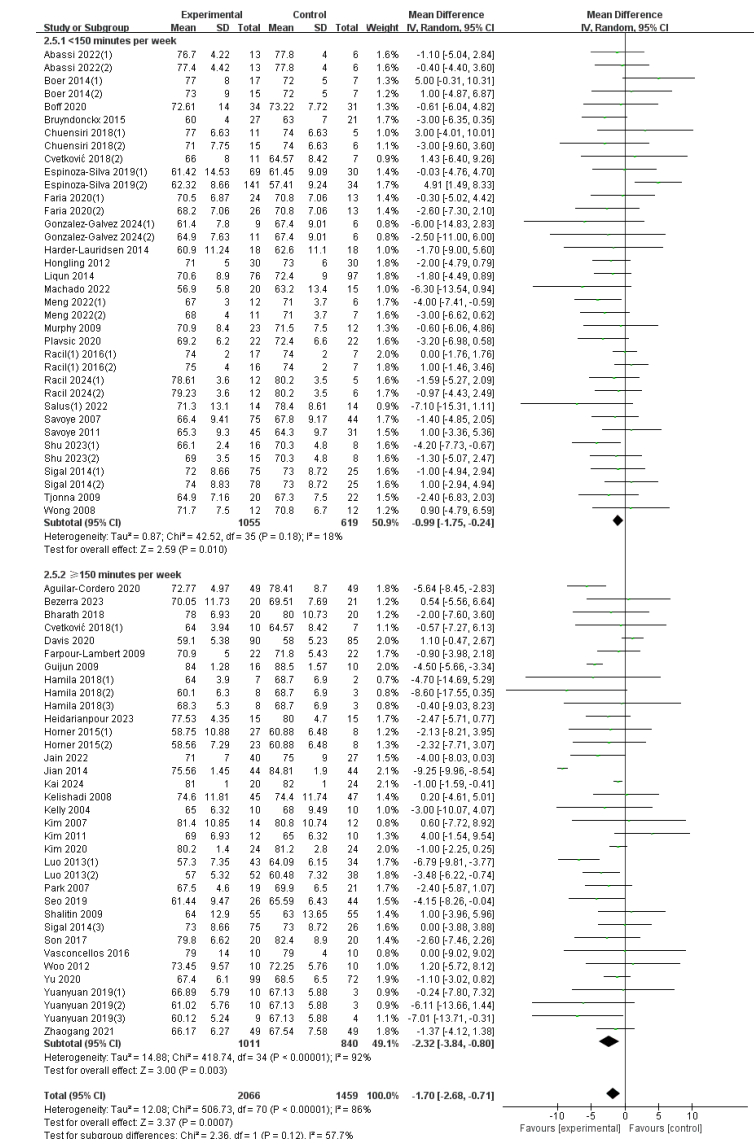


Figure S10.6. Forest plot of subgroup analyses by intervention duration

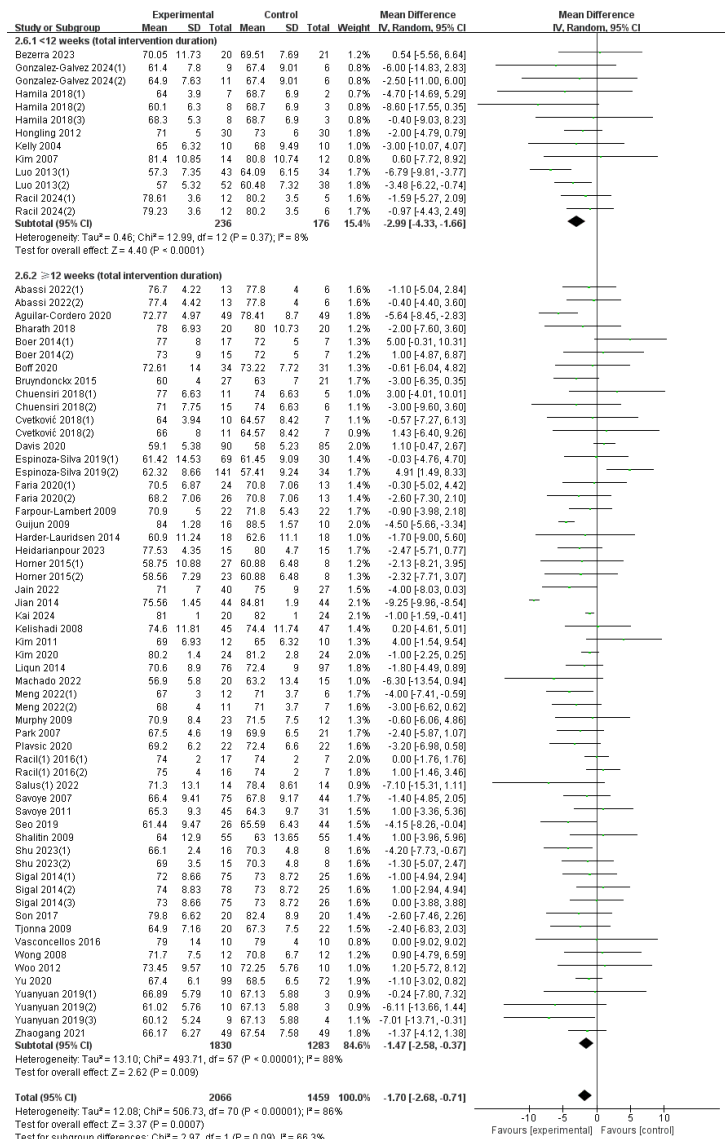


Figure S10.7. Forest plot of subgroup analyses by region

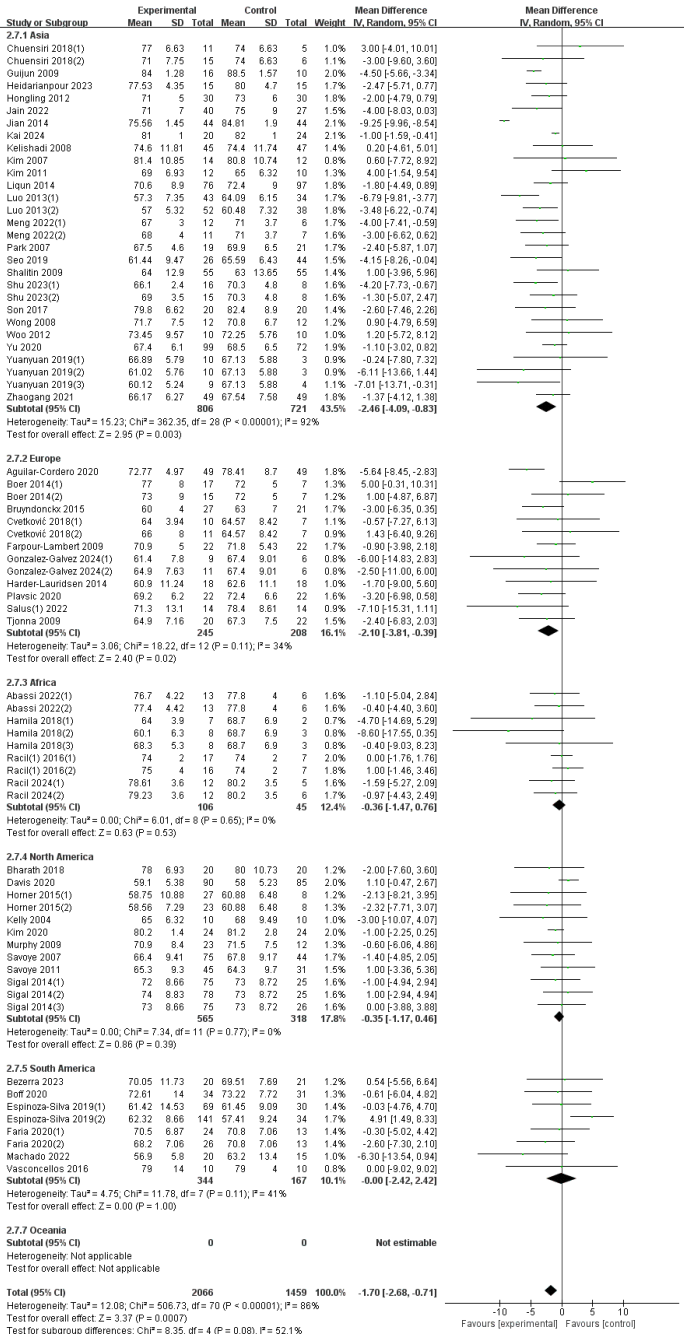


Figure S10.8. Forest plot of subgroup analyses by economic status

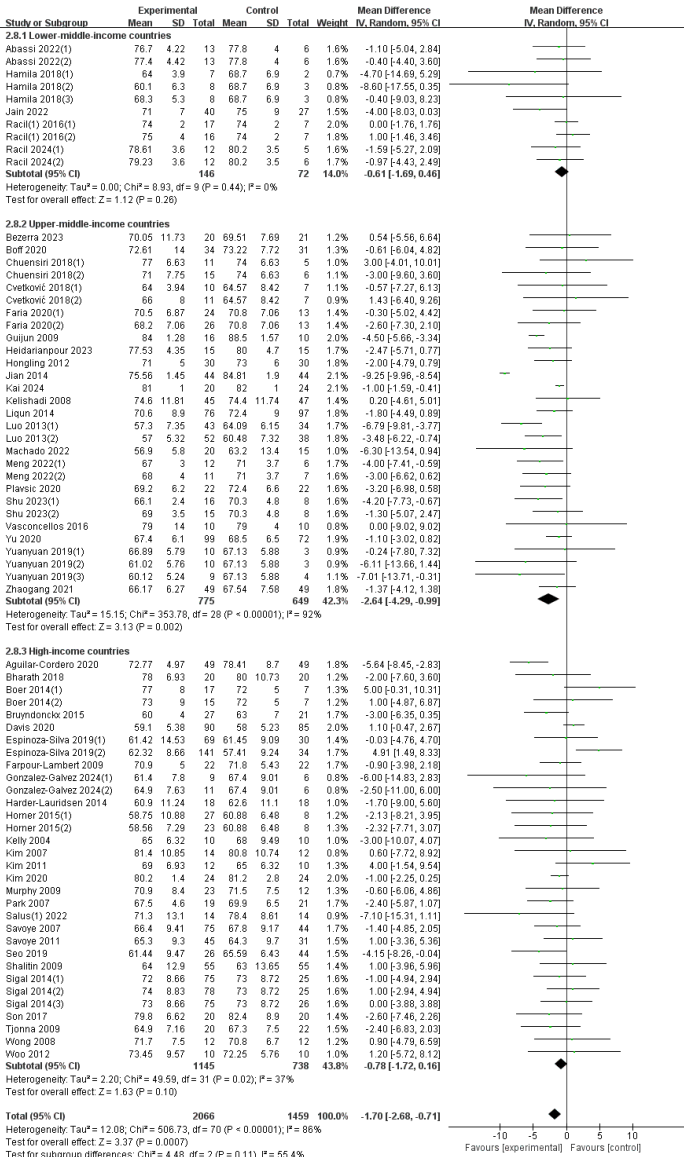


Figure S10.9. Forest plot of subgroup analyses by weight status

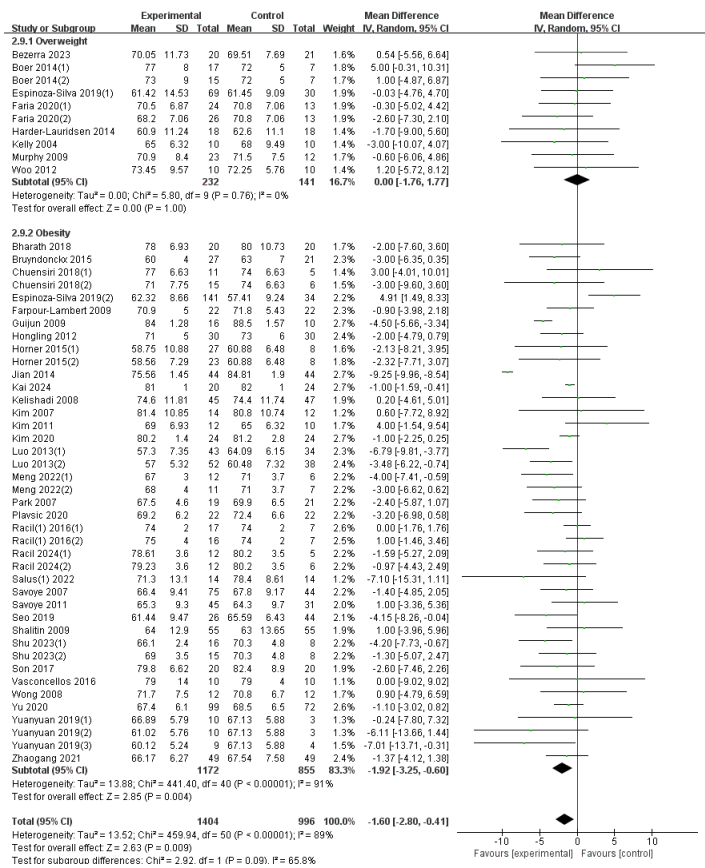


Figure S10.10. Forest plot of subgroup analyses by sex

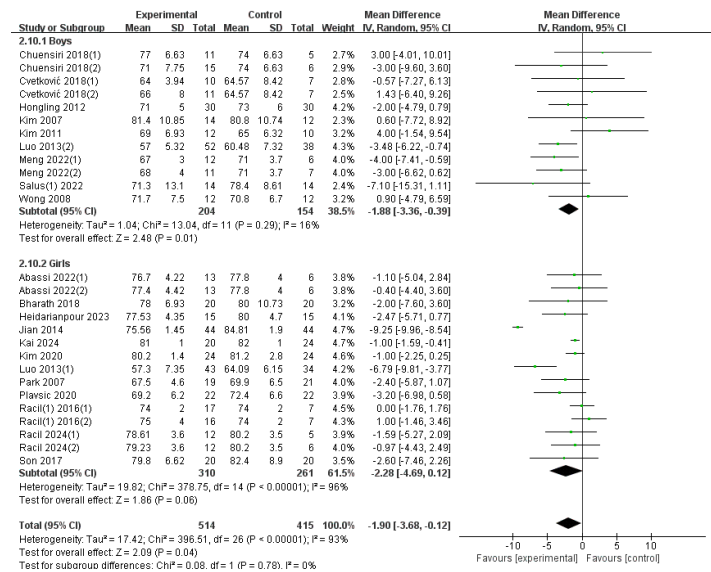


Figure S11. Forest plots of subgroup analyses for TC in children and adolescents with overweight or obesity

Figure S11.1. Forest plot of subgroup analyses by type of exercise

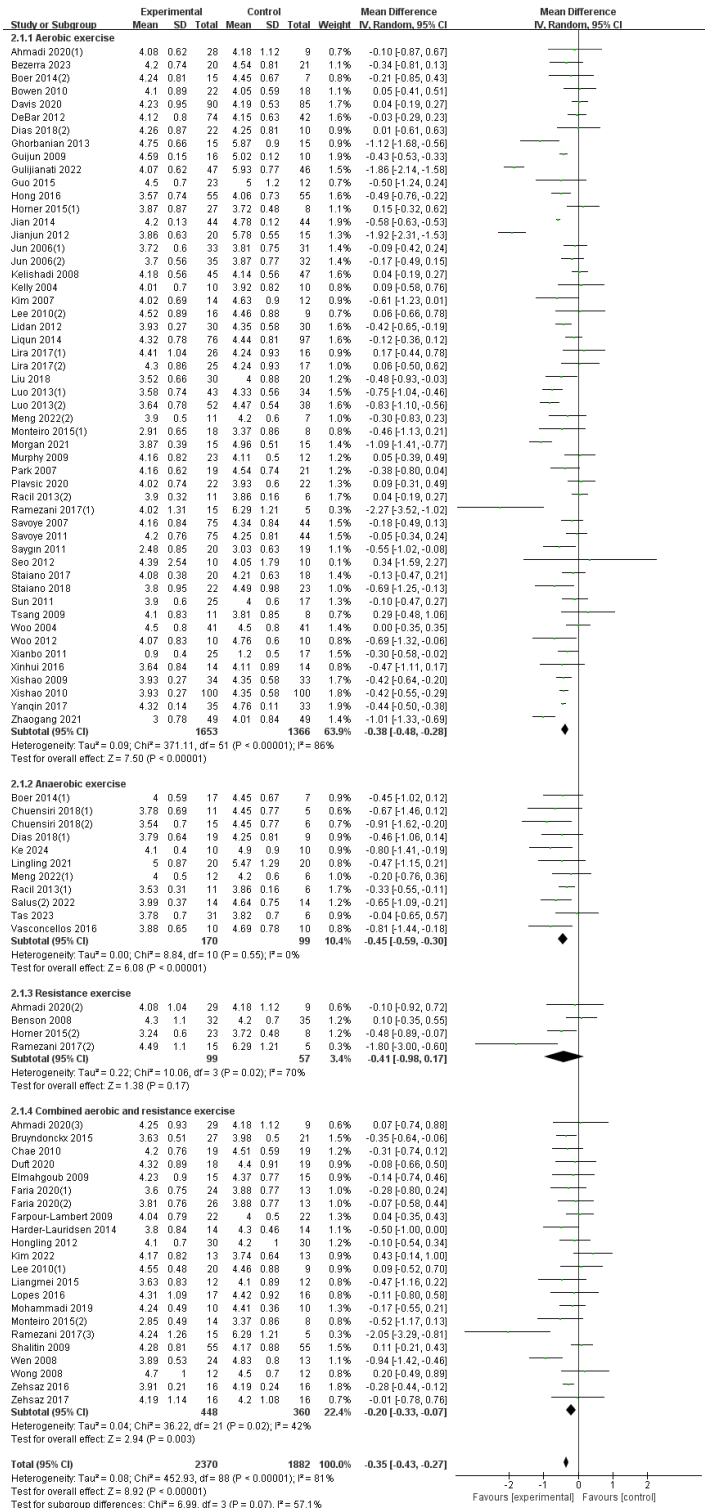


Figure S11.2. Forest plot of subgroup analyses by exercise intensity

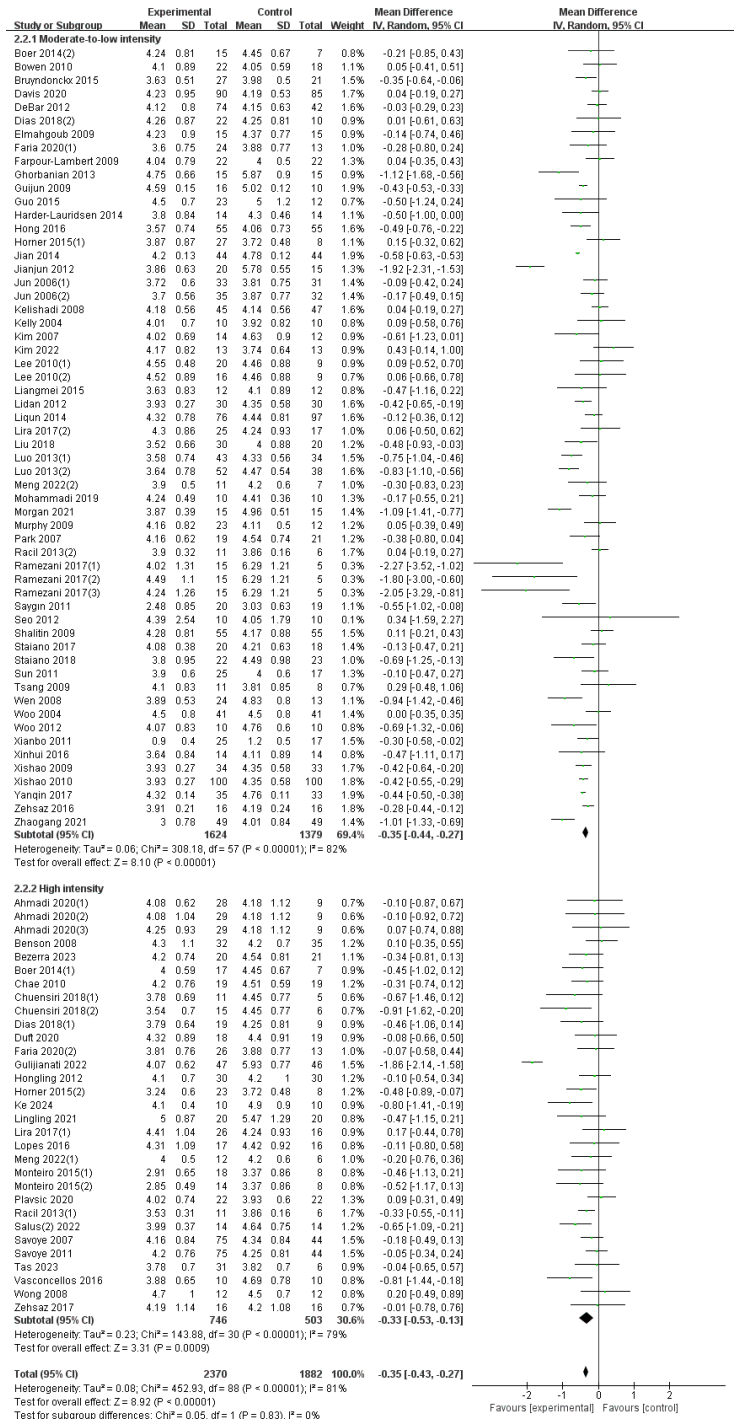


Figure S11.3. Forest plot of subgroup analyses by duration per session

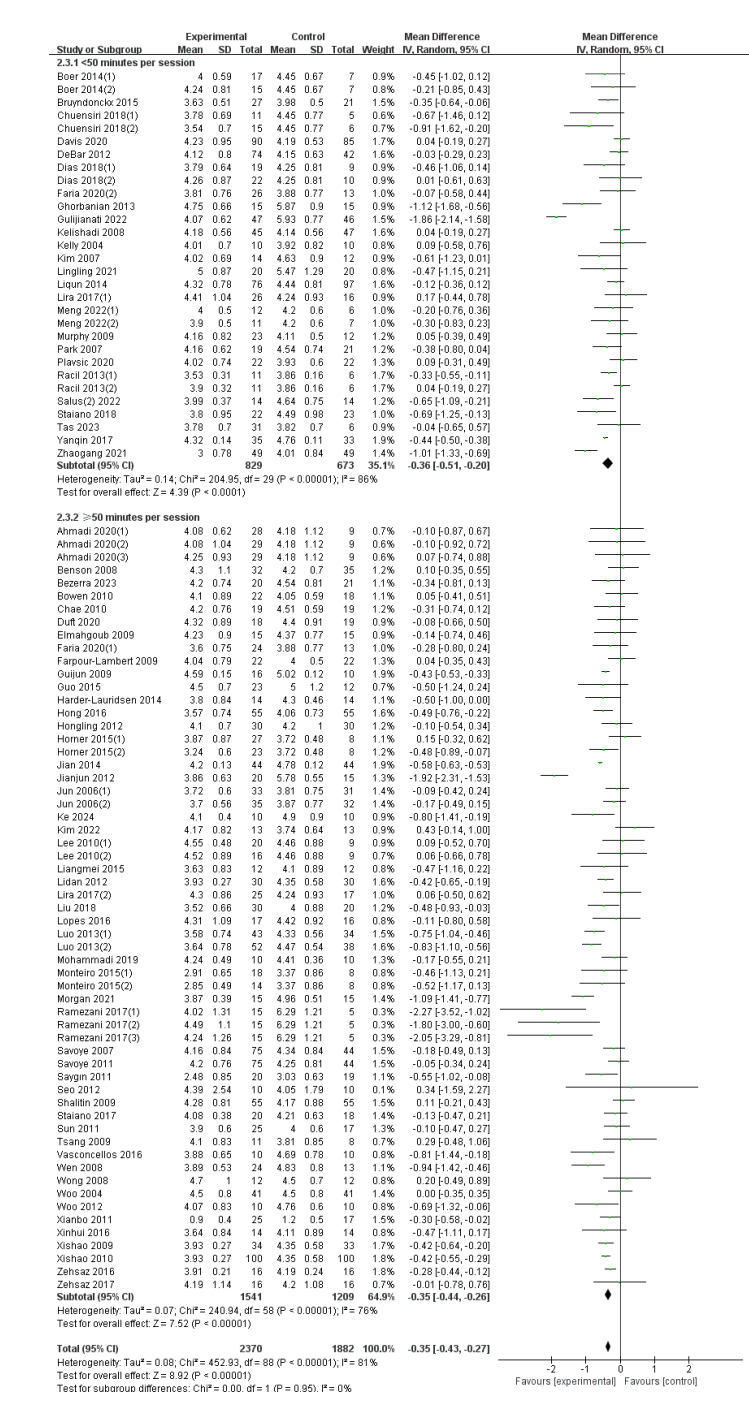


Figure S11.4. Forest plot of subgroup analyses by exercise frequency

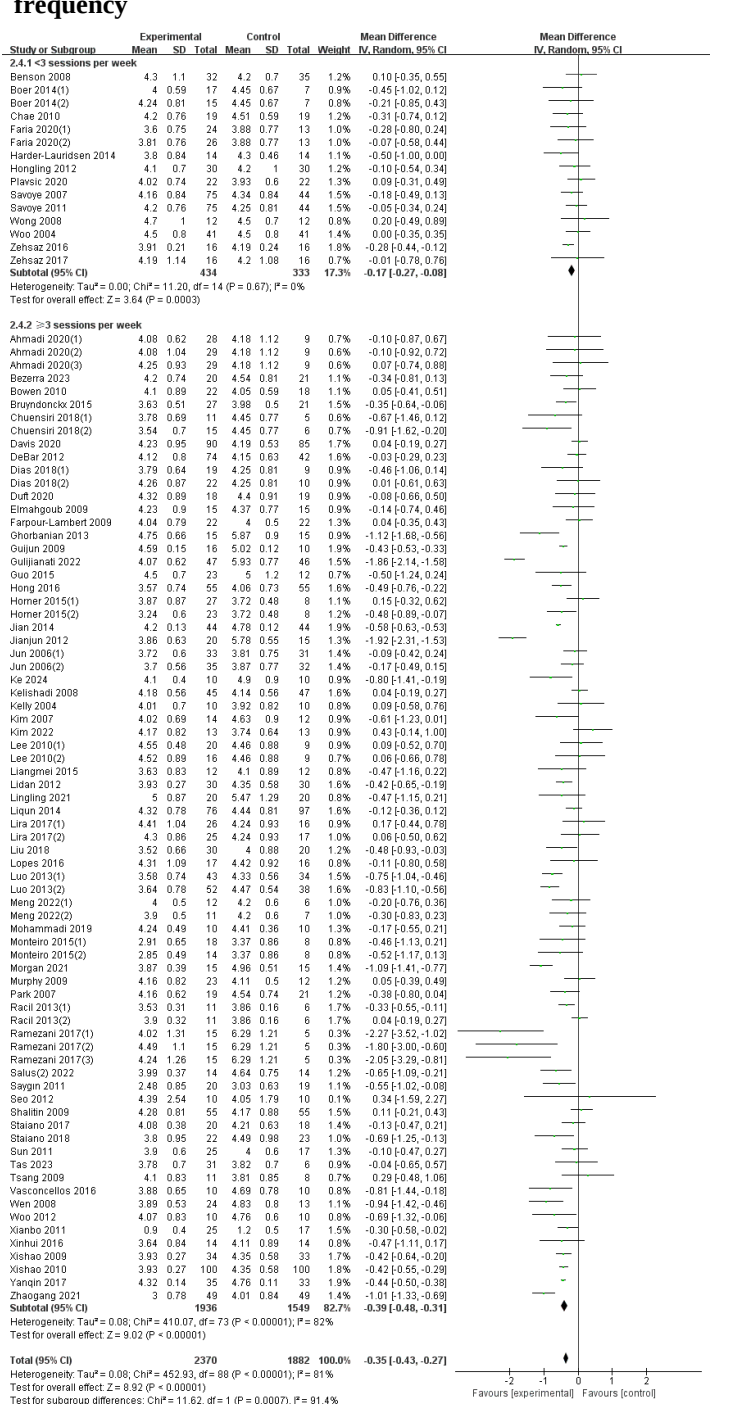


Figure S11.5. Forest plot of subgroup analyses by weekly exercise duration

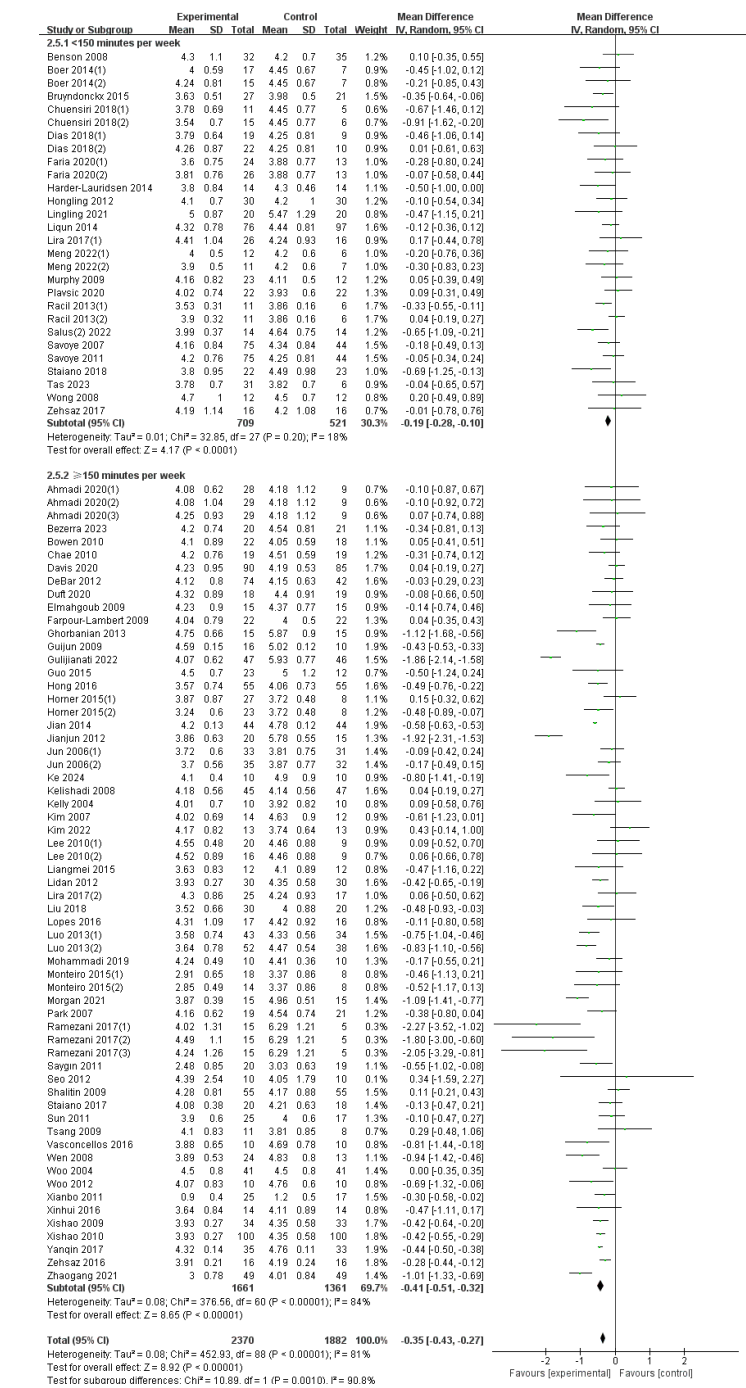


Figure S11.6. Forest plot of subgroup analyses by intervention duration

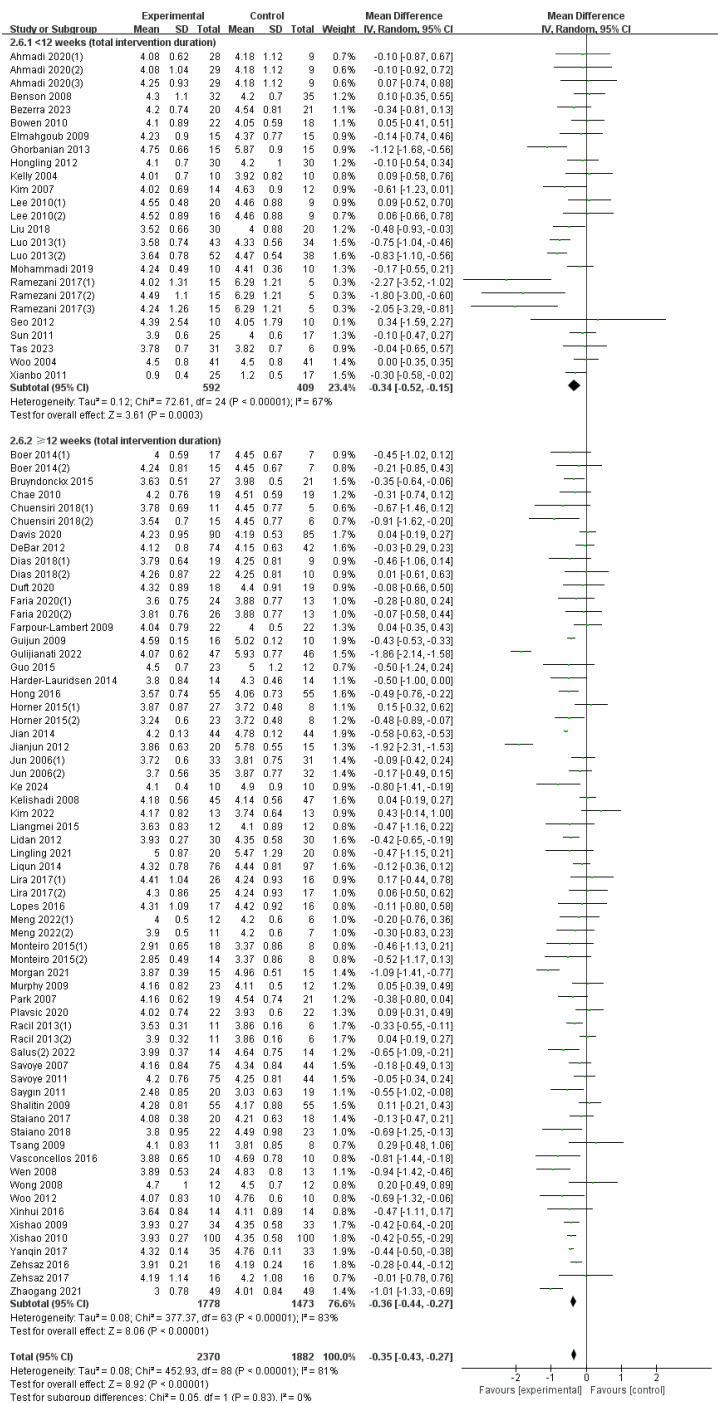


Figure S11.7. Forest plot of subgroup analyses by region

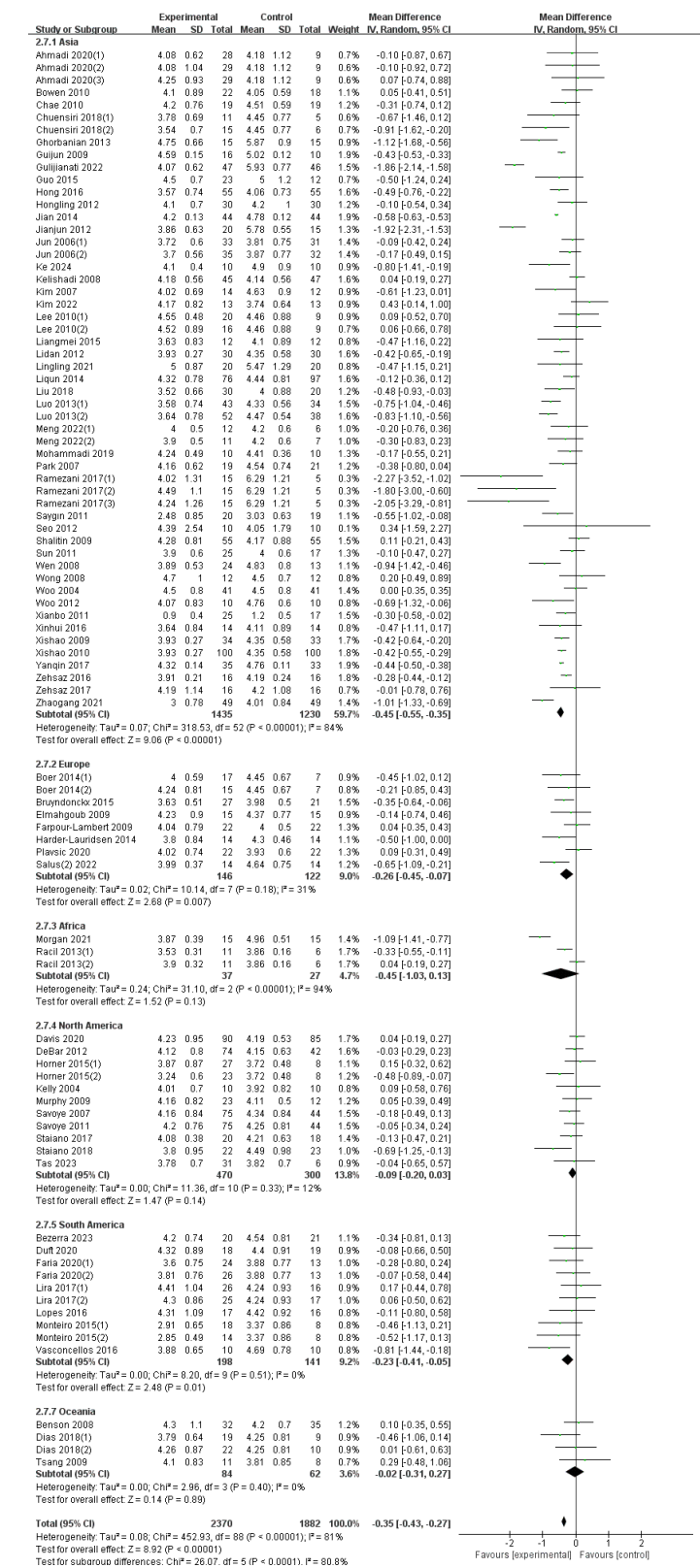


Figure S11.8. Forest plot of subgroup analyses by economic status

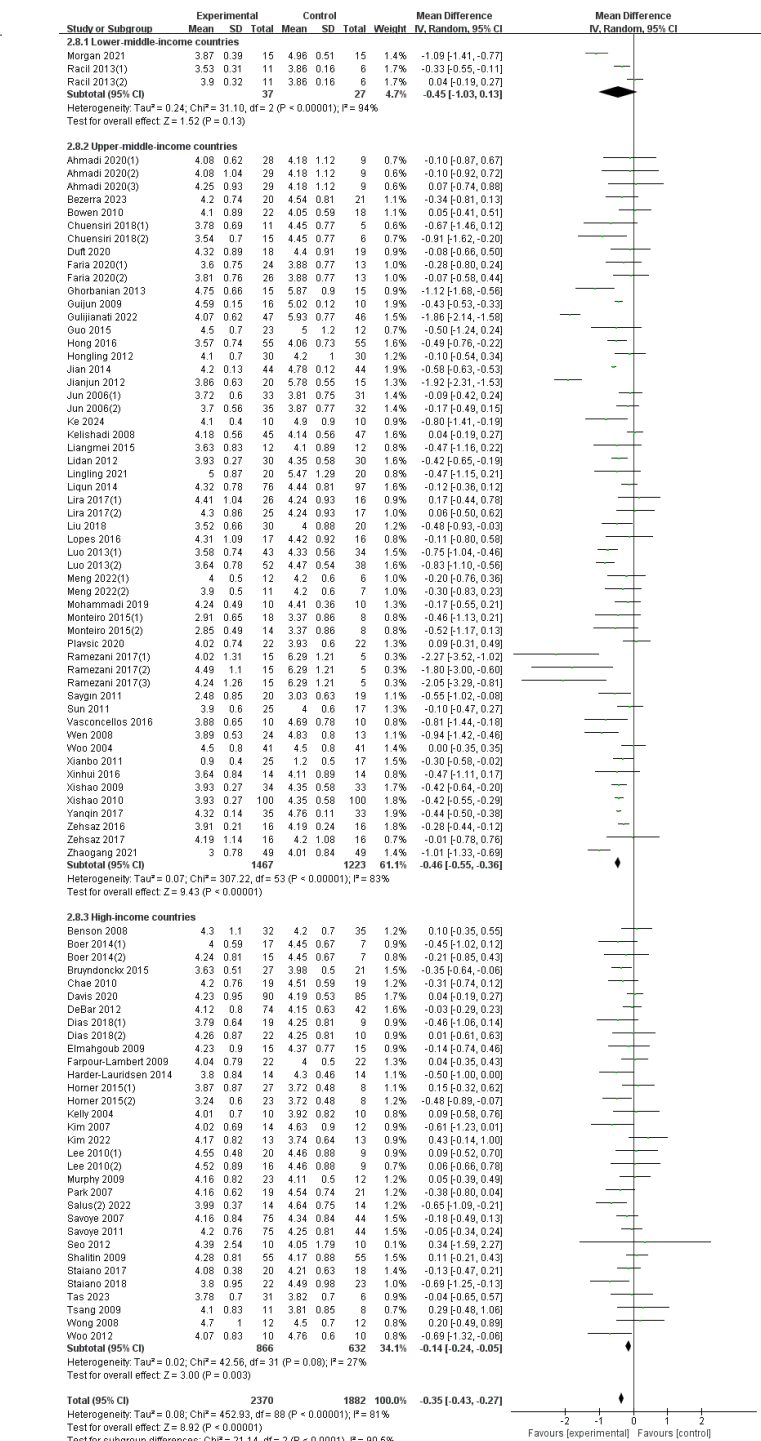


Figure S11.9. Forest plot of subgroup analyses by weight status

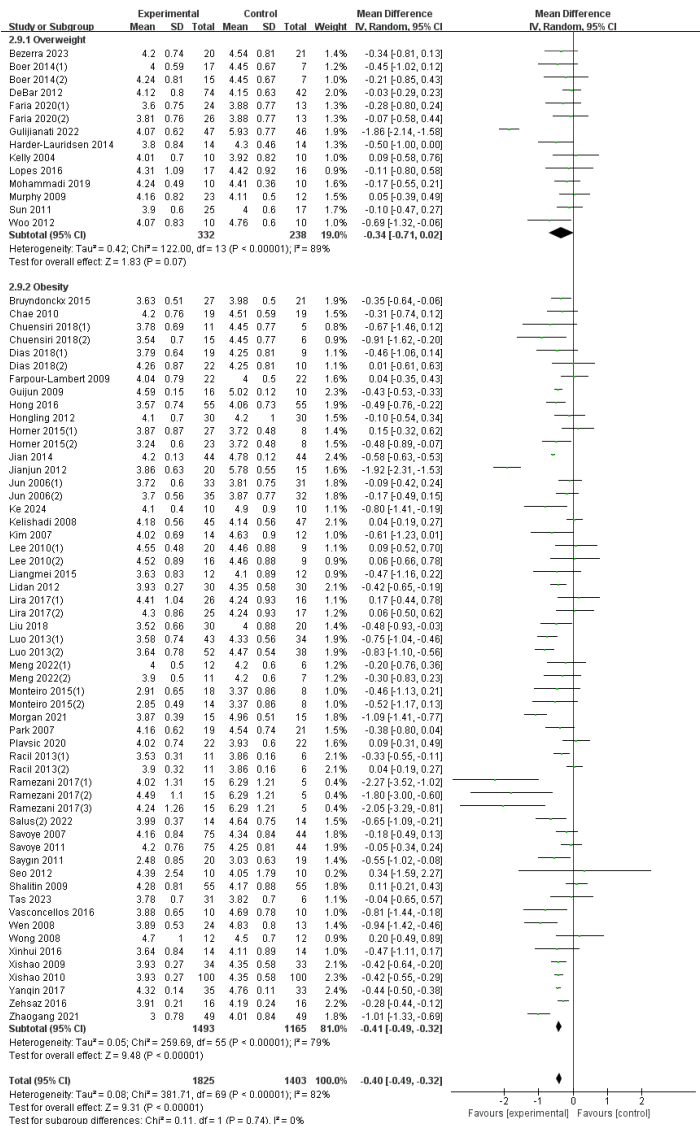


Figure S11.10. Forest plot of subgroup analyses by sex

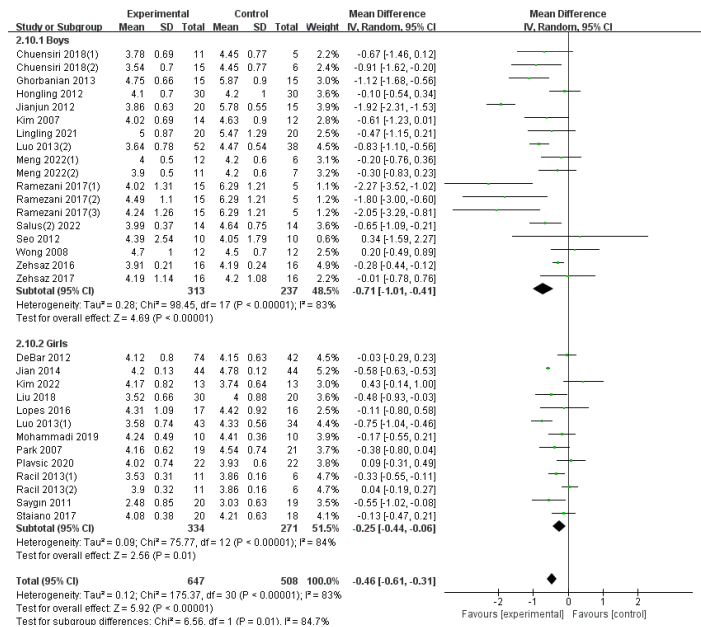


Figure S11.11. Forest plot of subgroup analyses by metabolic status

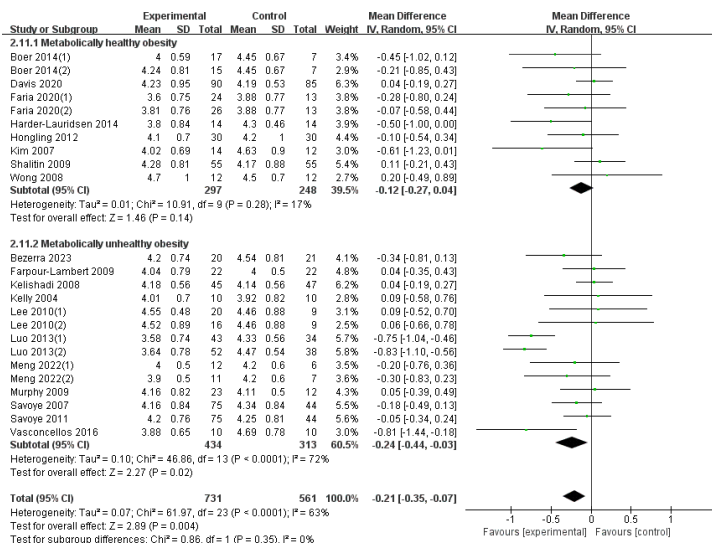


Figure S12. Forest plots of subgroup analyses for TG in children and adolescents with overweight or obesity

Figure S12.1. Forest plot of subgroup analyses by type of exercise

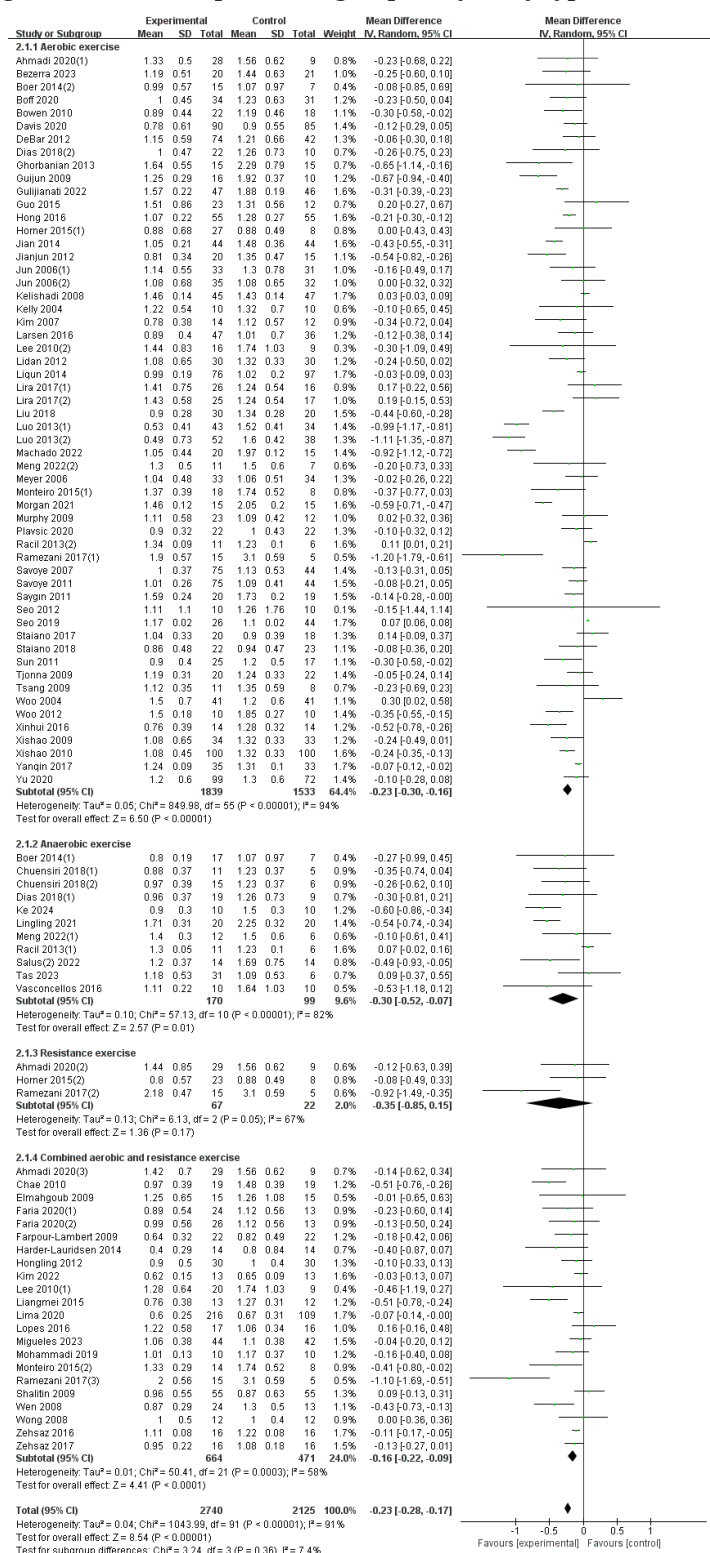


Figure S12.2. Forest plot of subgroup analyses by exercise intensity

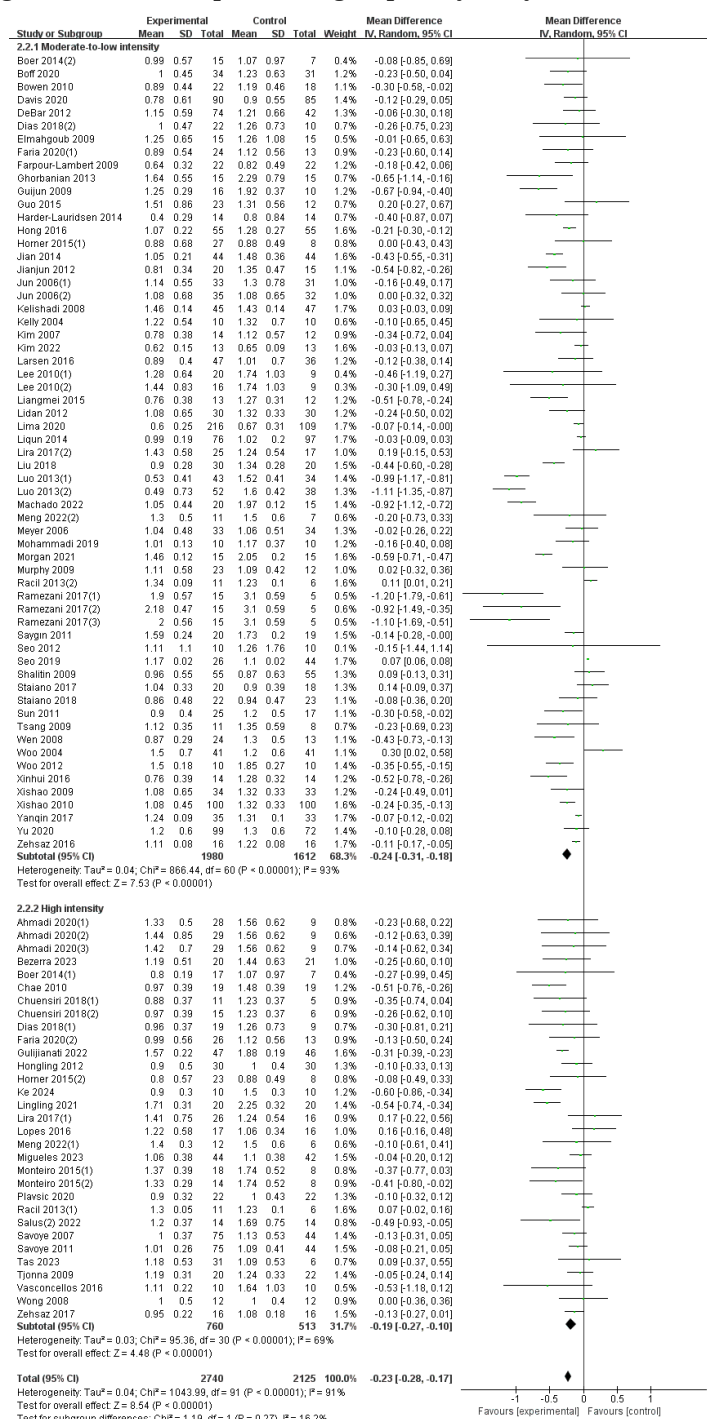


Figure S12.3. Forest plot of subgroup analyses by duration per session

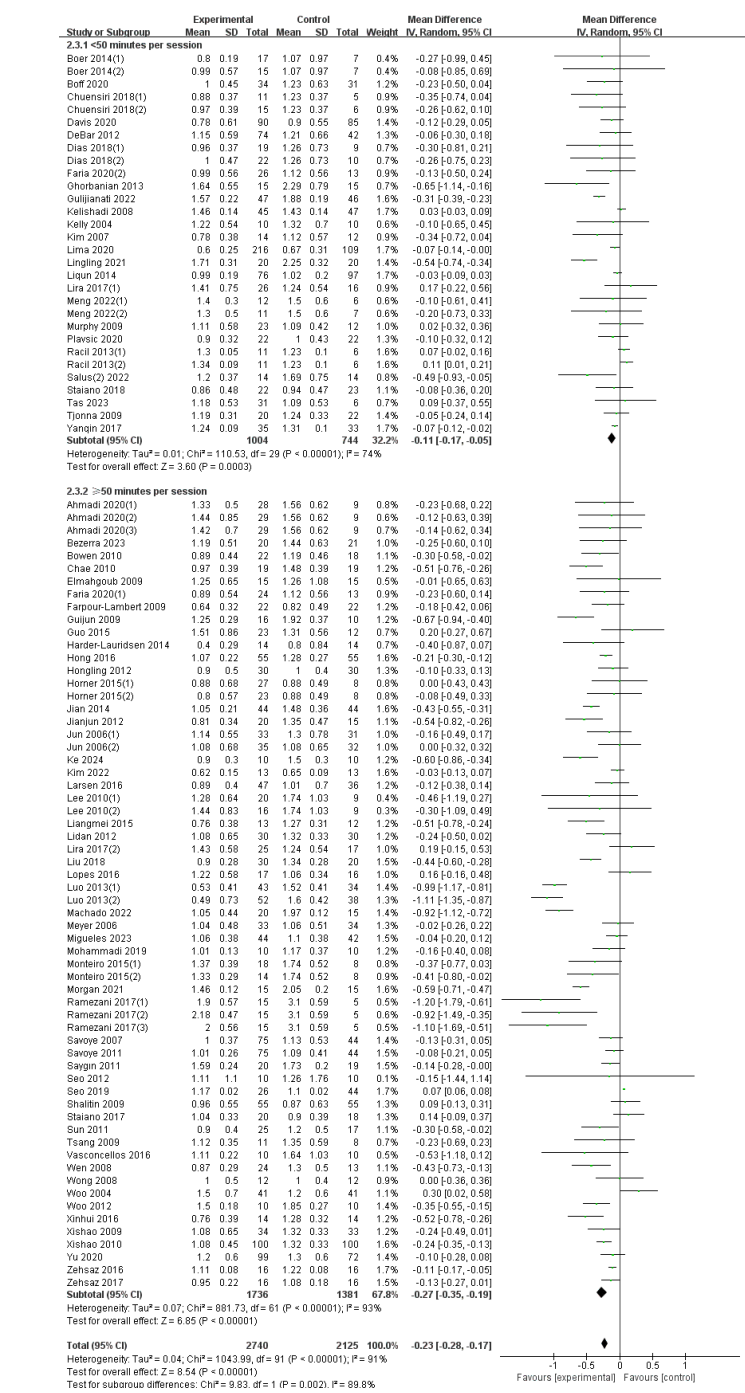


Figure S12.4. Forest plot of subgroup analyses by exercise frequency

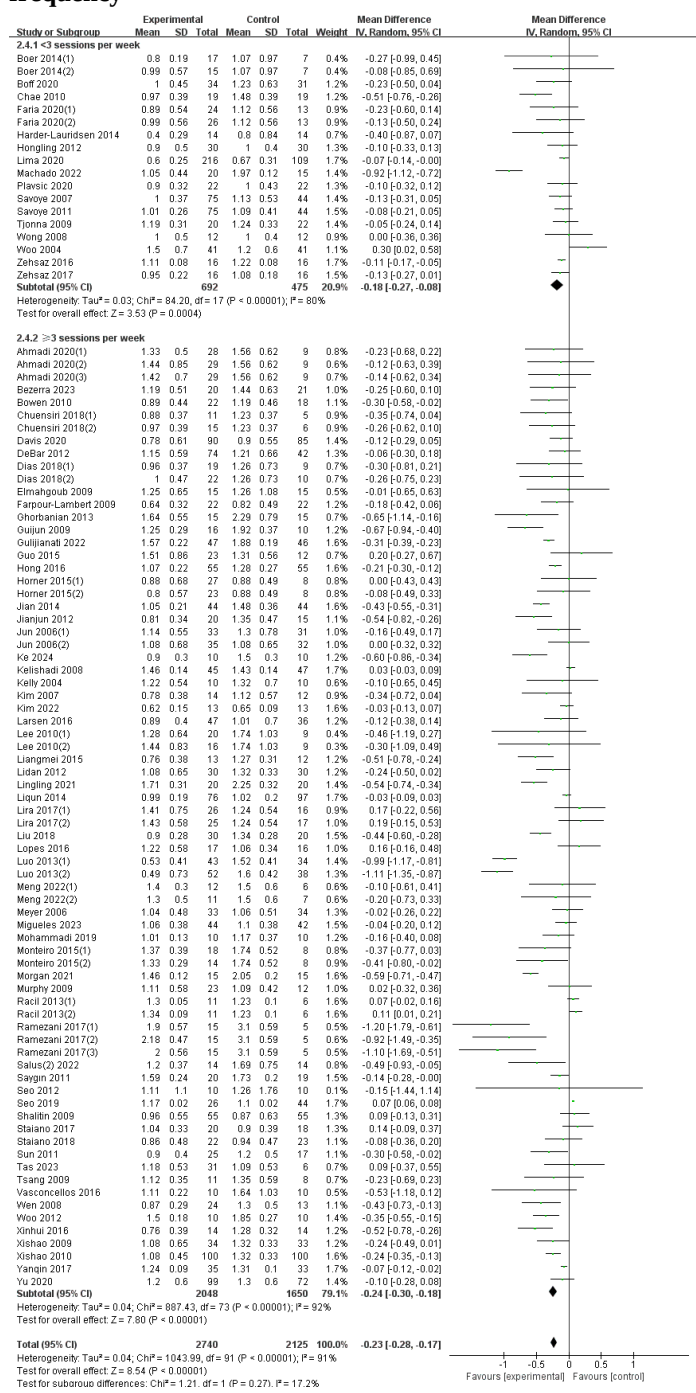


Figure S12.5. Forest plot of subgroup analyses by weekly exercise duration

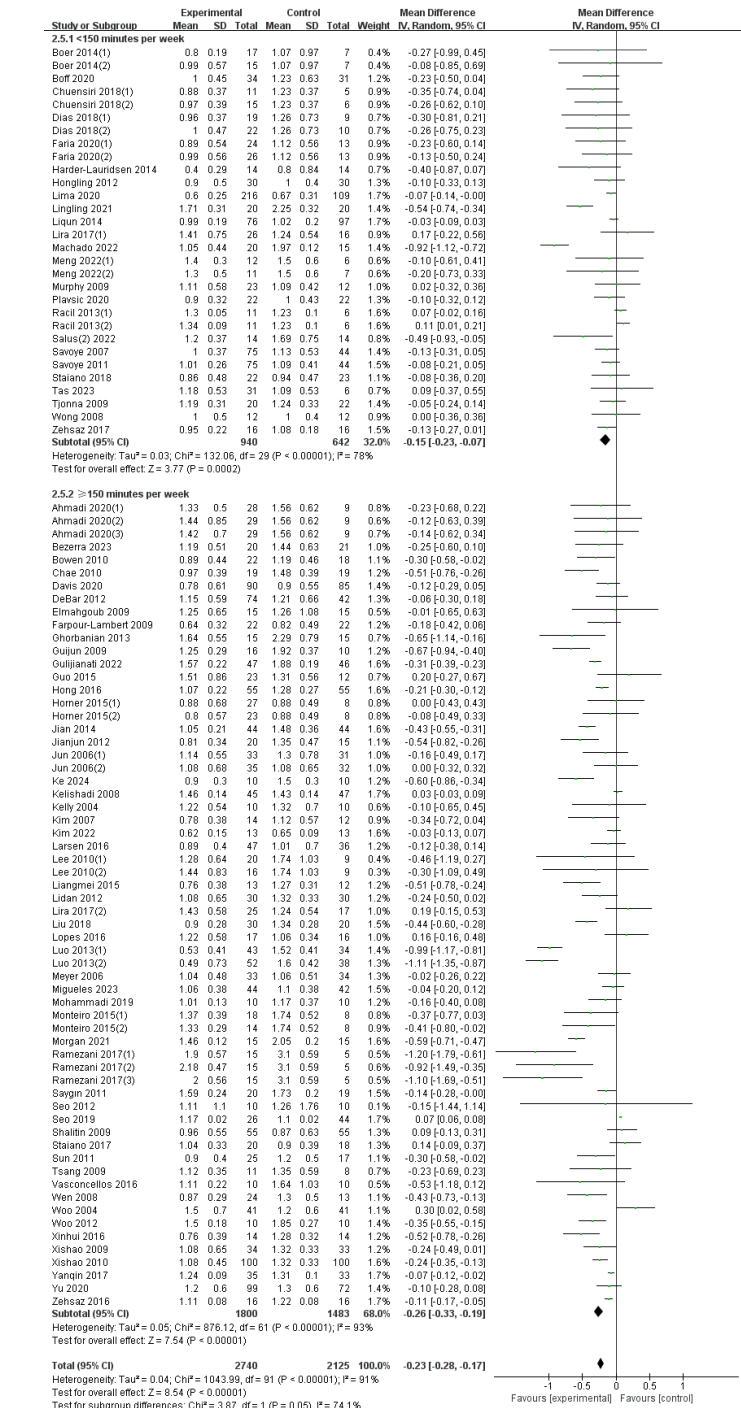


Figure S12.6. Forest plot of subgroup analyses by

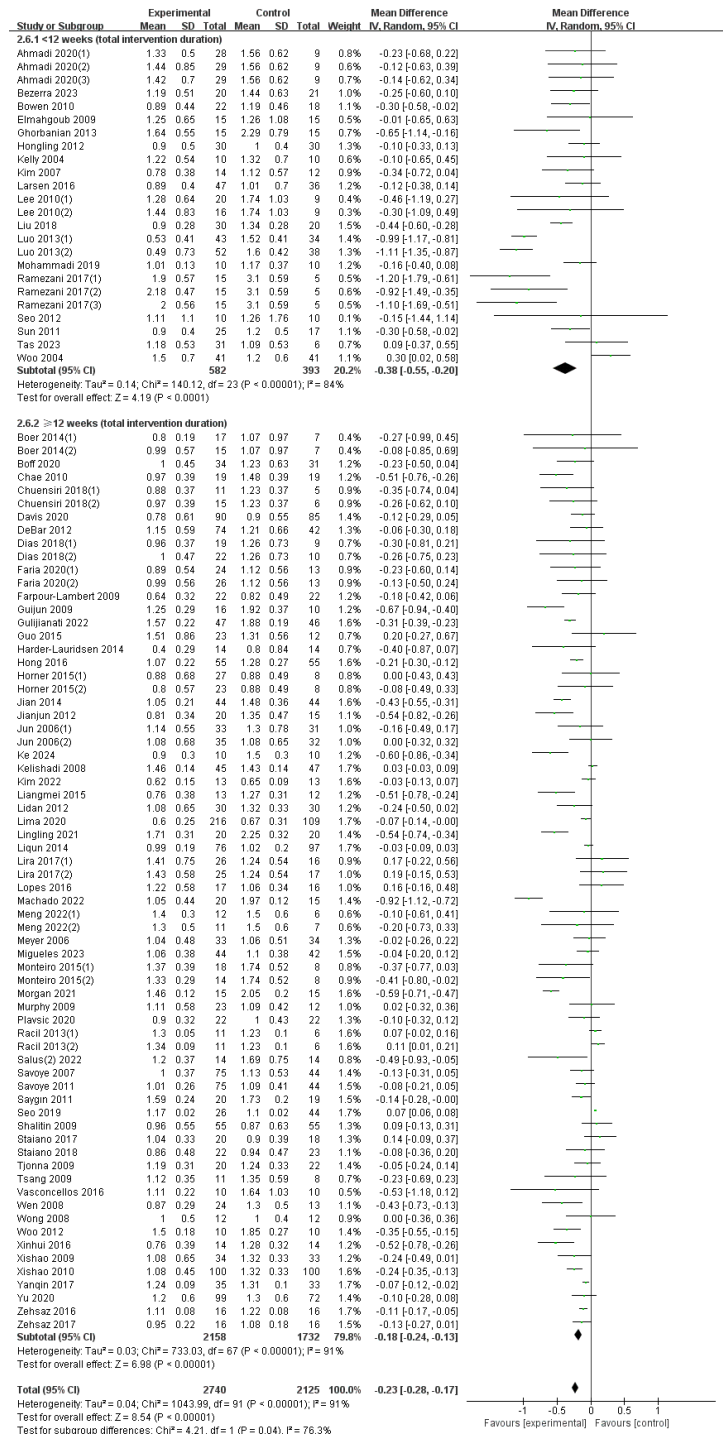


Figure S12.7. Forest plot of subgroup analyses by region

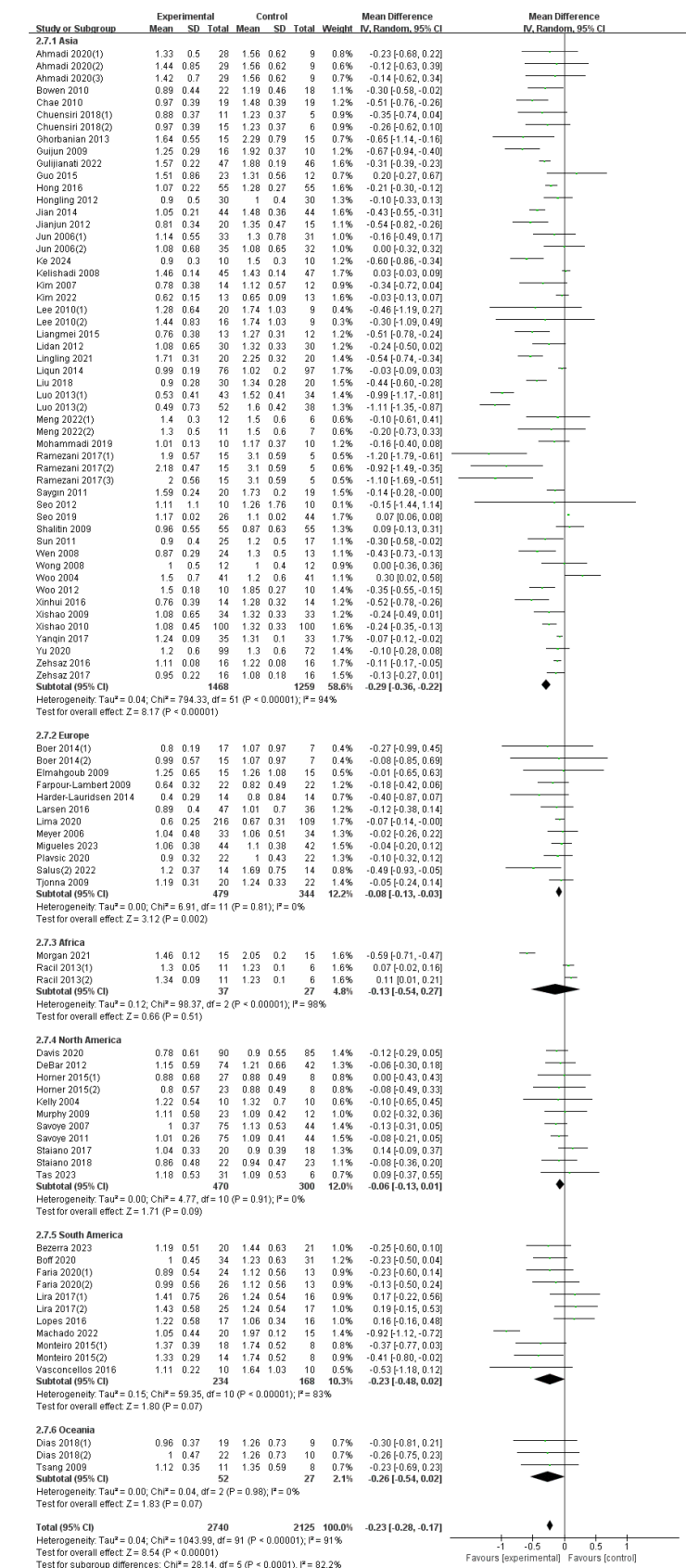


Figure S12.8. Forest plot of subgroup analyses by economic status

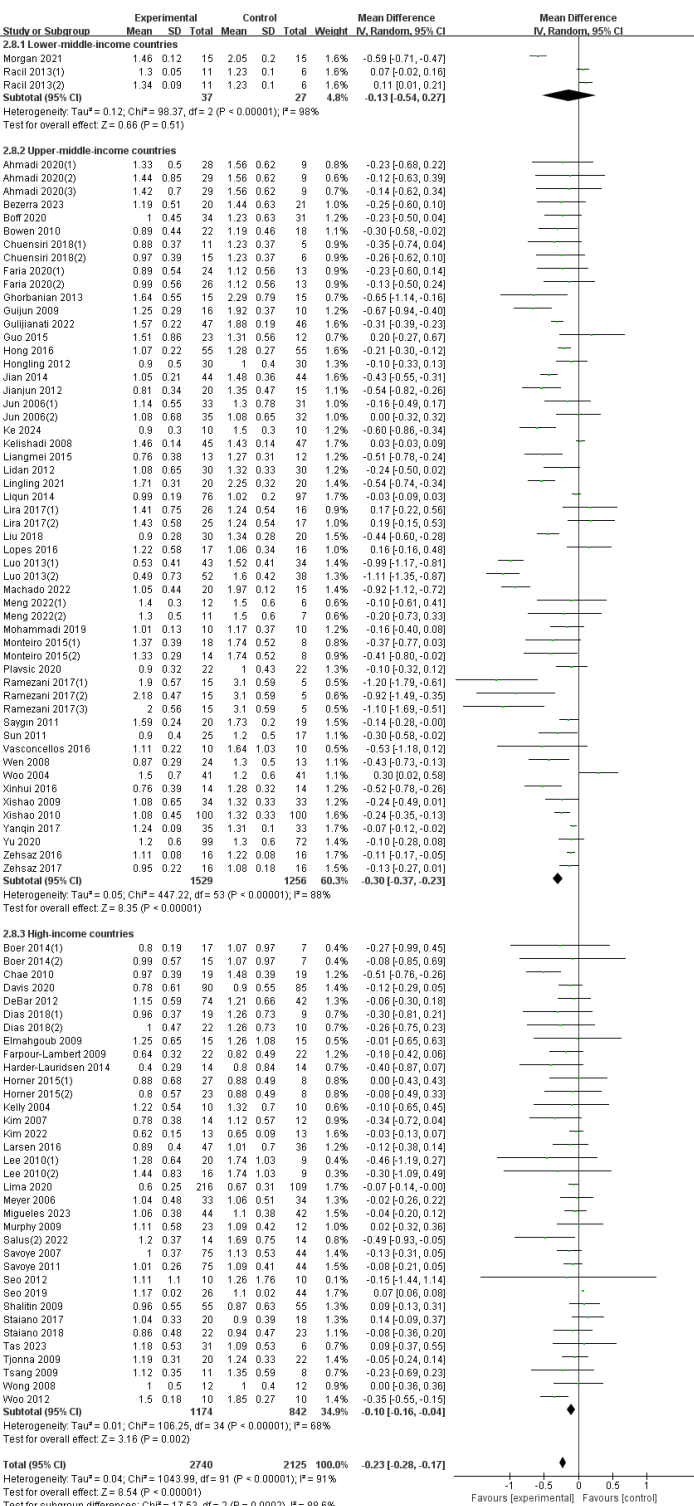


Figure S12.9. Forest plot of subgroup analyses by weight status

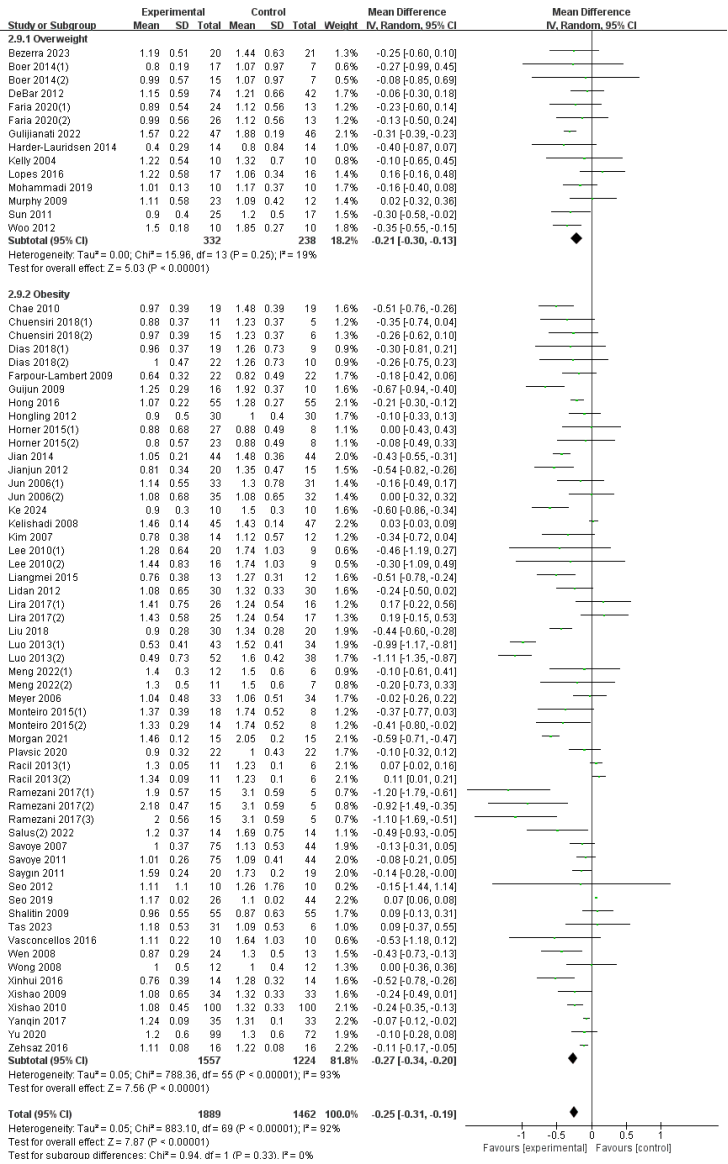


Figure S12.10. Forest plot of subgroup analyses by sex

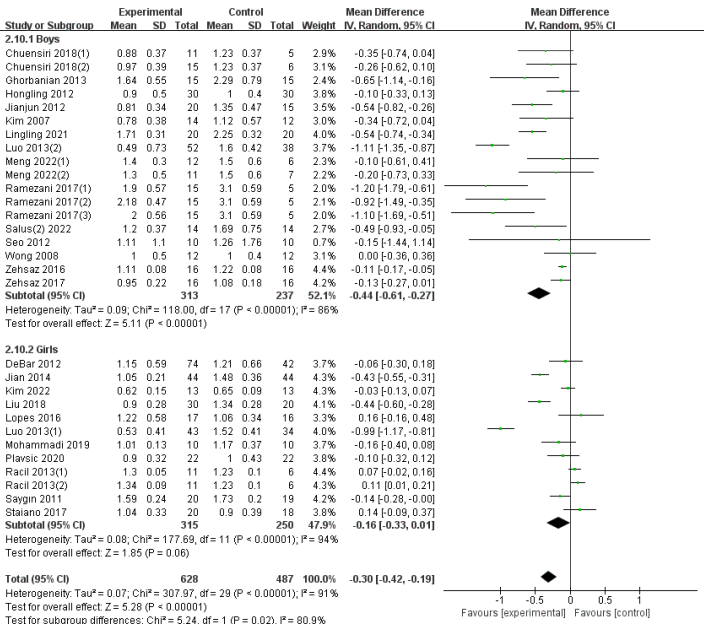


Figure S13. Forest plots of subgroup analyses for HDL-C in children and adolescents with overweight or obesity

Figure S13.1. Forest plot of subgroup analyses by type of exercise

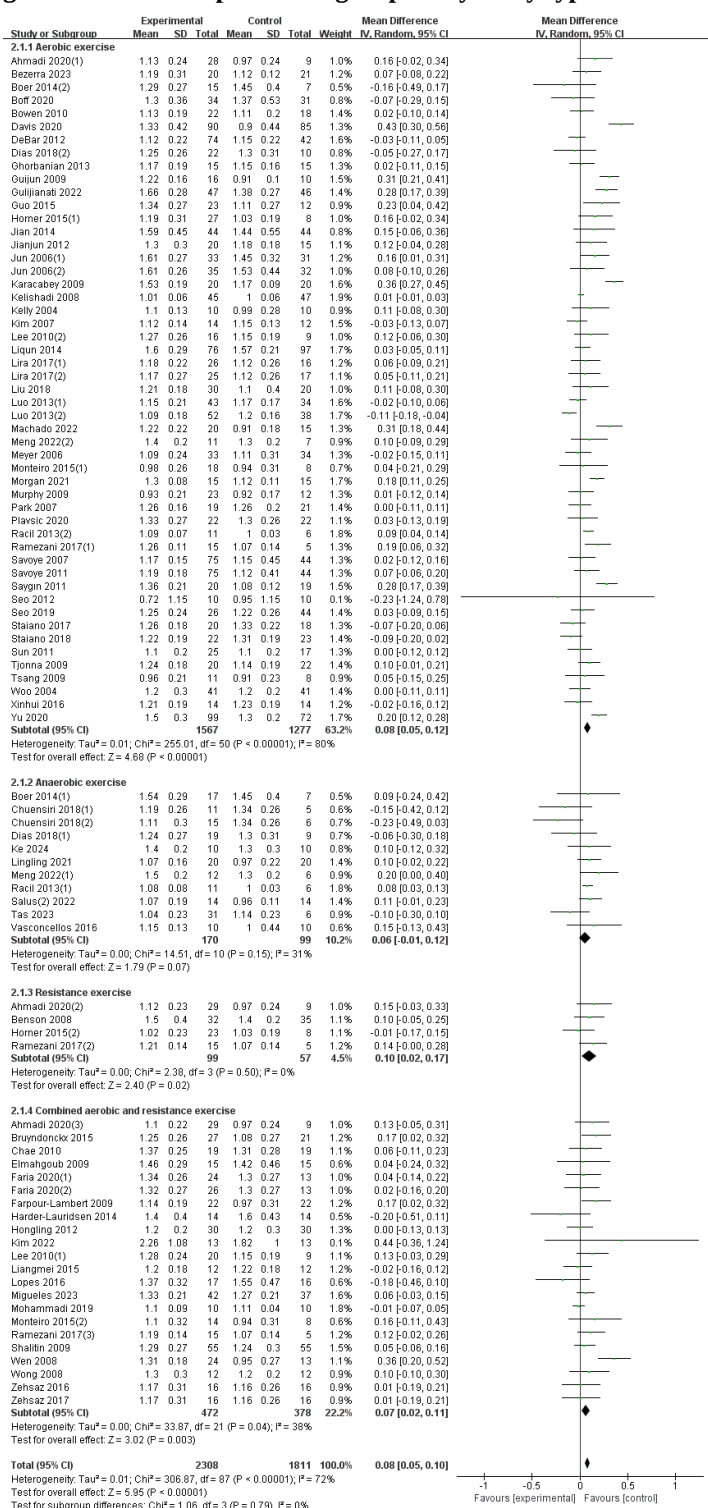


Figure S13.2. Forest plot of subgroup analyses by exercise intensity

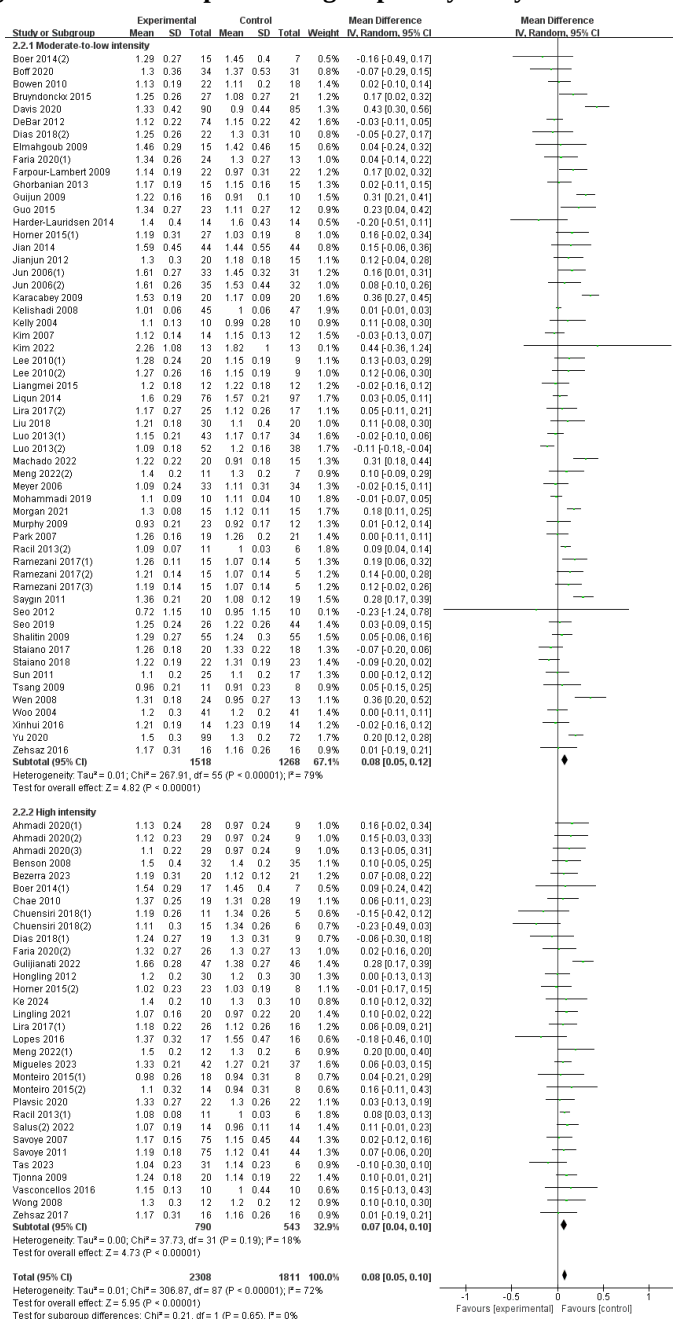


Figure S13.3. Forest plot of subgroup analyses by duration per session

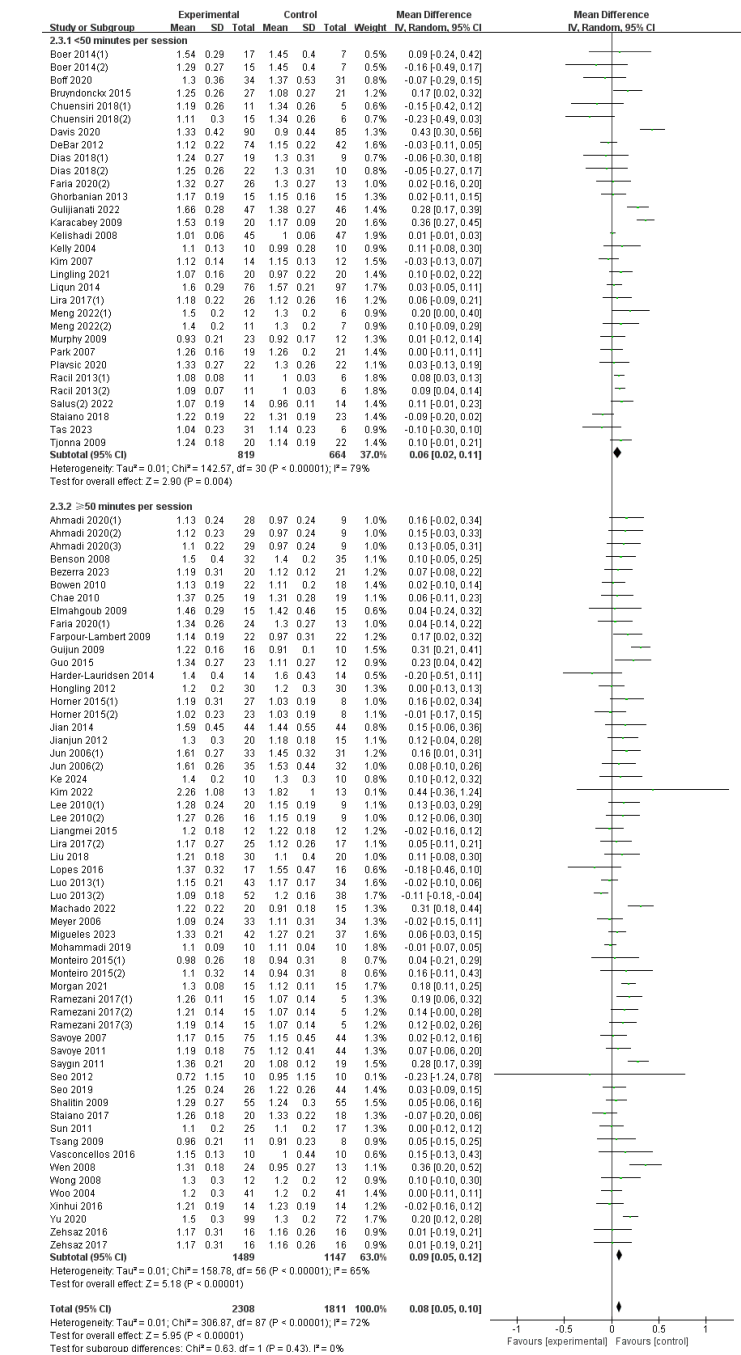


Figure S13.4. Forest plot of subgroup analyses by exercise frequency

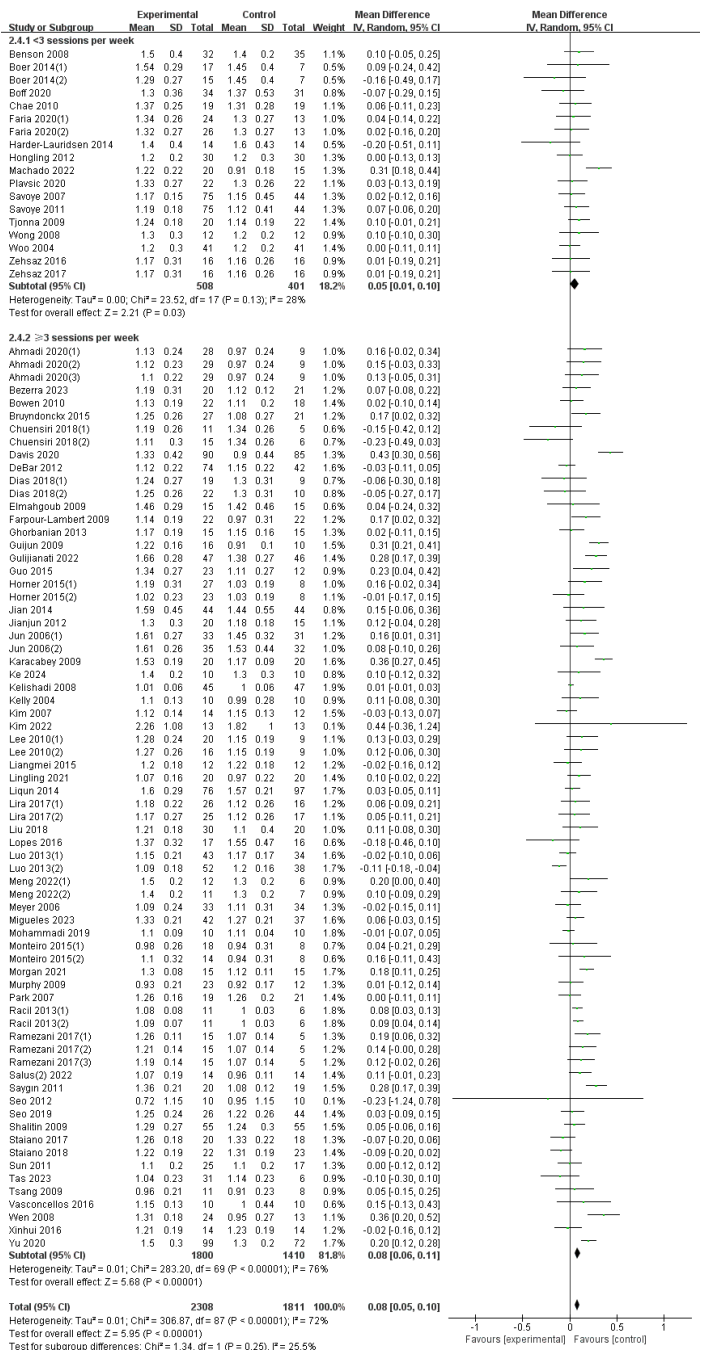


Figure S13.5. Forest plot of subgroup analyses by weekly exercise duration

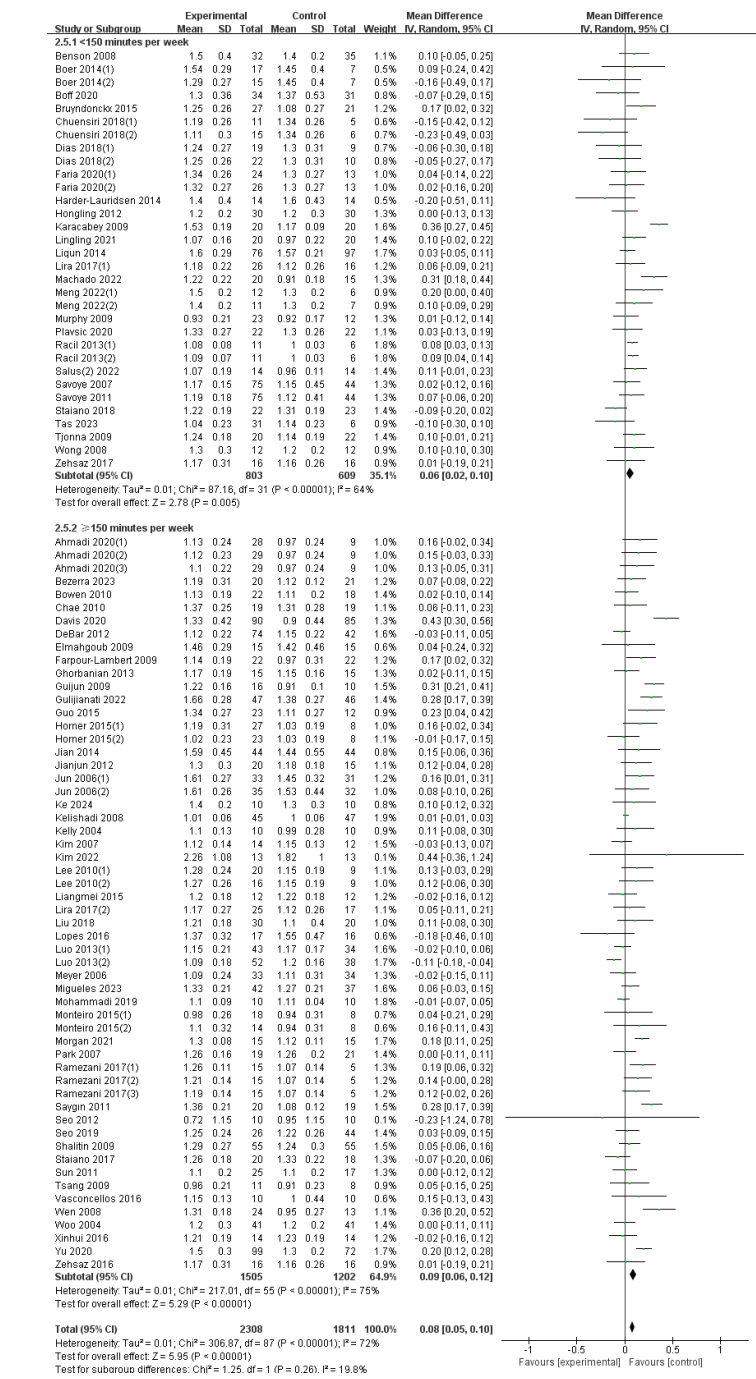


Figure S13.6. Forest plot of subgroup analyses by intervention duration

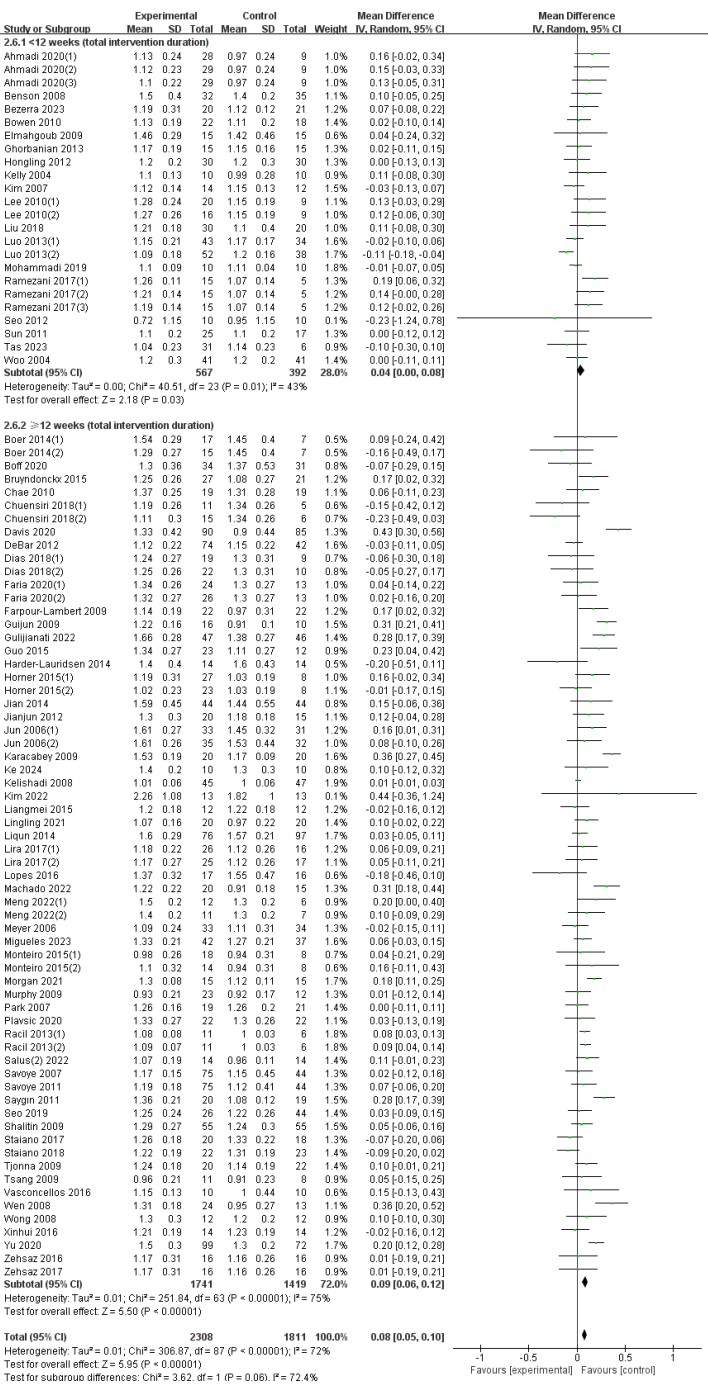


Figure S13.7. Forest plot of subgroup analyses by region

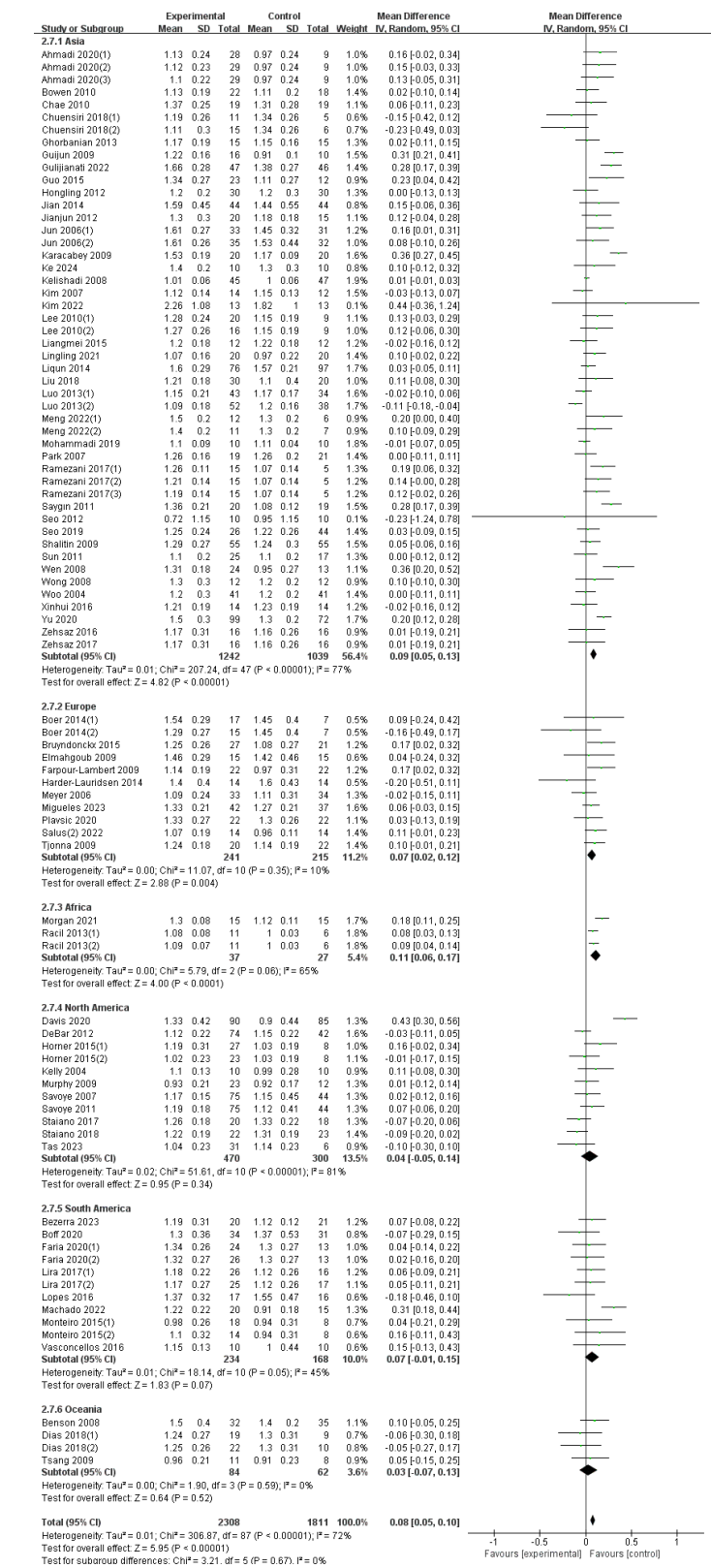


Figure S13.8. Forest plot of subgroup analyses by economic status

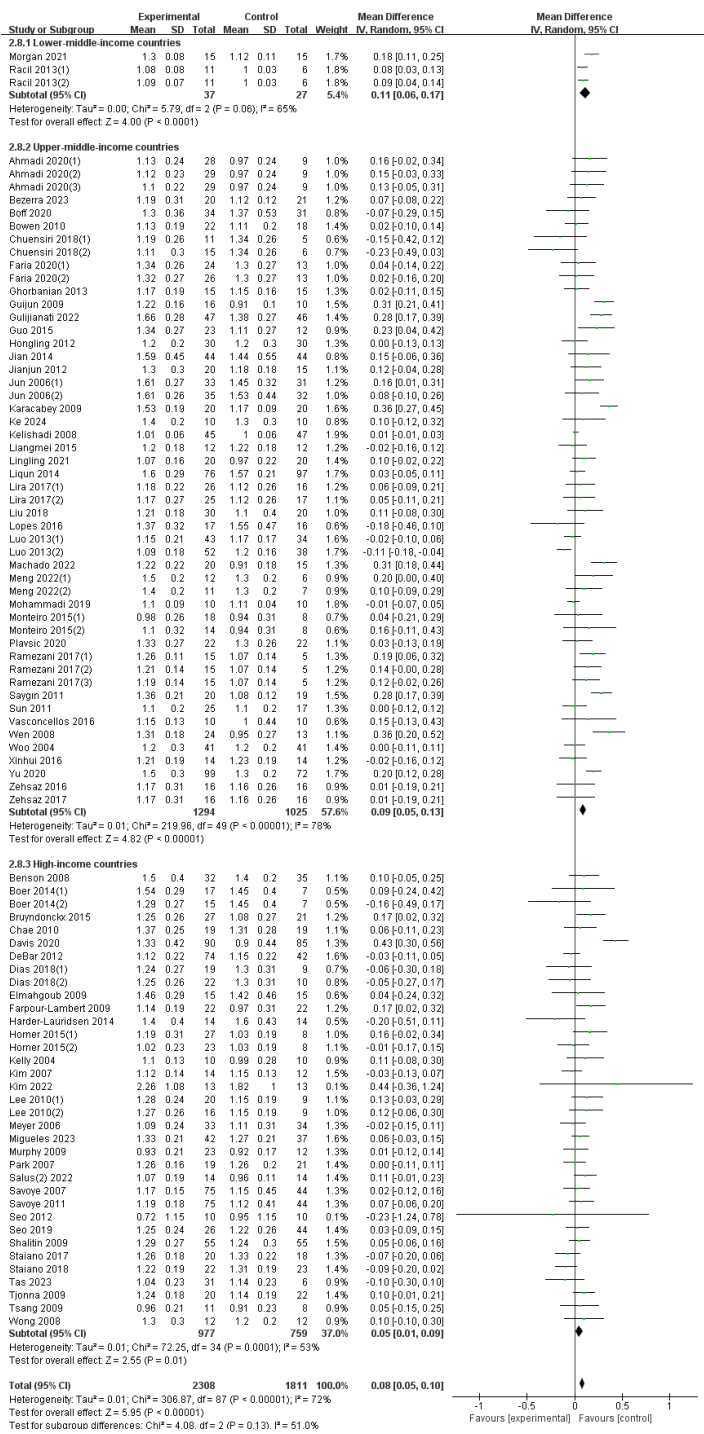


Figure S13.9. Forest plot of subgroup analyses by weight status

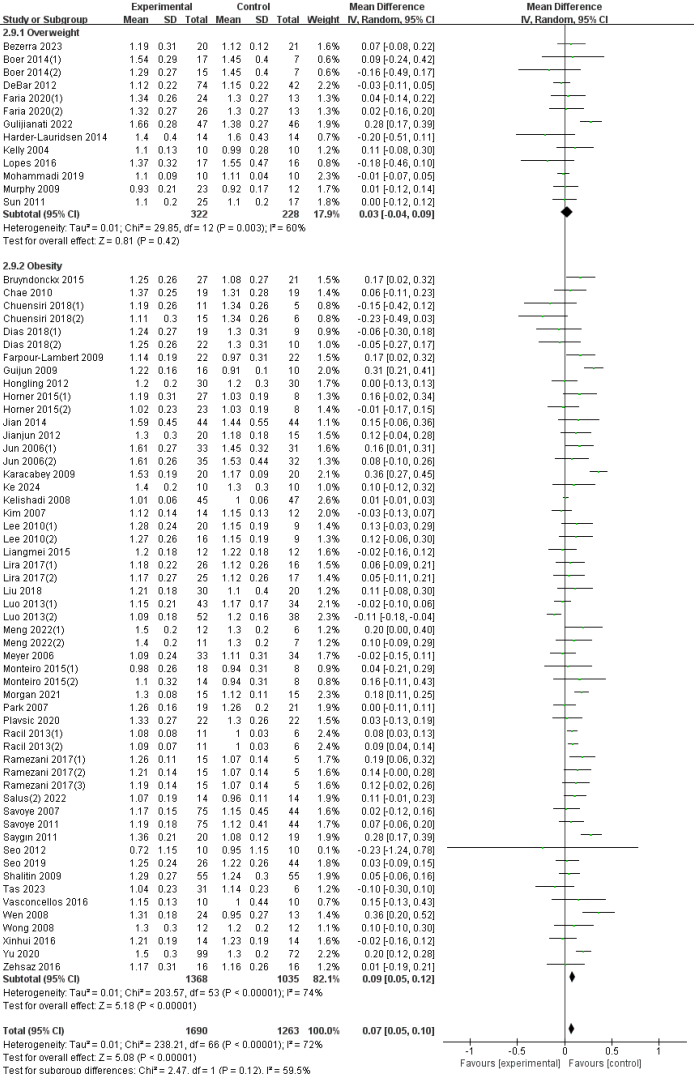


Figure S13.10. Forest plot of subgroup analyses by sex

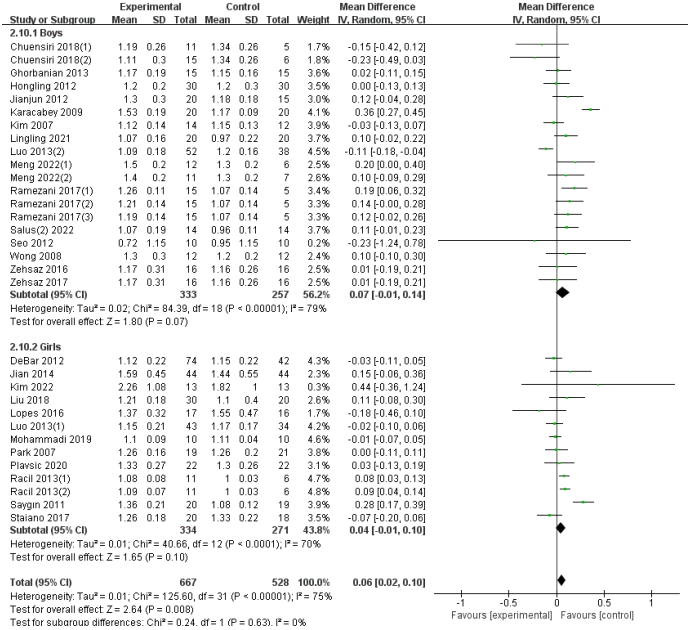


Figure S14. Forest plots of subgroup analyses for LDL-C in children and adolescents with overweight or obesity

Figure S14.1. Forest plot of subgroup analyses by type of exercise

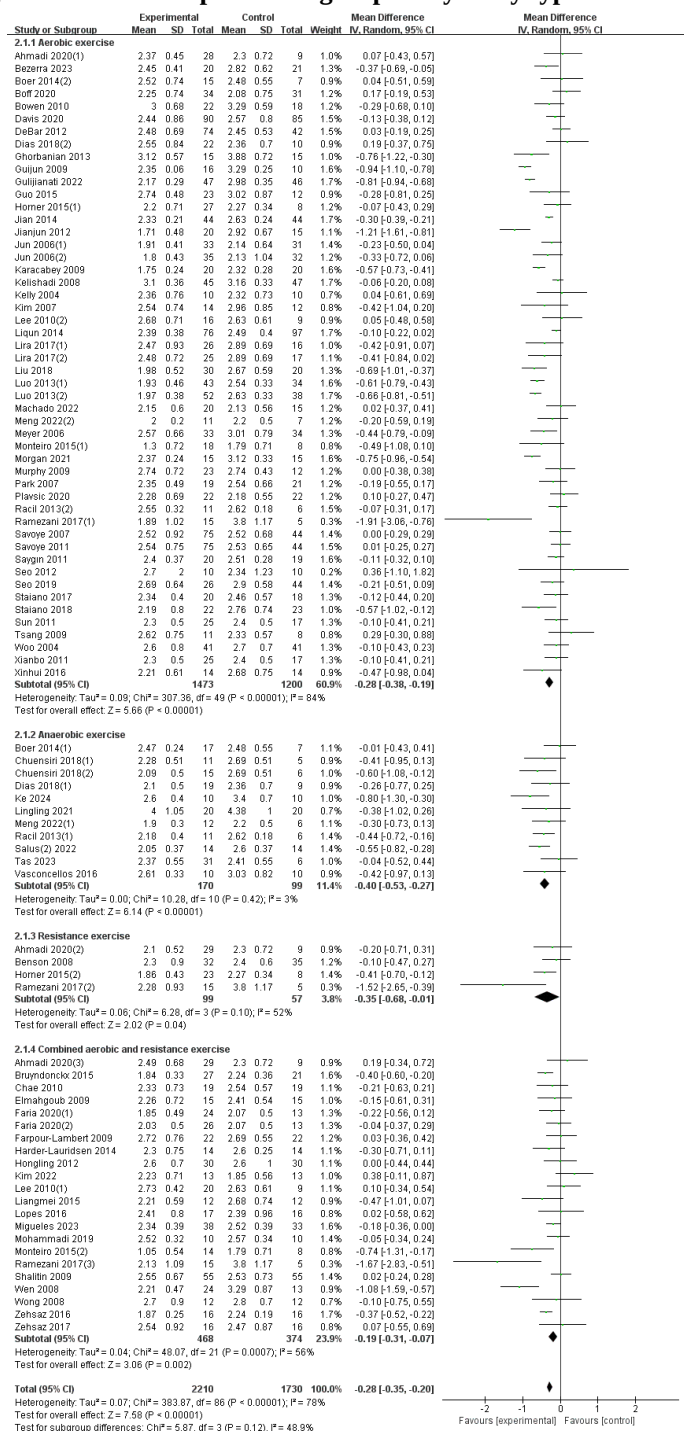


Figure S14.2. Forest plot of subgroup analyses by exercise intensity

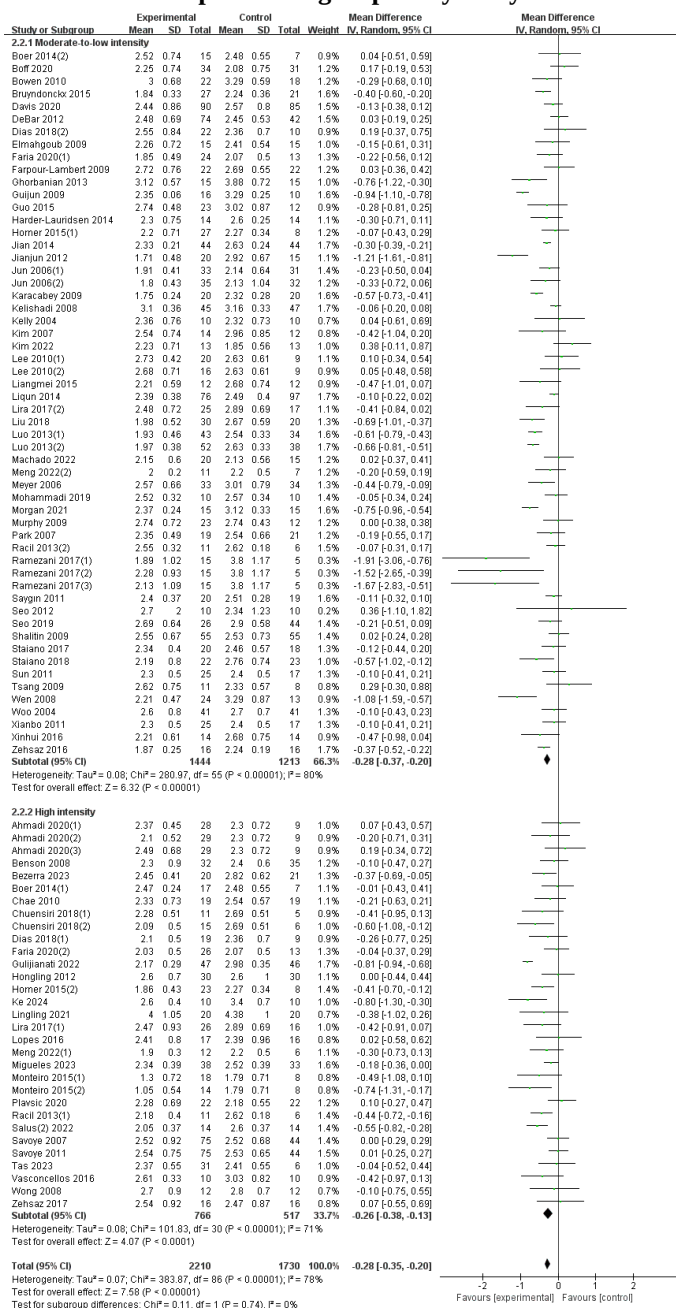


Figure S14.3. Forest plot of subgroup analyses by duration per session

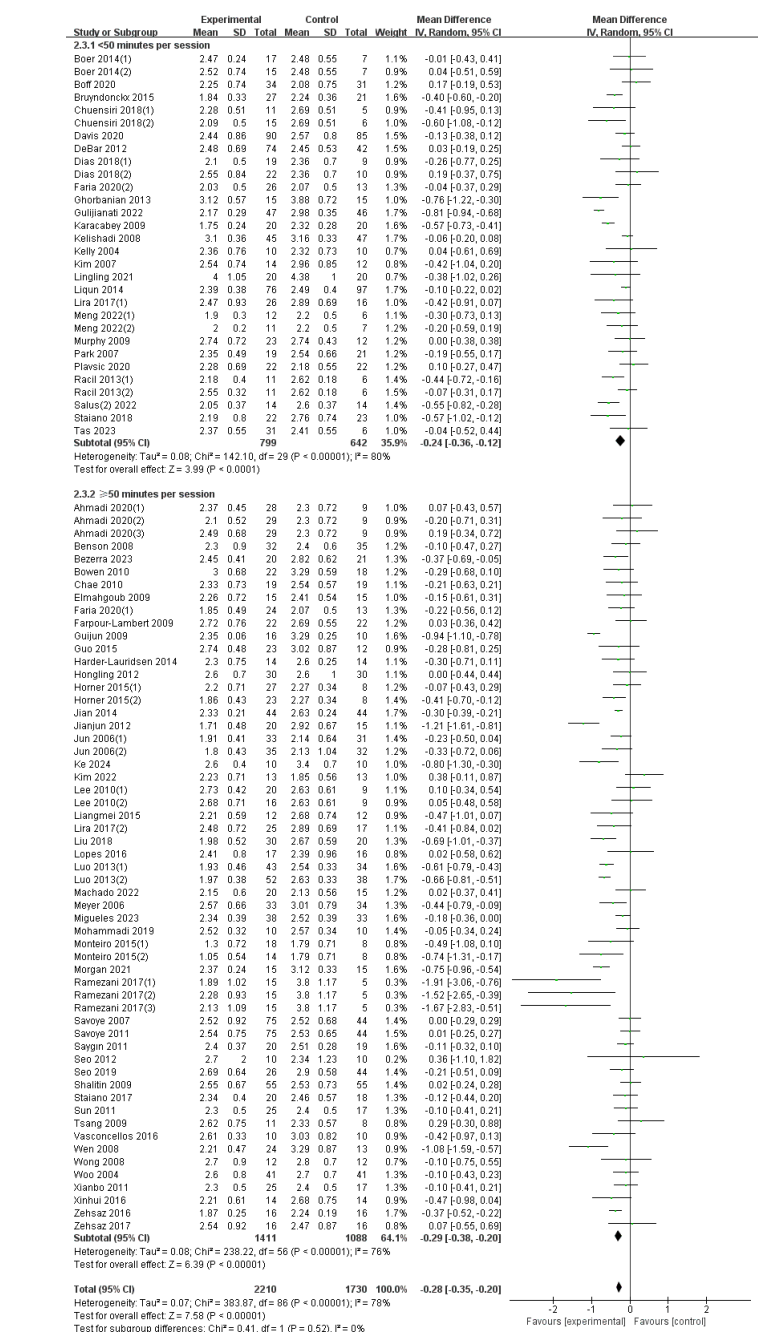


Figure S14.4. Forest plot of subgroup analyses by exercise frequency

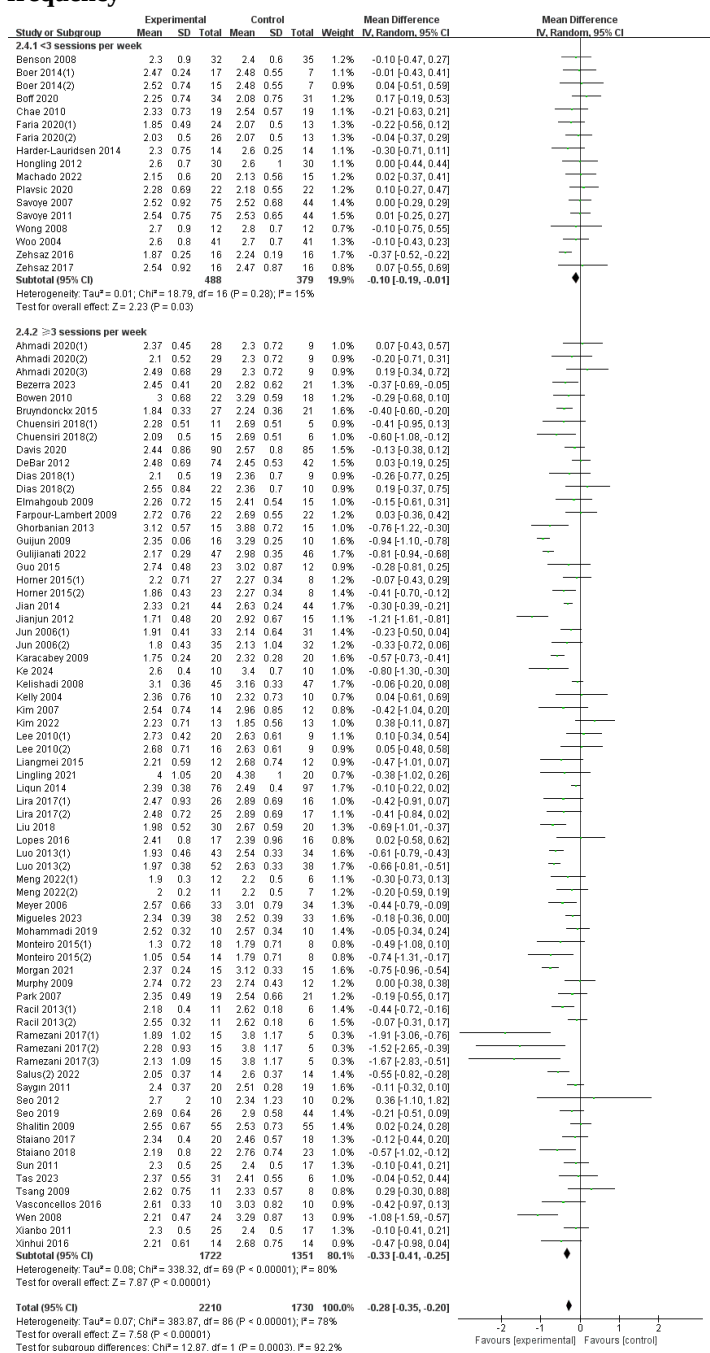


Figure S14.5. Forest plot of subgroup analyses by weekly exercise duration

Figure S14.6. Forest plot of subgroup analyses by intervention duration

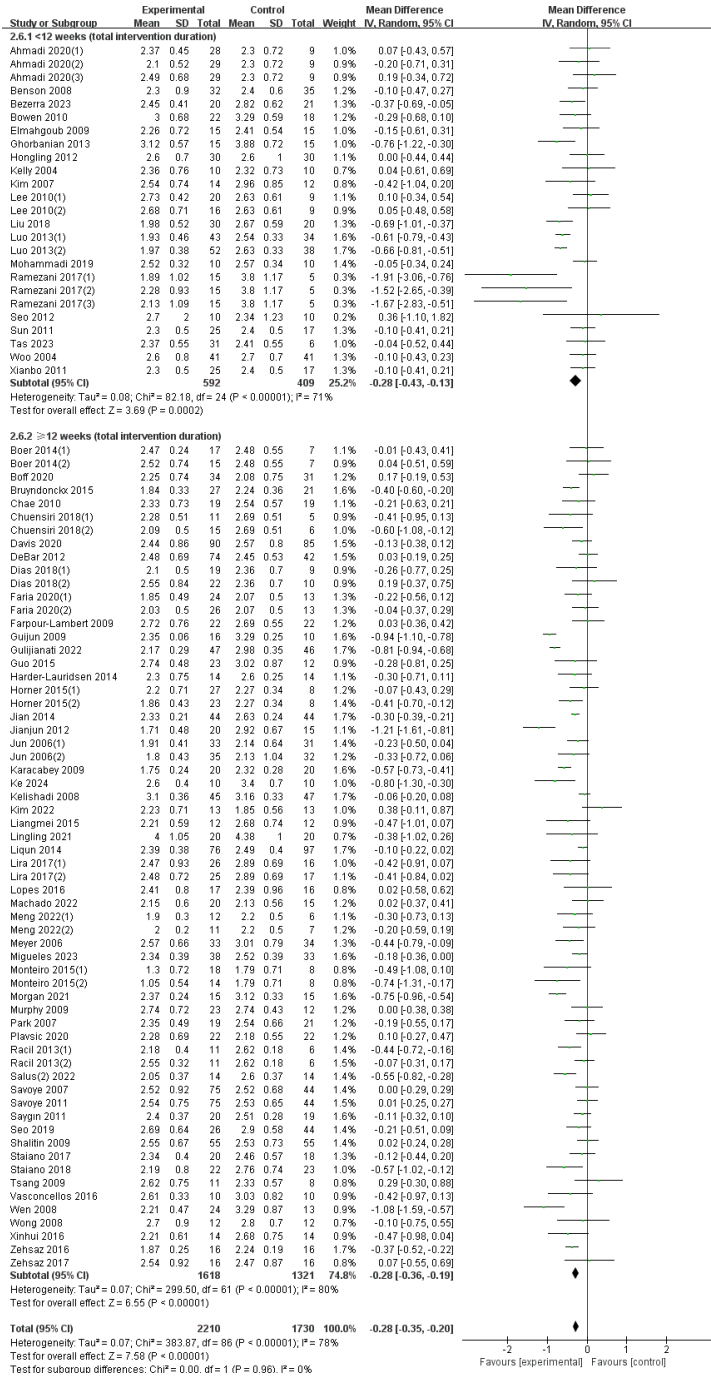
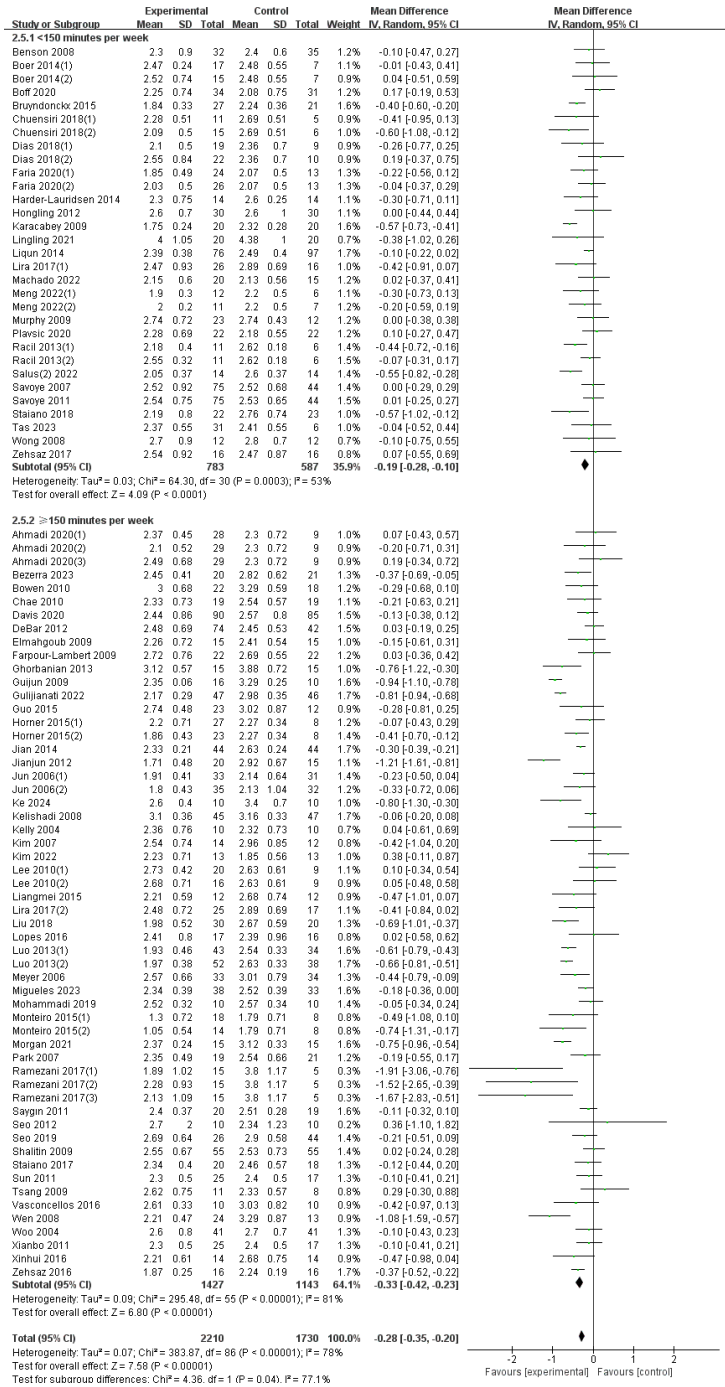


Figure S14.7. Forest plot of subgroup analyses by region

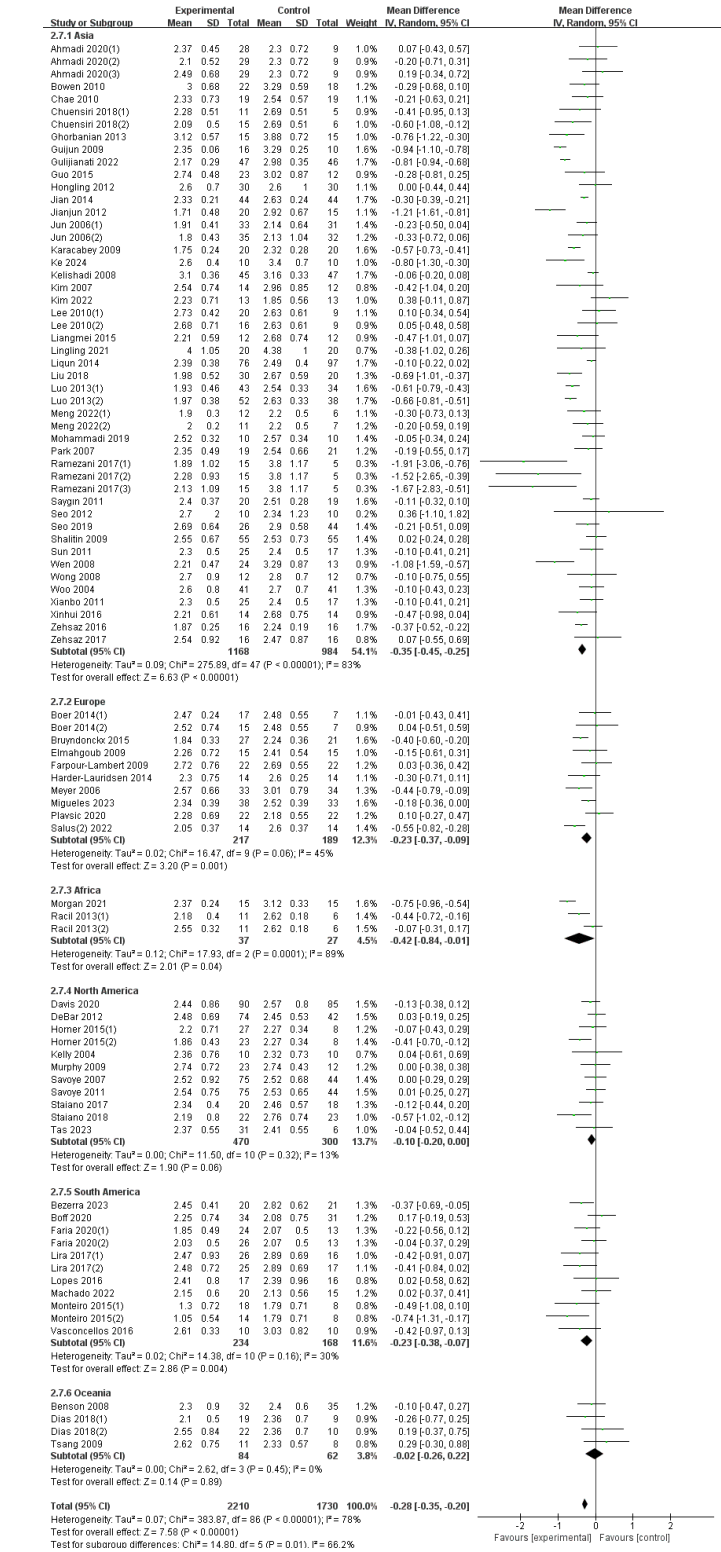


Figure S14.8. Forest plot of subgroup analyses by economic status

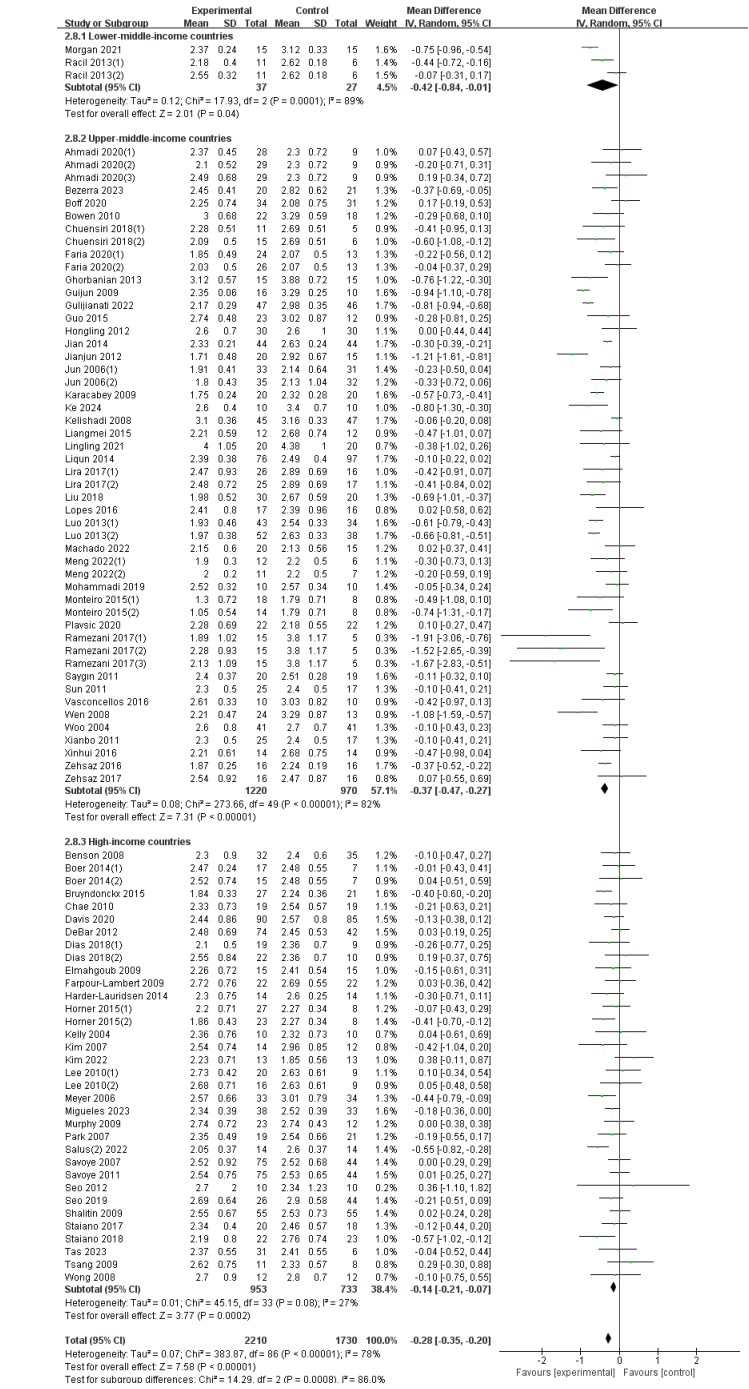


Figure S14.9. Forest plot of subgroup analyses by weight status

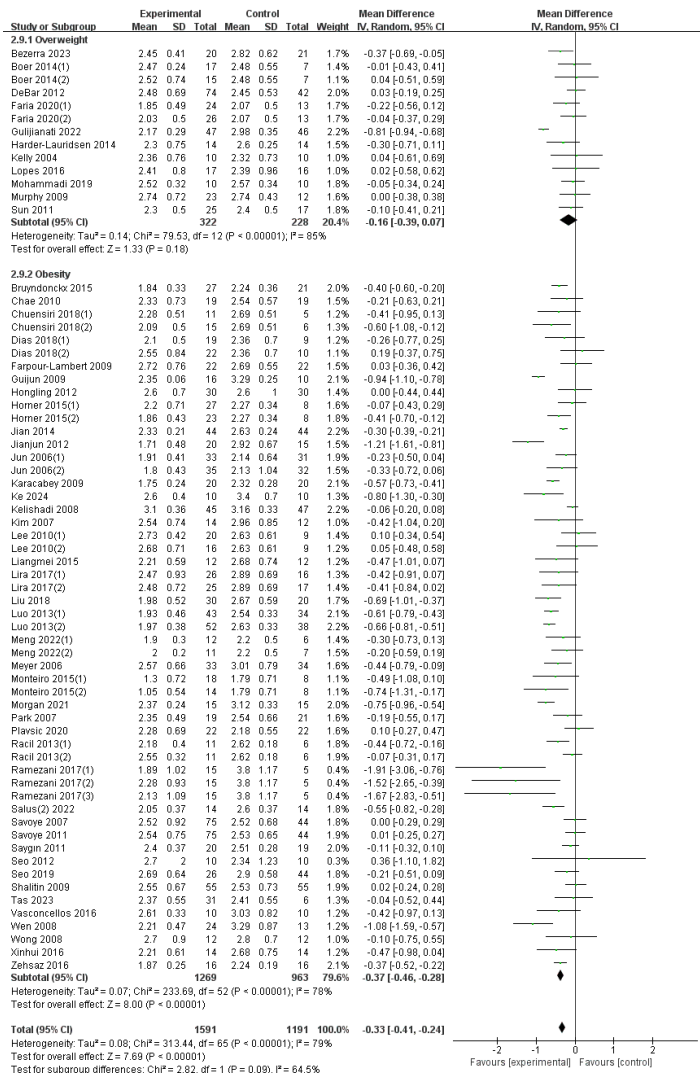


Figure S14.10. Forest plot of subgroup analyses by sex

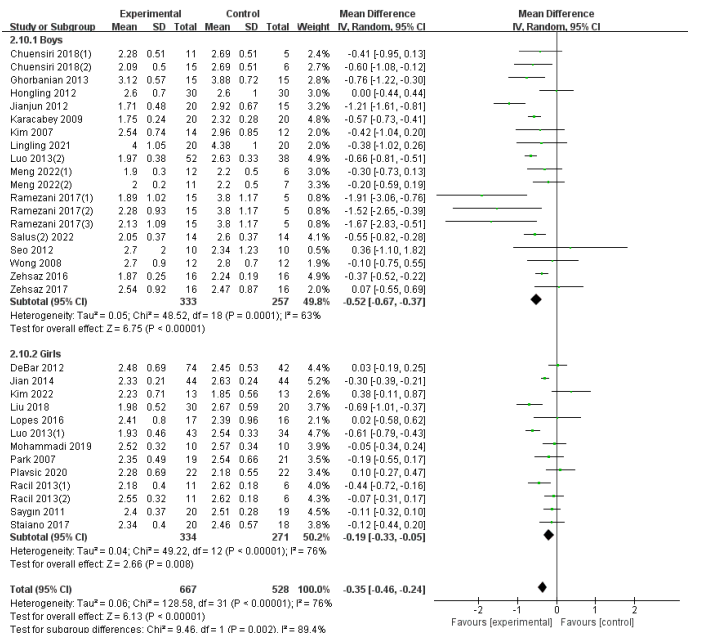


Figure S14.11. Forest plot of subgroup analyses by metabolic status

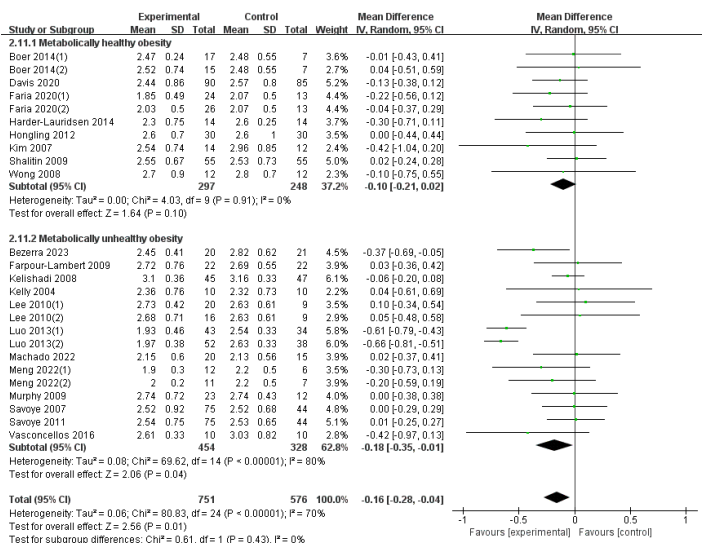


Figure S15. Forest plots of subgroup analyses for FPG in children and adolescents with overweight or obesity

Figure S15.1. Forest plot of subgroup analyses by type of exercise

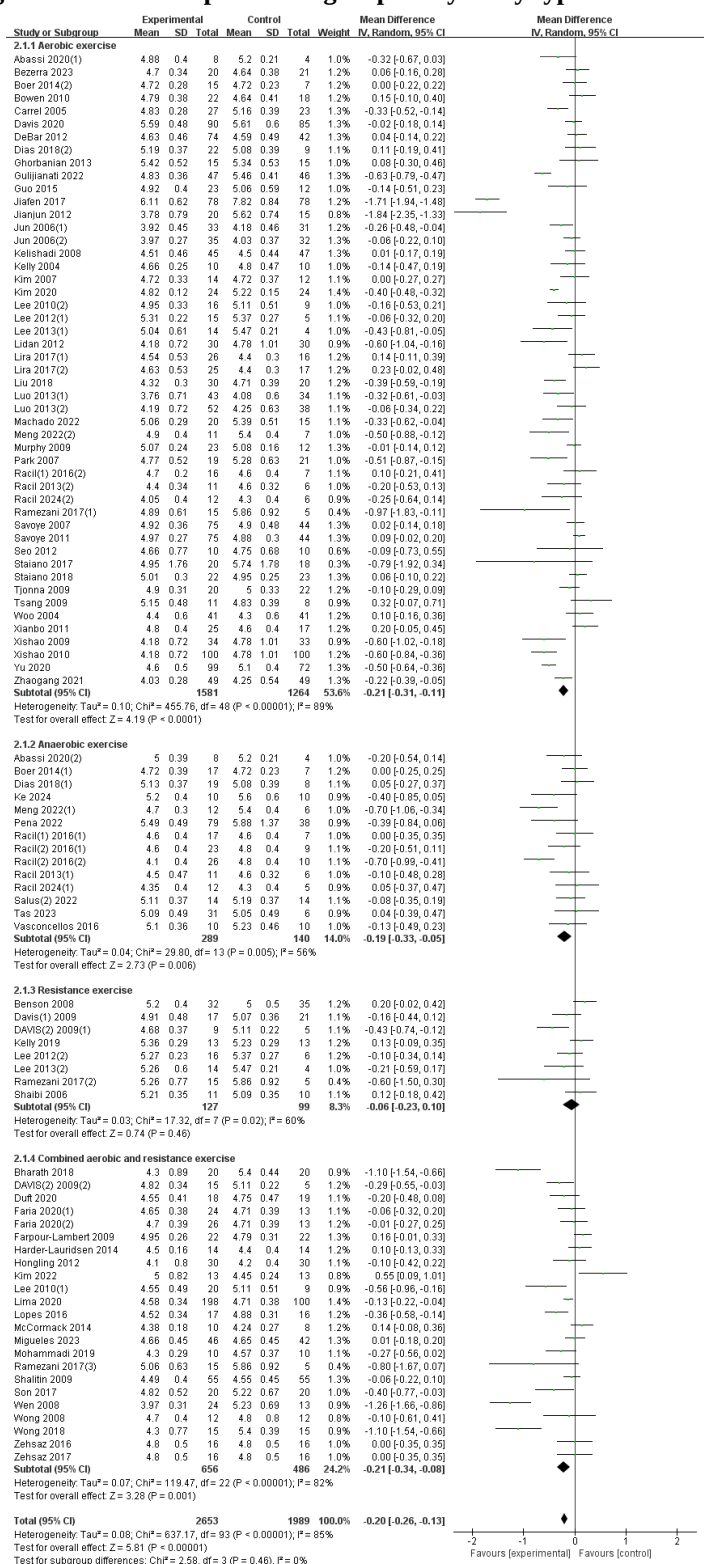


Figure S15.2. Forest plot of subgroup analyses by exercise intensity

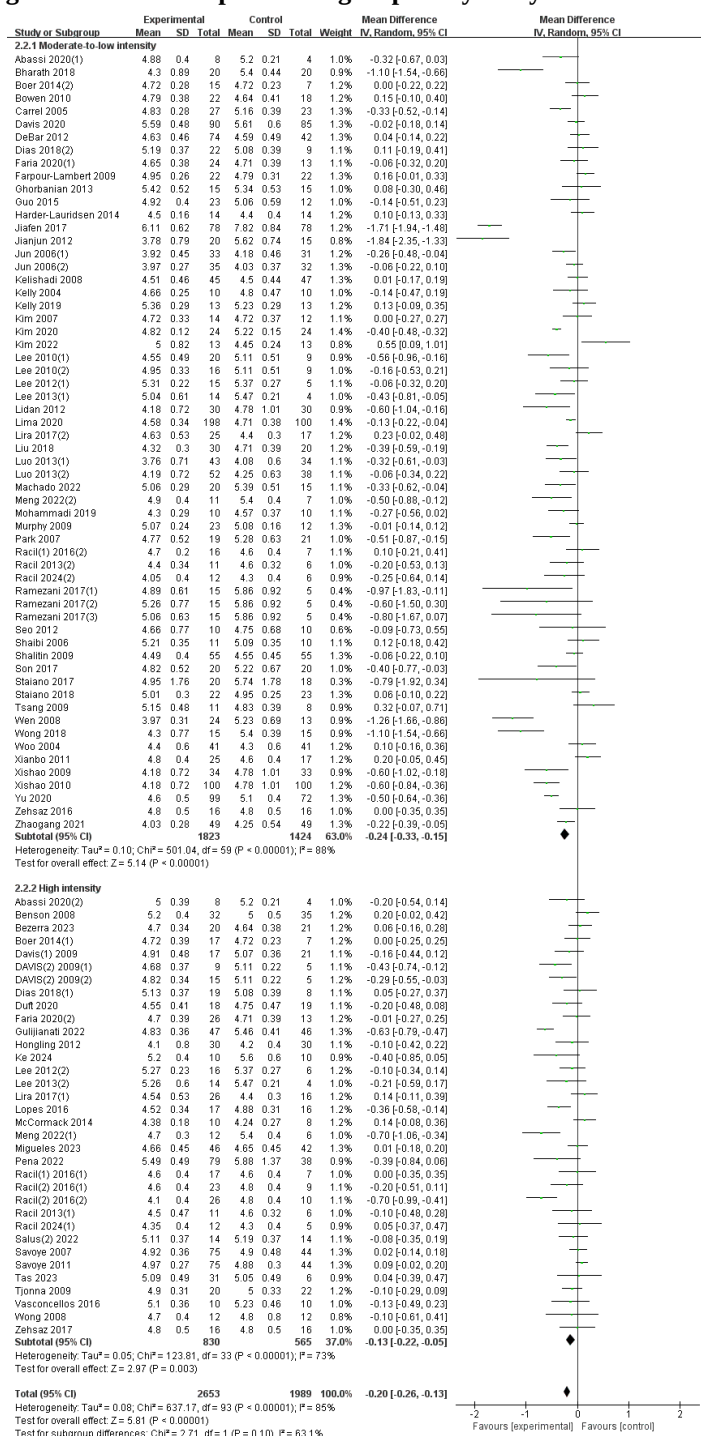


Figure S15.3. Forest plot of subgroup analyses by duration per session

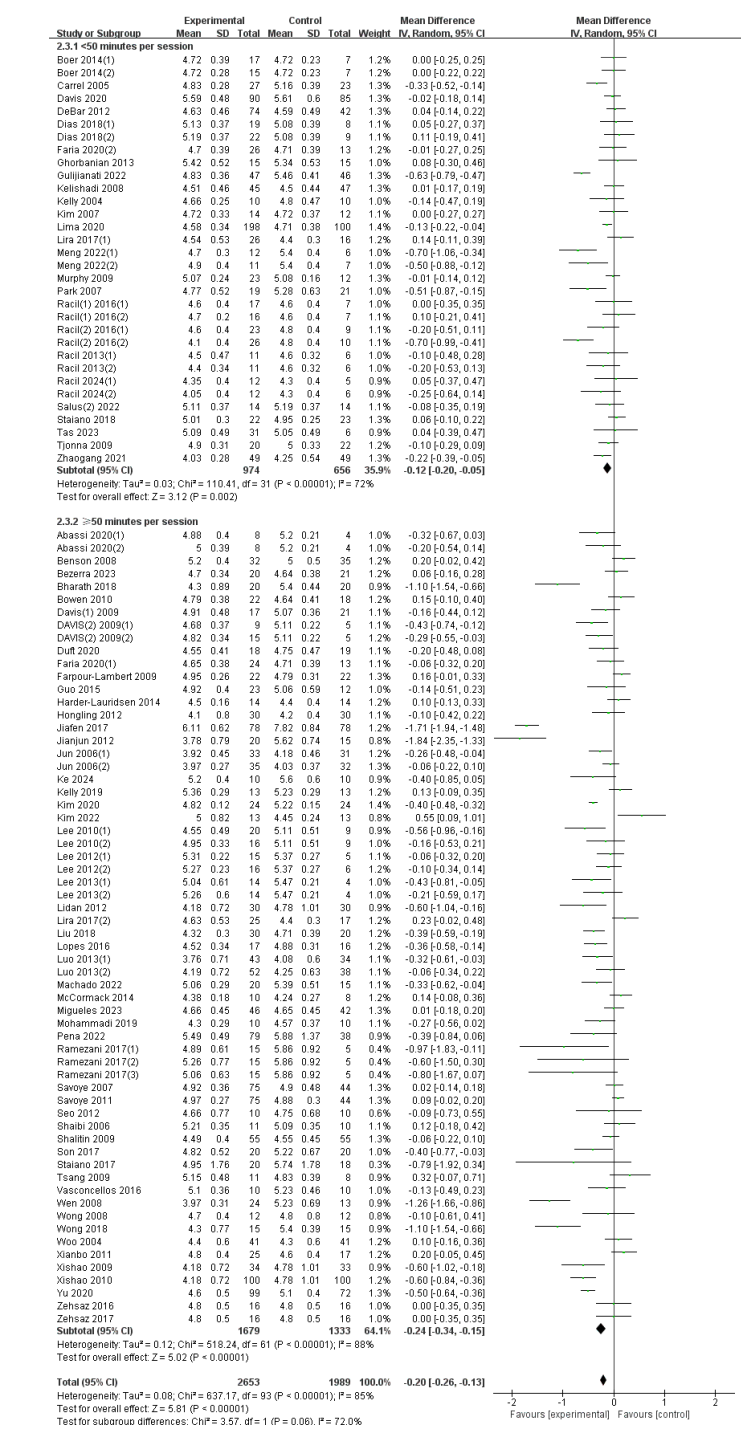


Figure S15.4. Forest plot of subgroup analyses by exercise frequency

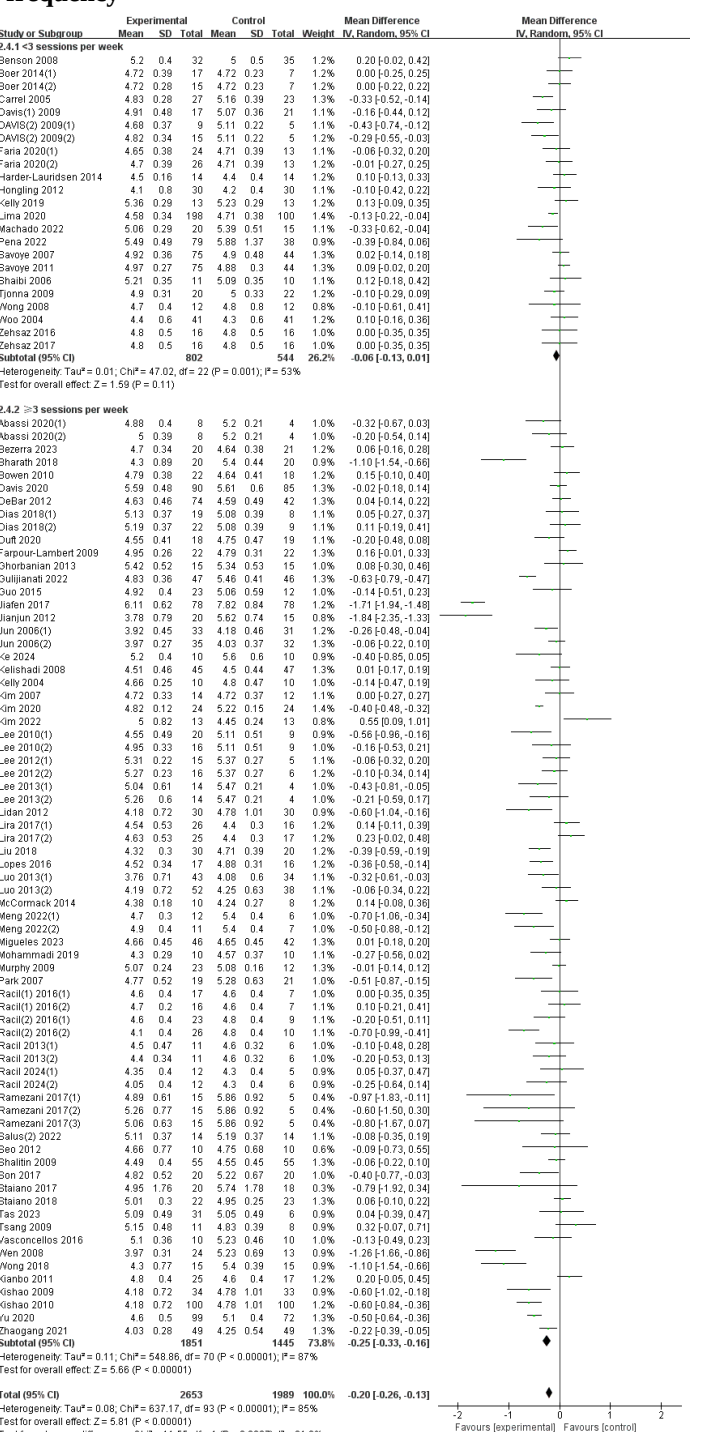


Figure S15.5. Forest plot of subgroup analyses by weekly exercise duration

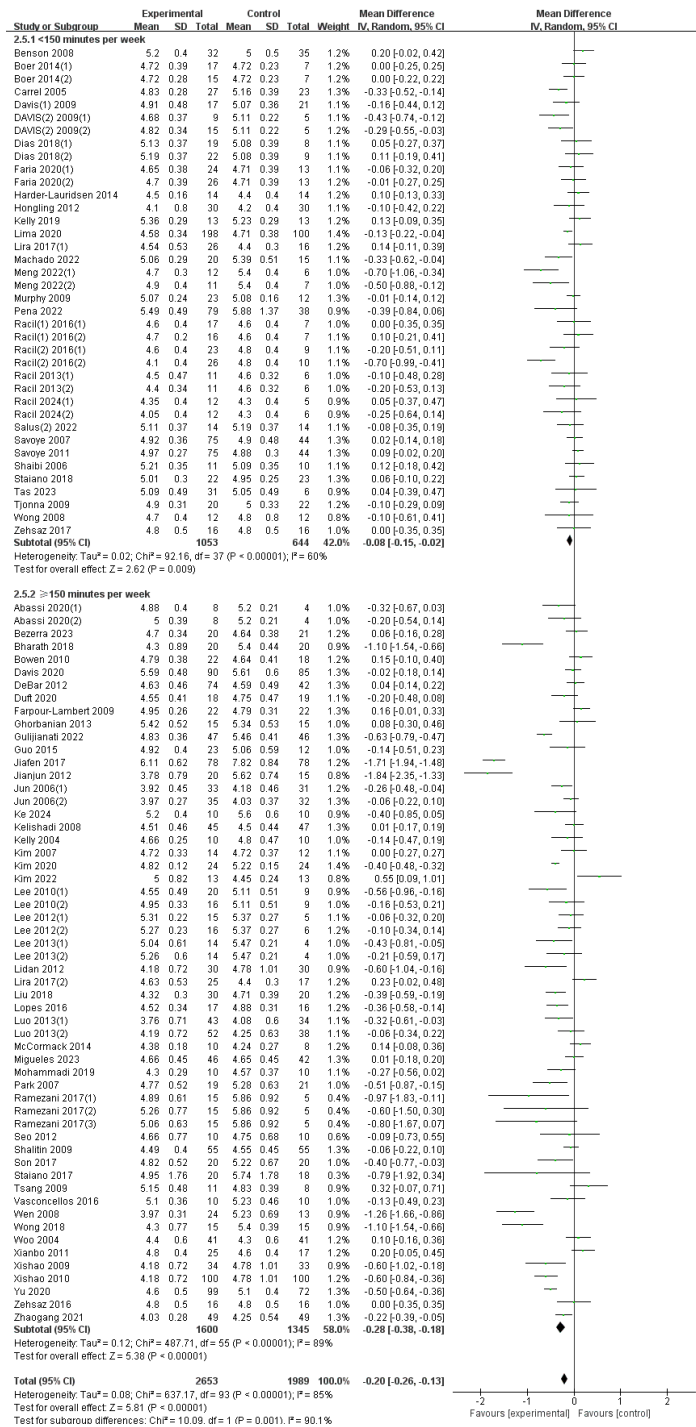


Figure S15.6. Forest plot of subgroup analyses by

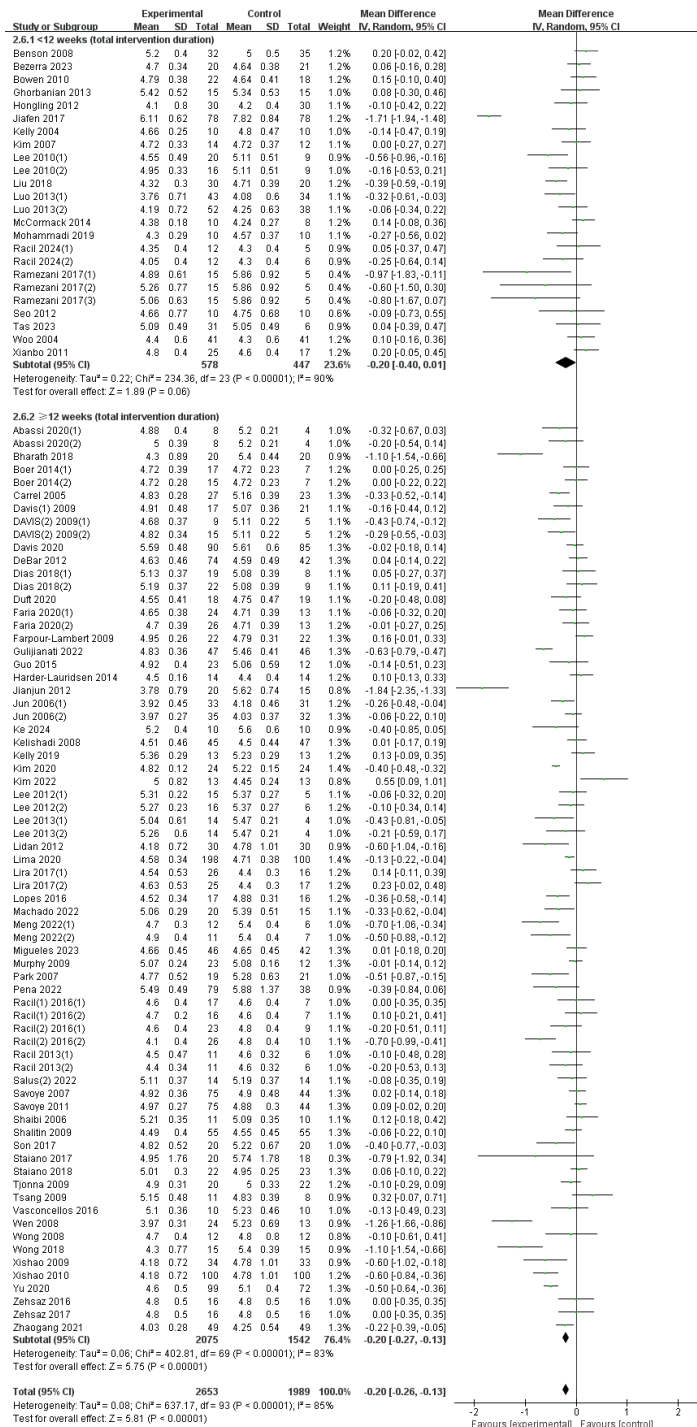


Figure S15.7. Forest plot of subgroup analyses by region

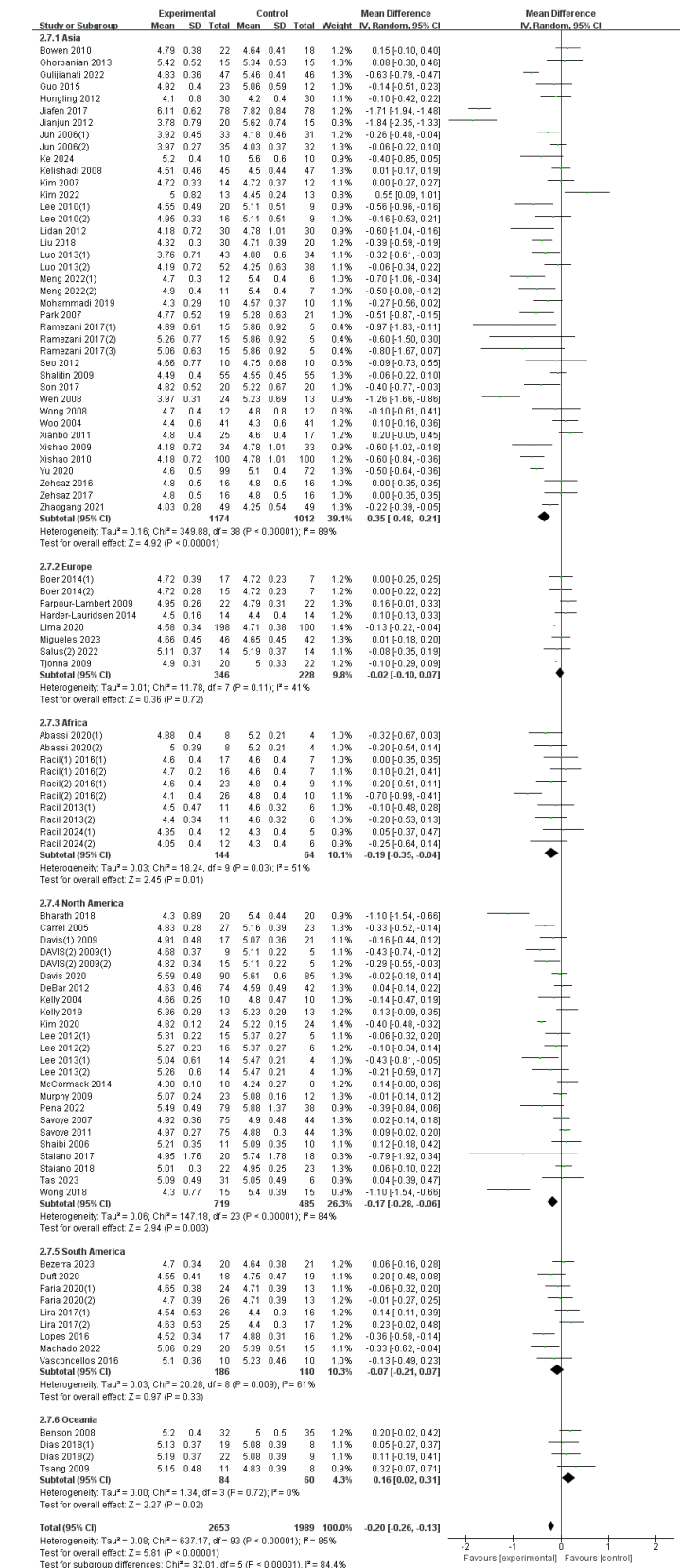


Figure S15.8. Forest plot of subgroup analyses by economic status

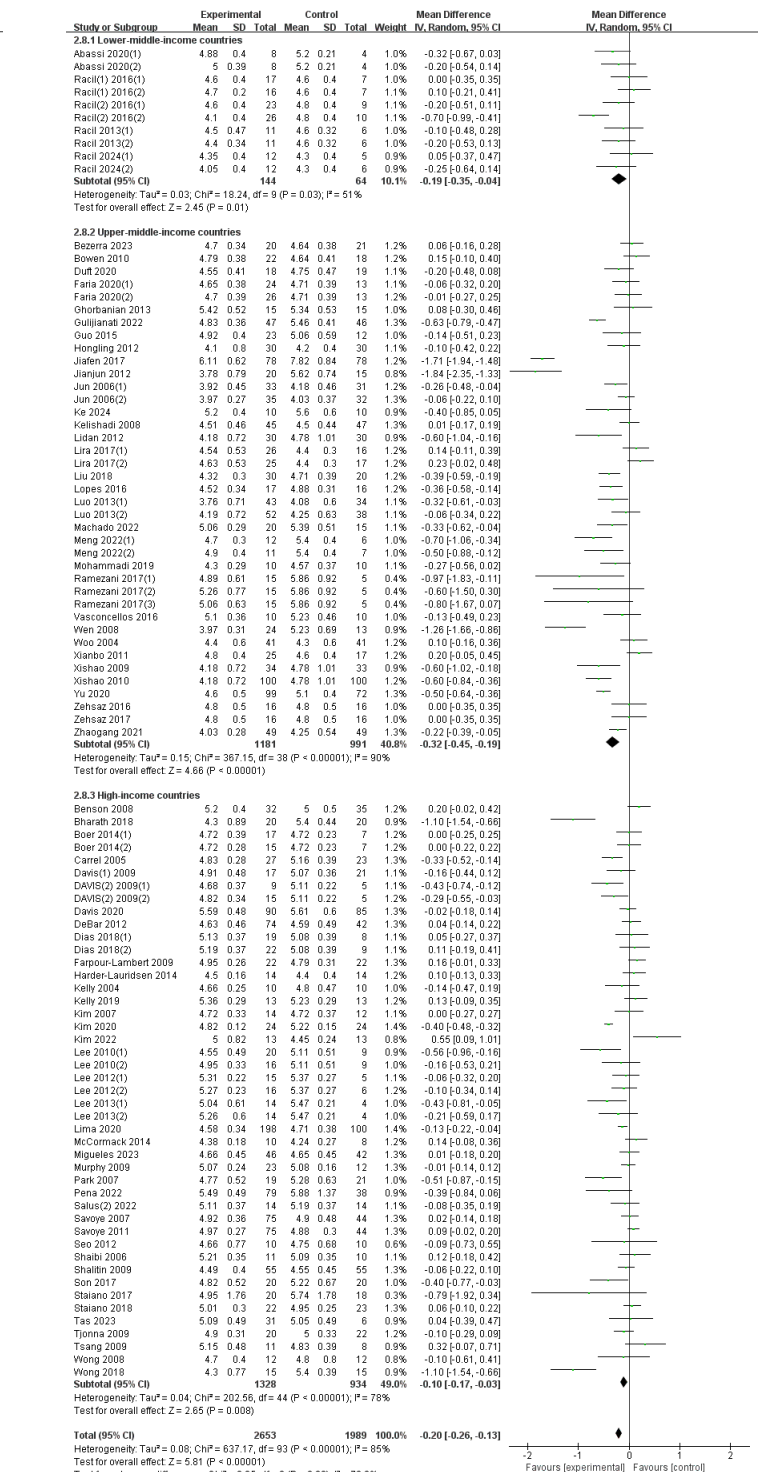


Figure S15.9. Forest plot of subgroup analyses by weight status

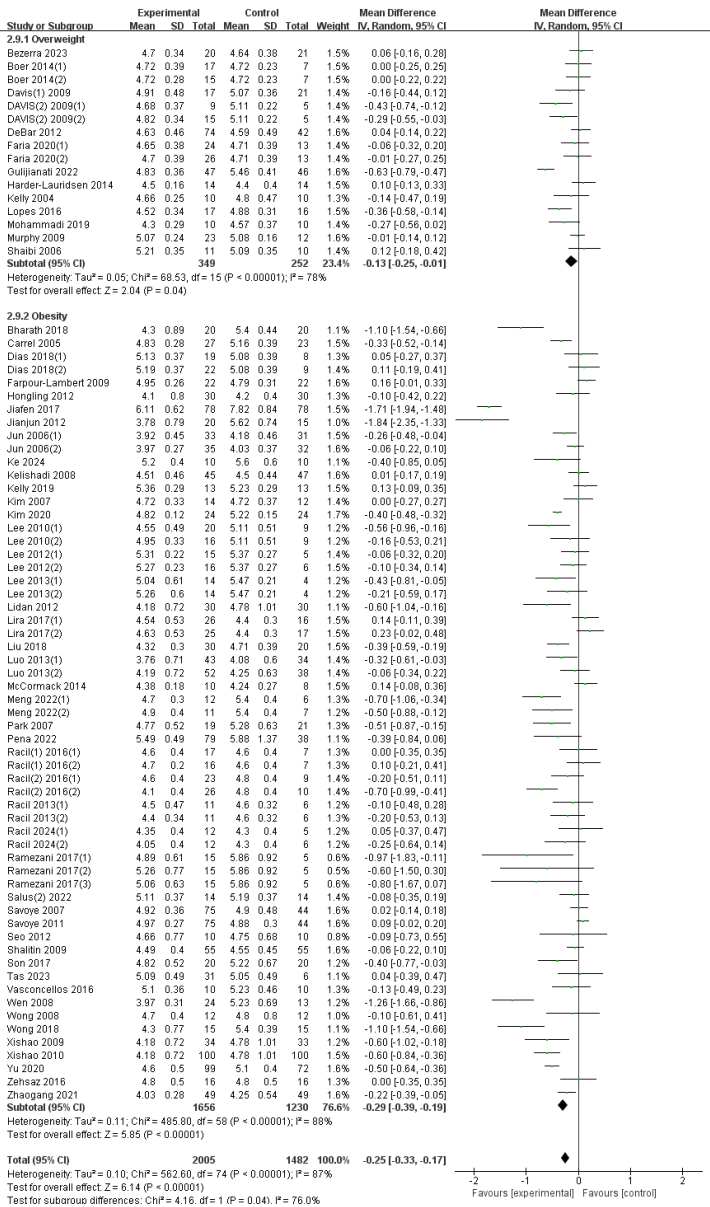


Figure S15.10. Forest plot of subgroup analyses by sex

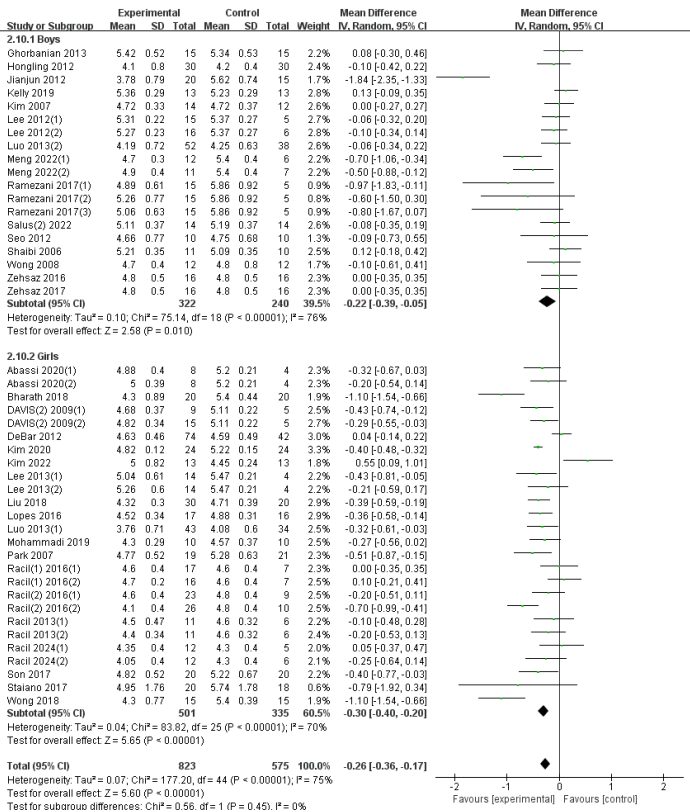


Figure S16. Forest plots of subgroup analyses for HbA1c in children and adolescents with overweight or obesity

Figure S16.1. Forest plot of subgroup analyses by type of exercise

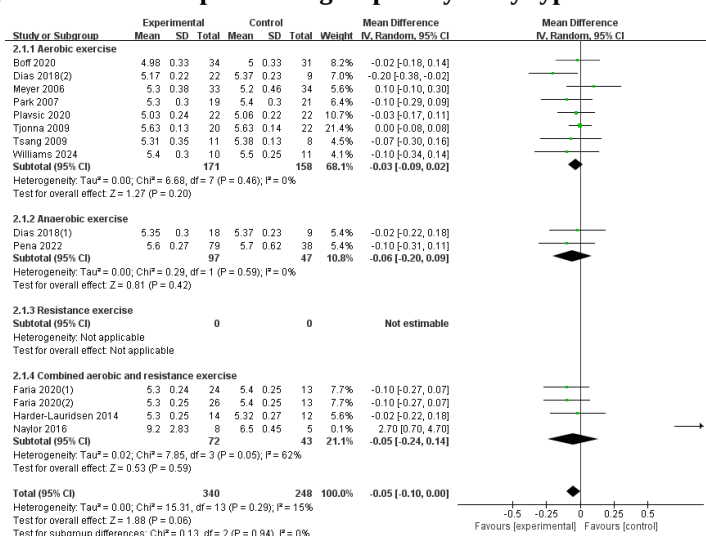


Figure S16.2. Forest plot of subgroup analyses by exercise intensity

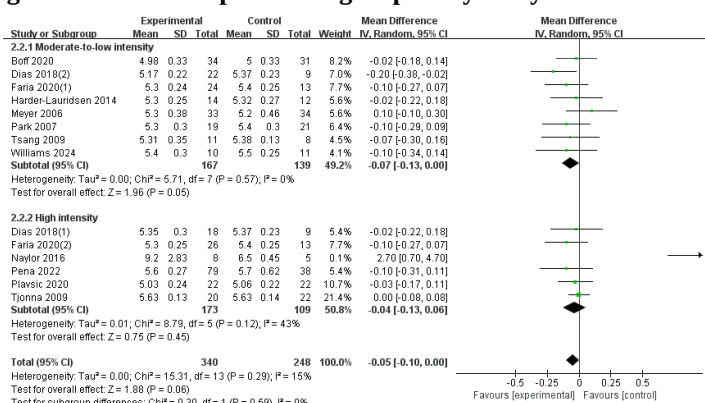


Figure S16.3. Forest plot of subgroup analyses by duration per session

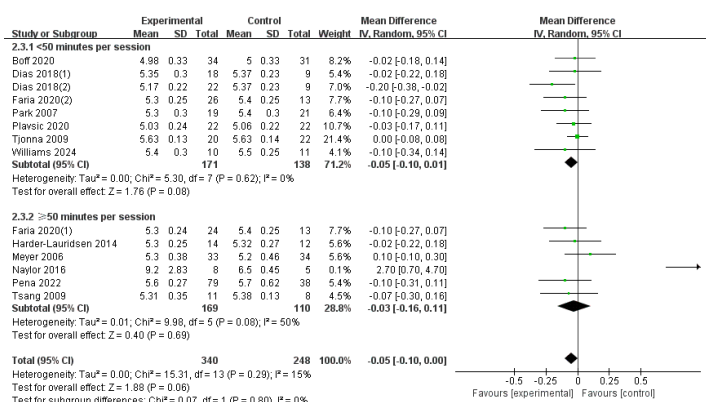


Figure S16.4. Forest plot of subgroup analyses by exercise frequency

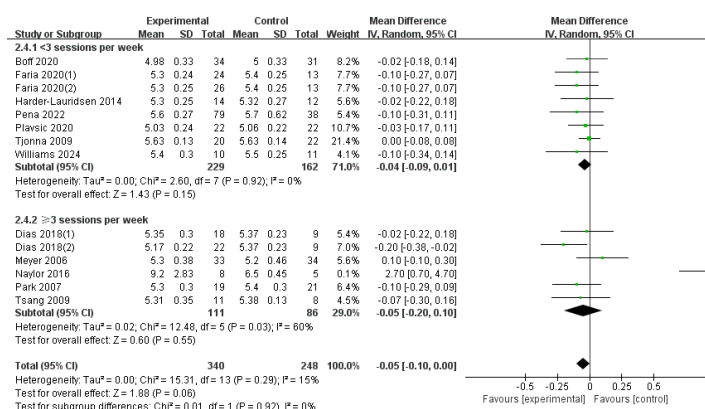


Figure S16.5. Forest plot of subgroup analyses by weekly exercise duration

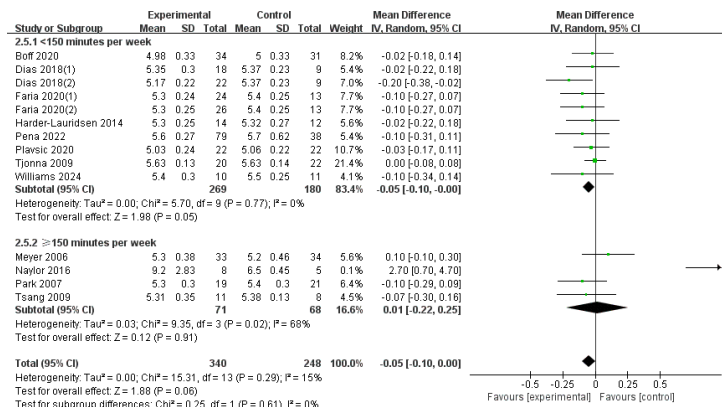


Figure S16.7. Forest plot of subgroup analyses by region

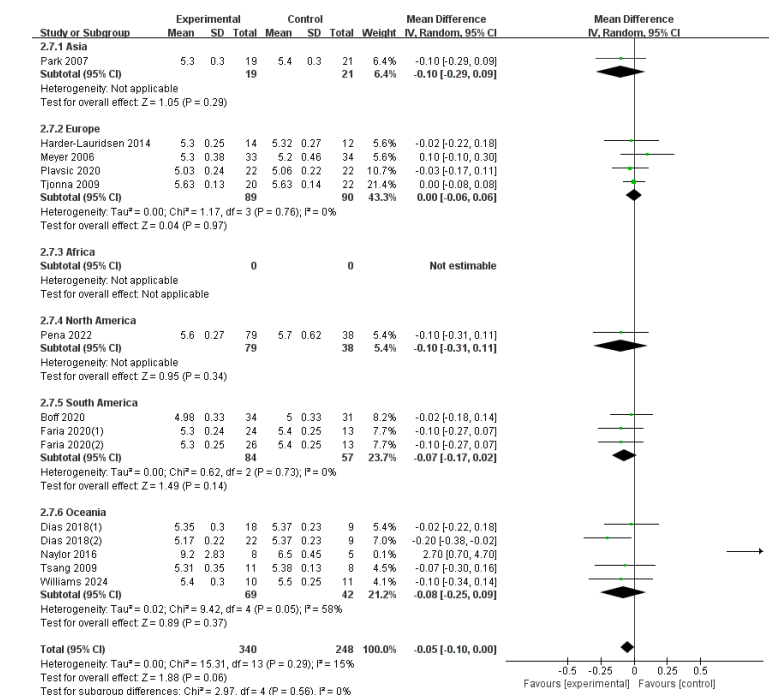


Figure S16.8. Forest plot of subgroup analyses by economic status

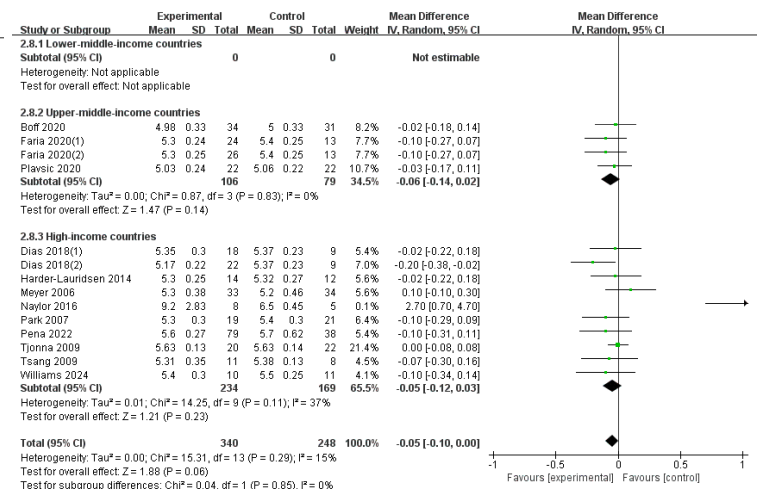


Figure S16.9. Forest plot of subgroup analyses by weight status

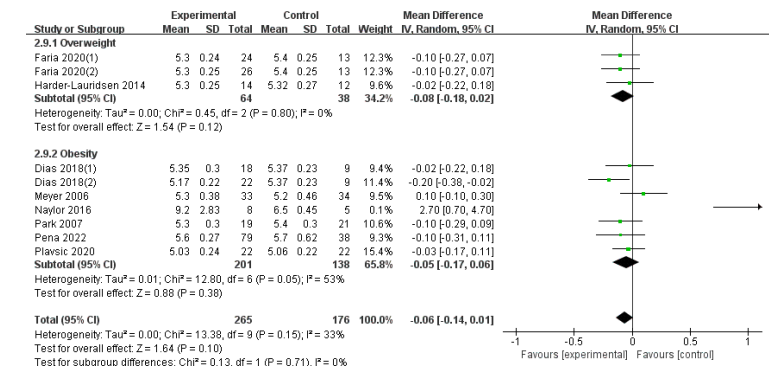


Figure S16.10. Forest plot of subgroup analyses by sex

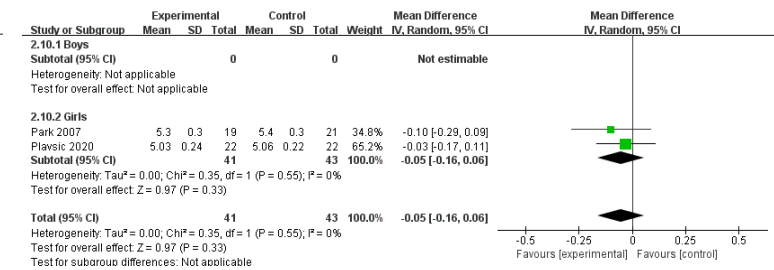


Figure S17. Forest plots of subgroup analyses for FINS in children and adolescents with overweight or obesity

Figure S17.1. Forest plot of subgroup analyses by type of exercise

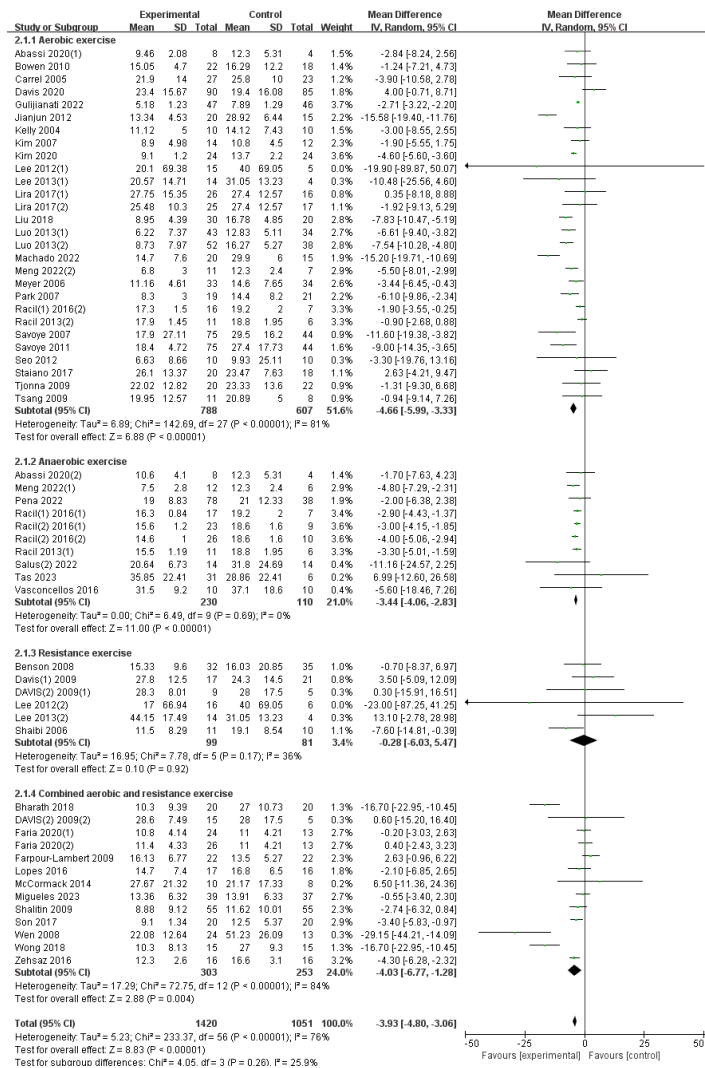


Figure S17.2. Forest plot of subgroup analyses by exercise intensity

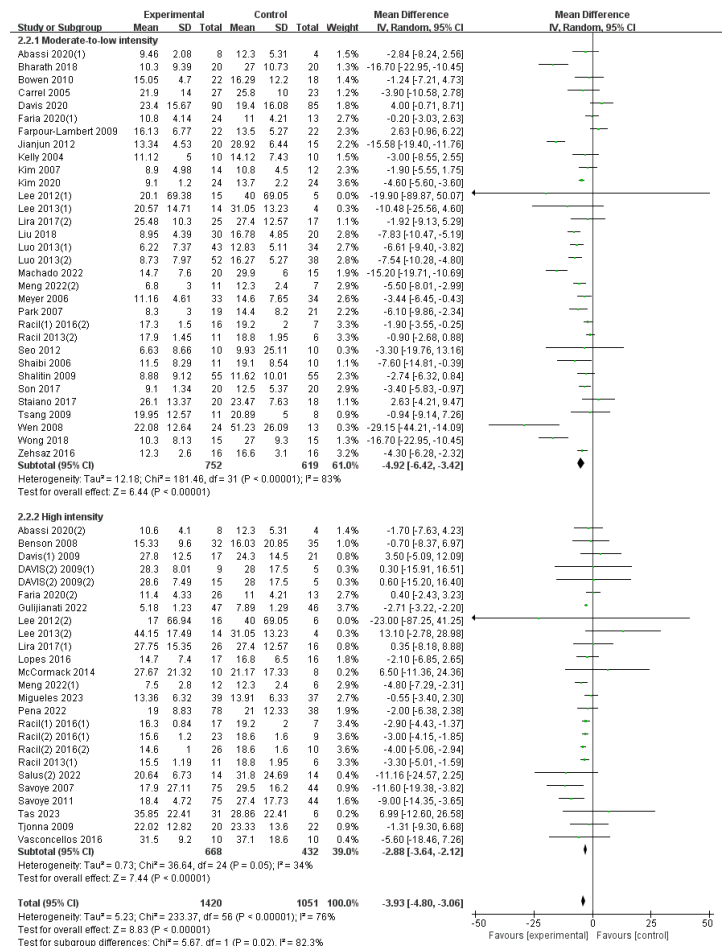


Figure S17.3. Forest plot of subgroup analyses by duration per session

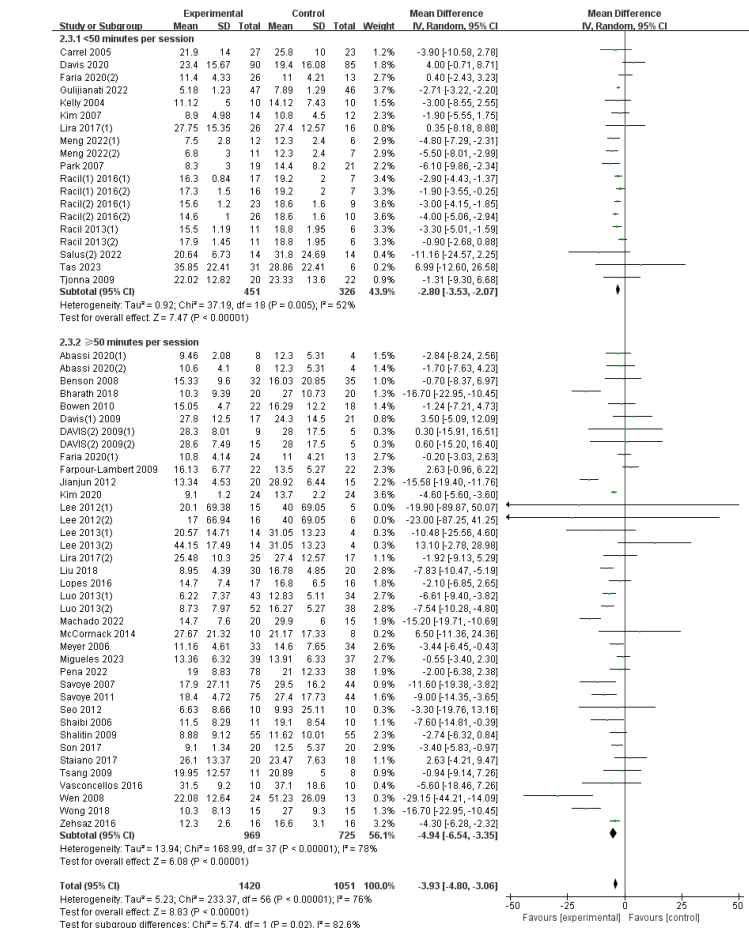


Figure S17.4. Forest plot of subgroup analyses by exercise frequency

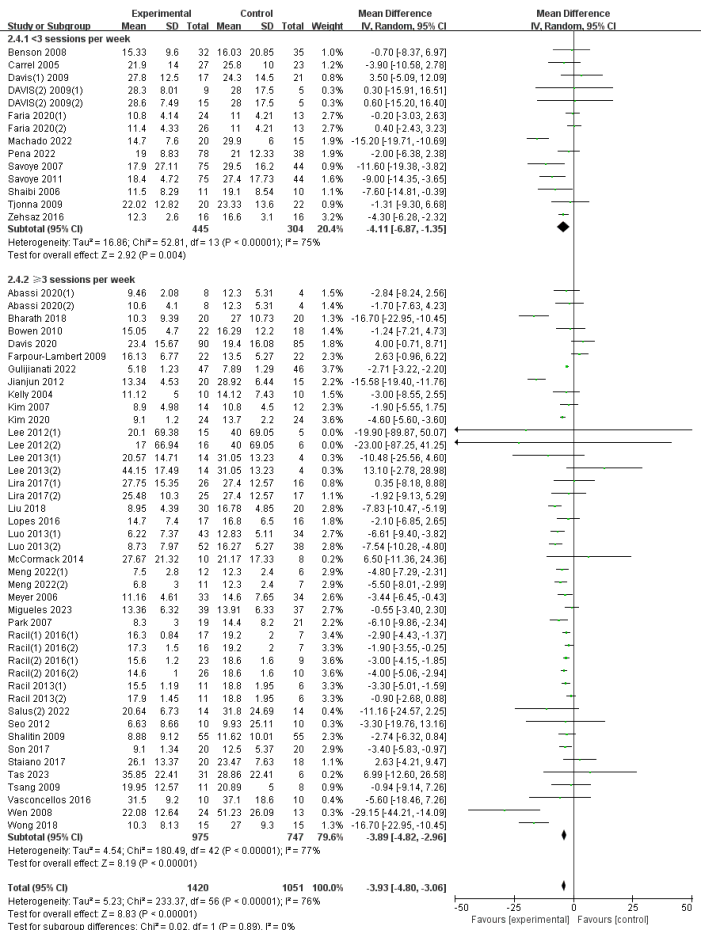


Figure S17.5. Forest plot of subgroup analyses by weekly exercise duration

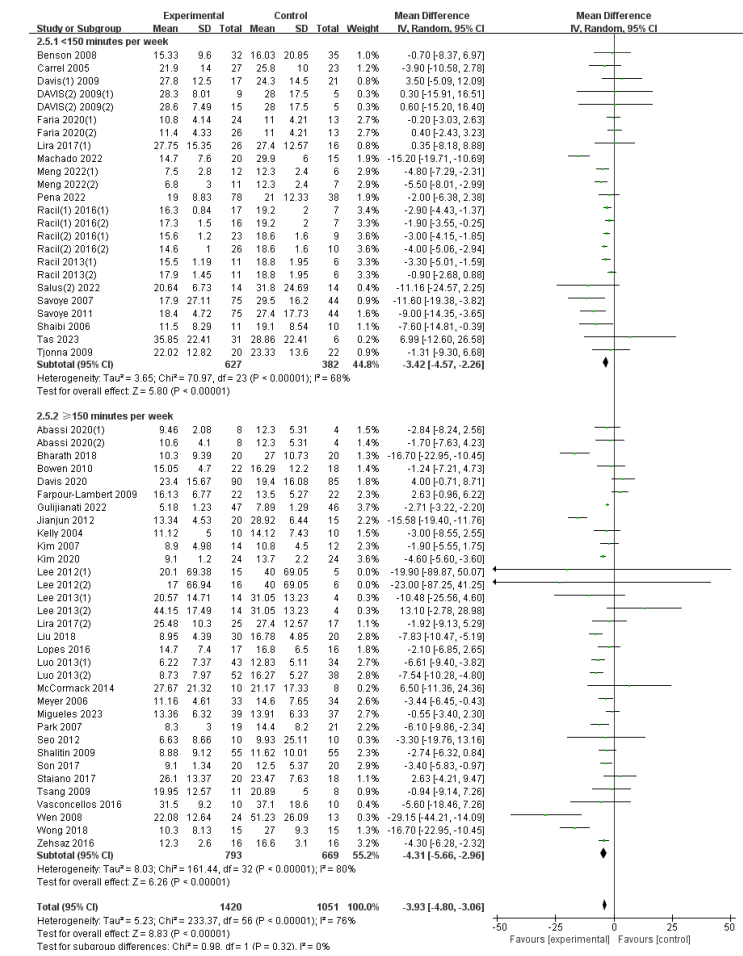


Figure S17.6. Forest plot of subgroup analyses by intervention duration

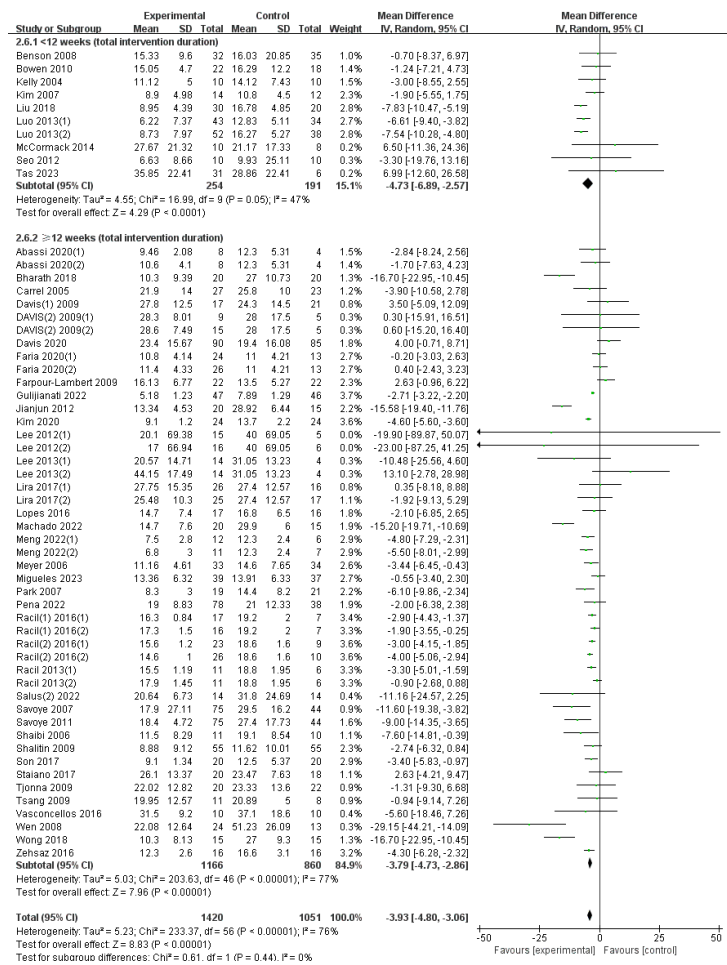


Figure S17.7. Forest plot of subgroup analyses by region

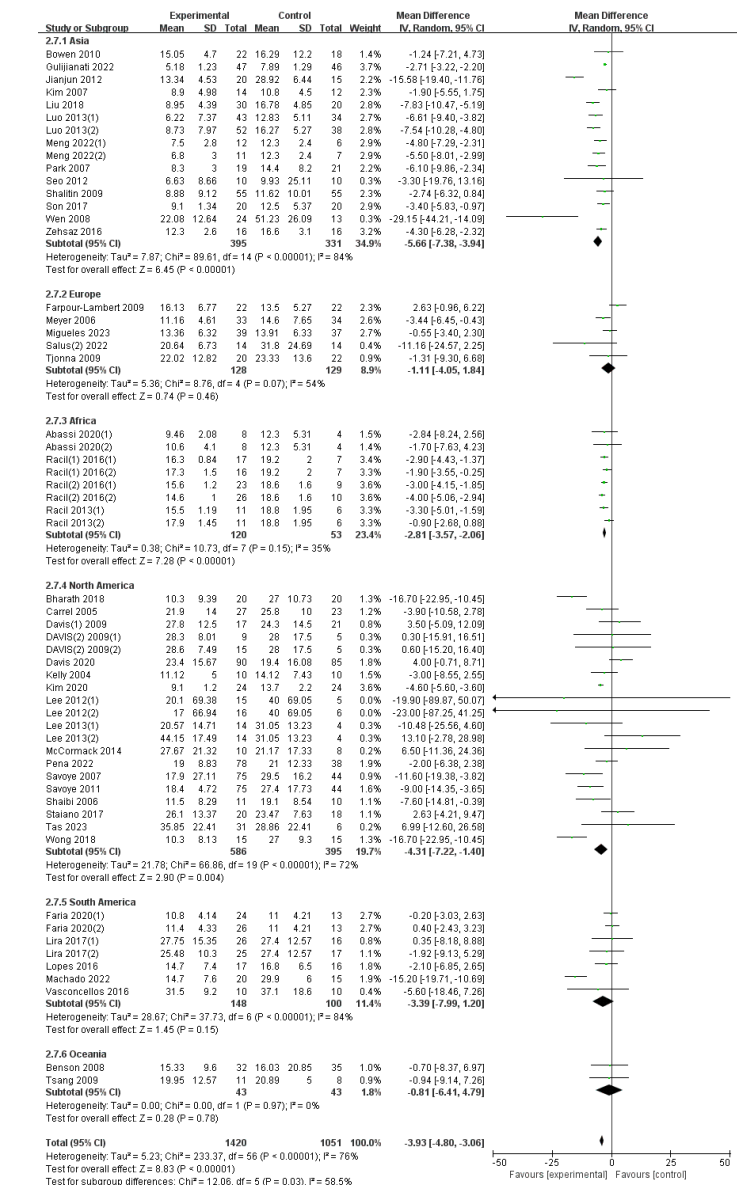


Figure S17.8. Forest plot of subgroup analyses by economic status

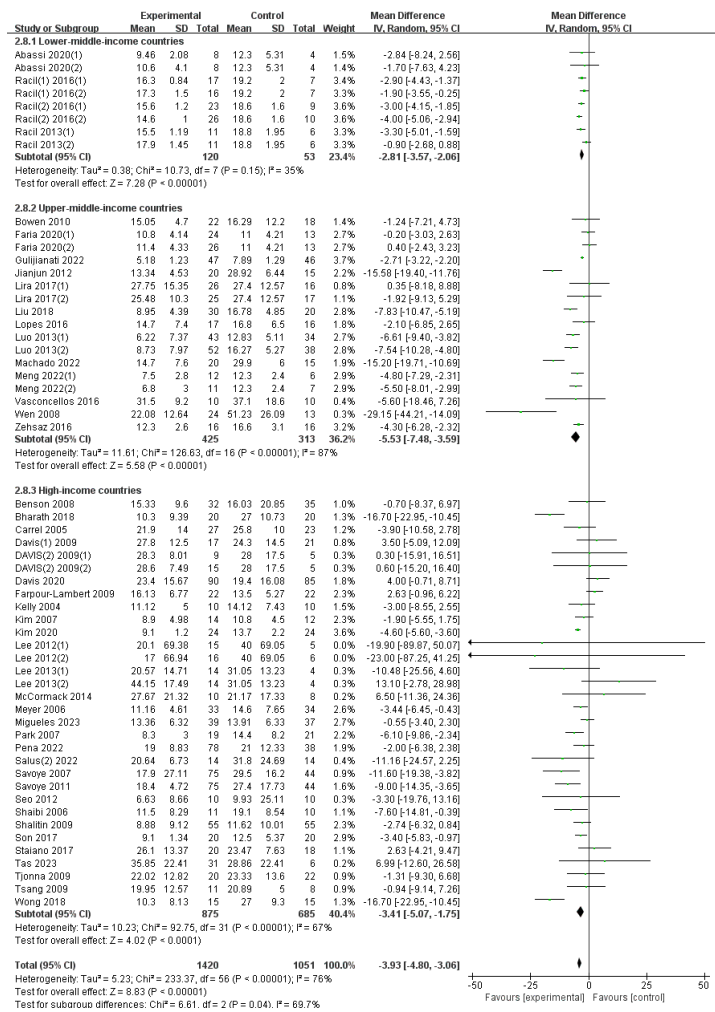


Figure S17.9. Forest plot of subgroup analyses by weight status

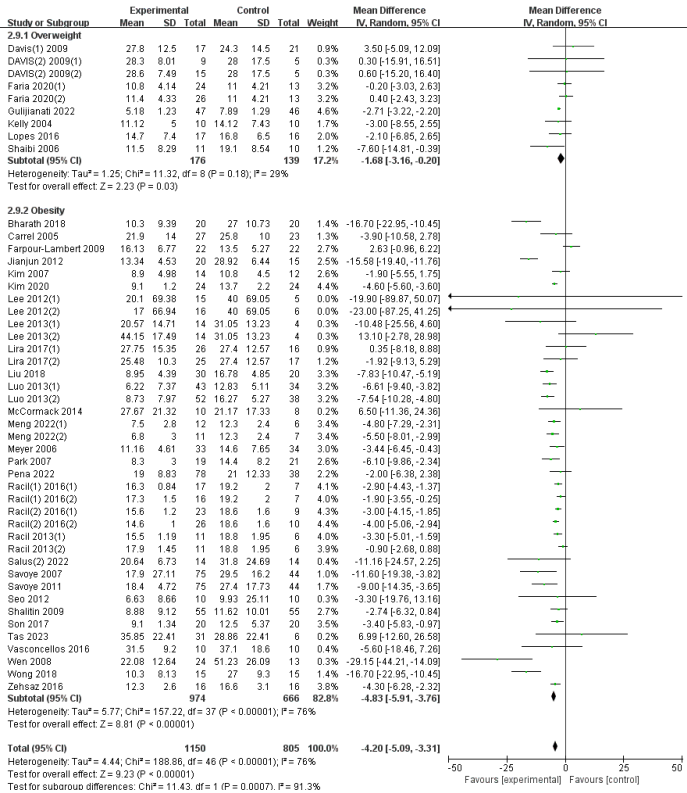


Figure S17.10. Forest plot of subgroup analyses by sex

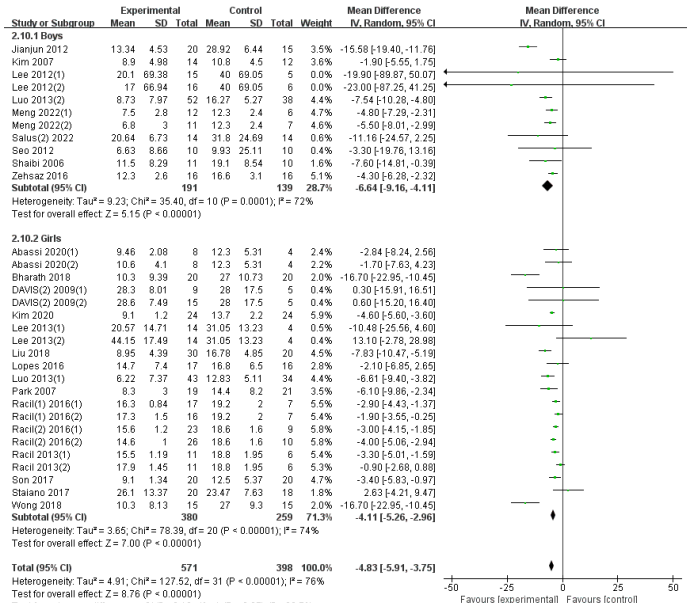


Figure S17.11. Forest plot of subgroup analyses by metabolic status

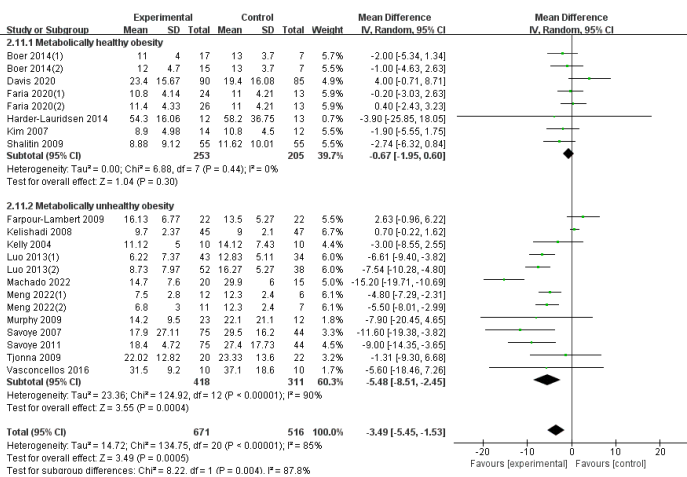


Figure S18. Forest plots of subgroup analyses for Depression in children and adolescents with overweight or obesity
Figure S18.1. Forest plot of subgroup analyses by type of exercise **Figure S18.2. Forest plot of subgroup analyses by exercise intensity**

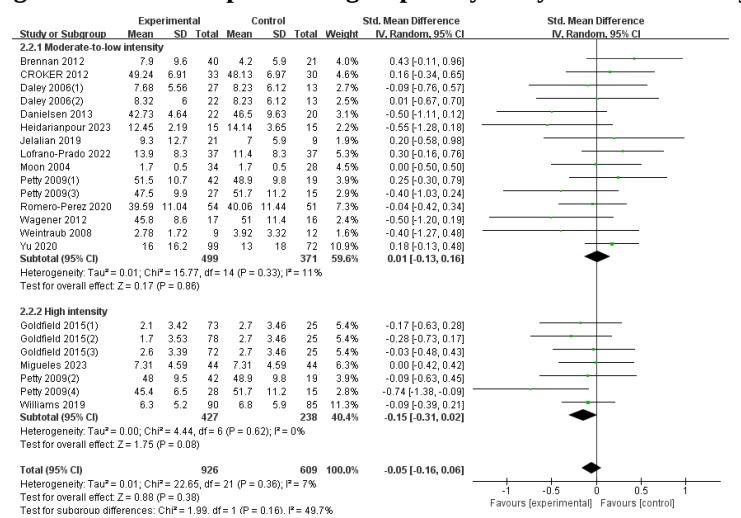
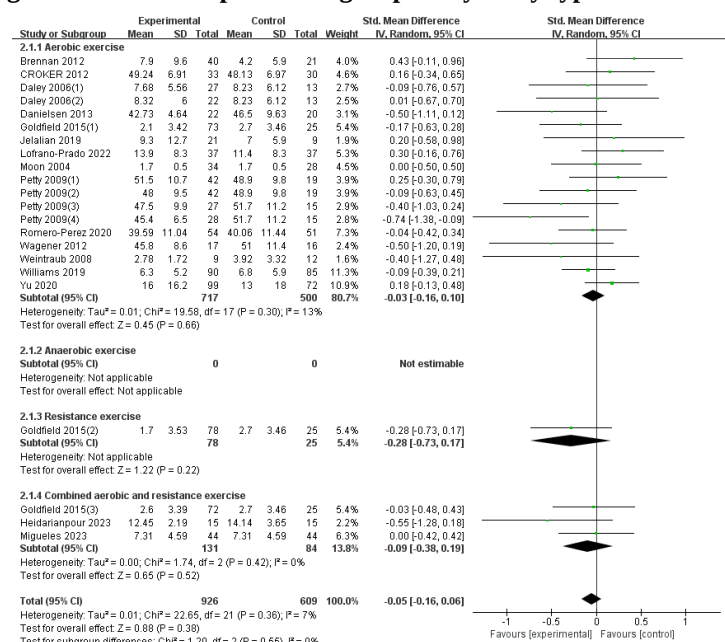


Figure S18.3. Forest plot of subgroup analyses by duration per session

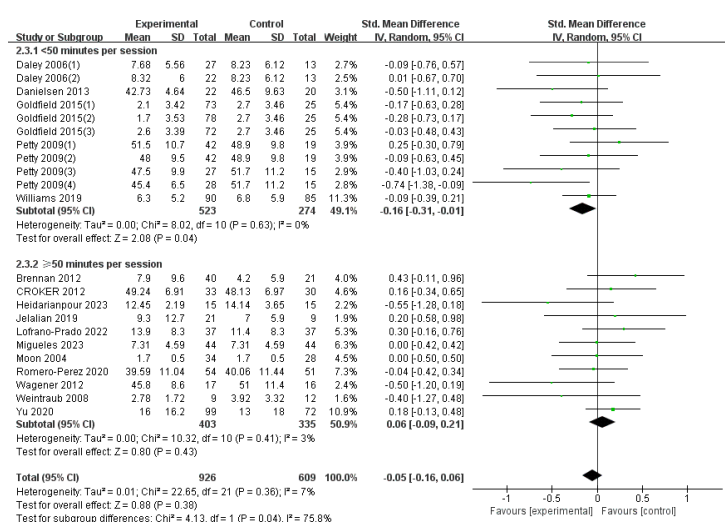


Figure S18.4. Forest plot of subgroup analyses by exercise frequency

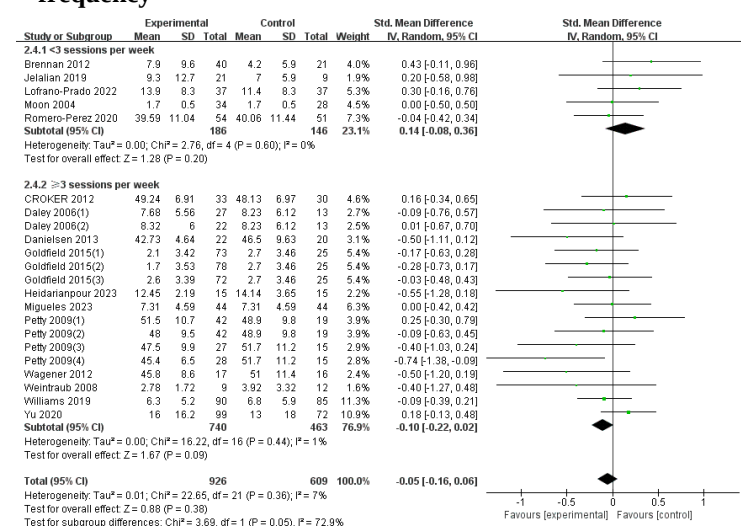


Figure S18.5. Forest plot of subgroup analyses by weekly exercise duration

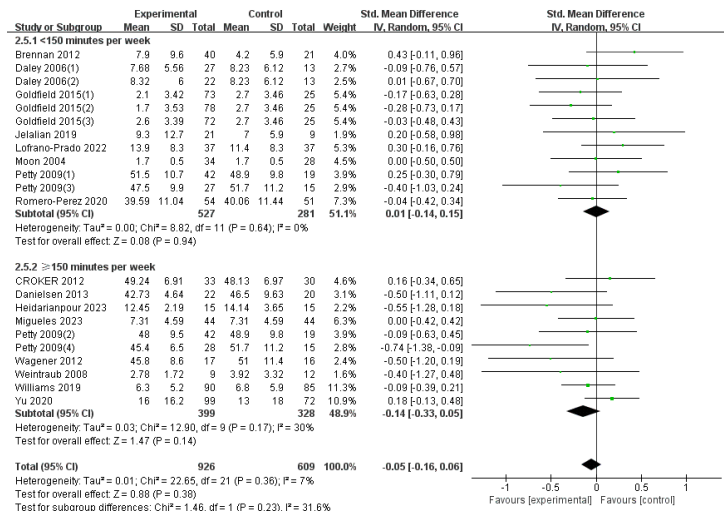


Figure S18.6. Forest plot of subgroup analyses by

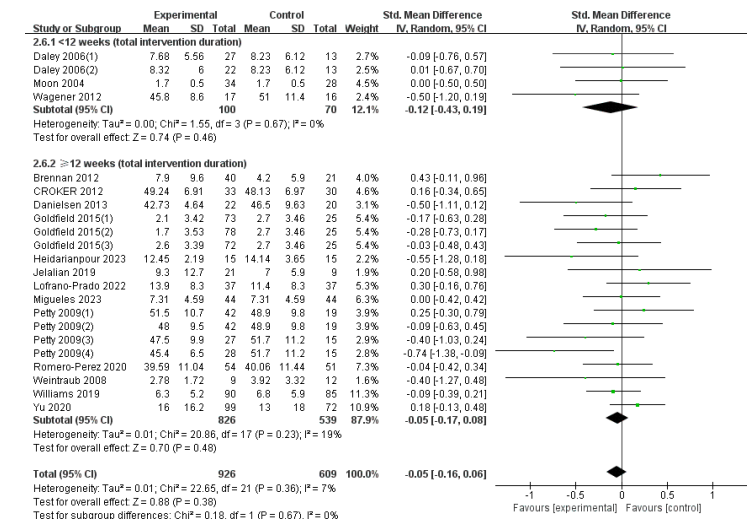


Figure S18.7. Forest plot of subgroup analyses by region

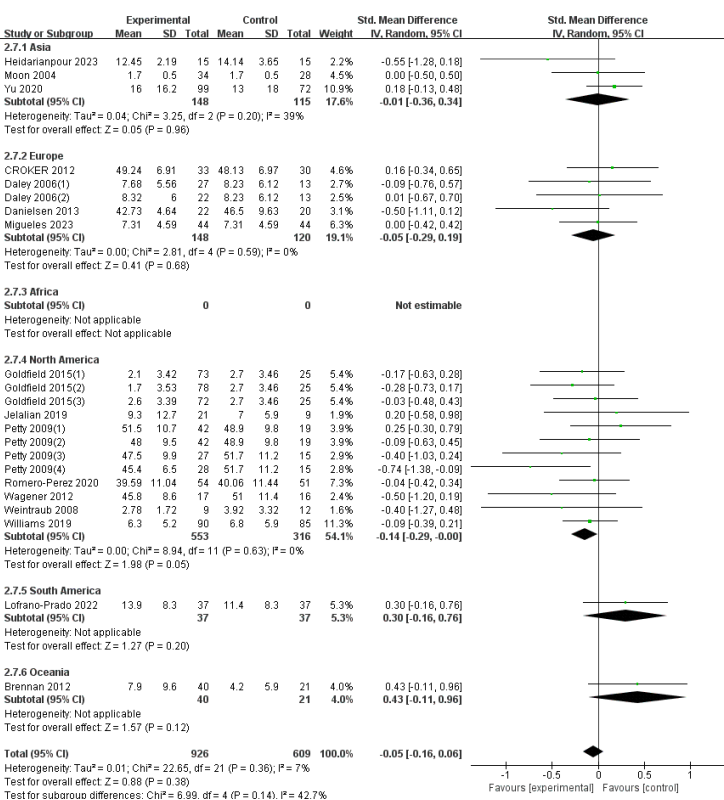


Figure S18.8. Forest plot of subgroup analyses by economic status

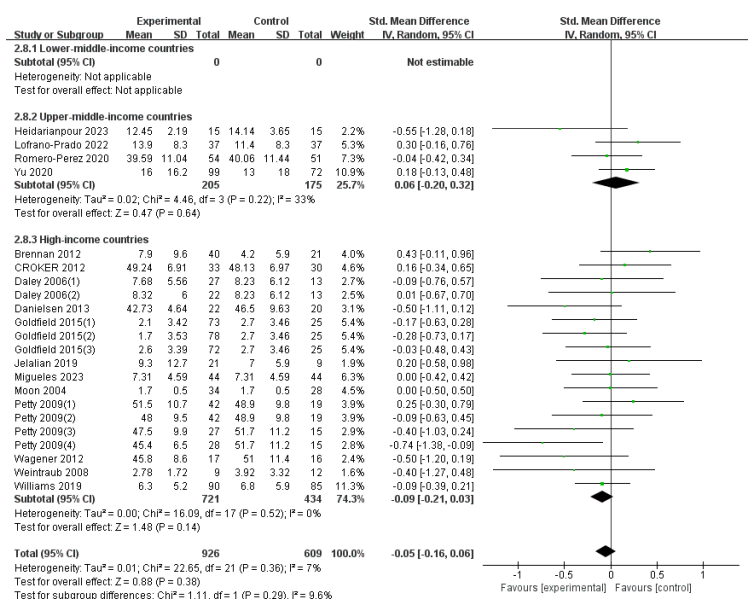


Figure S18.9. Forest plot of subgroup analyses by weight status

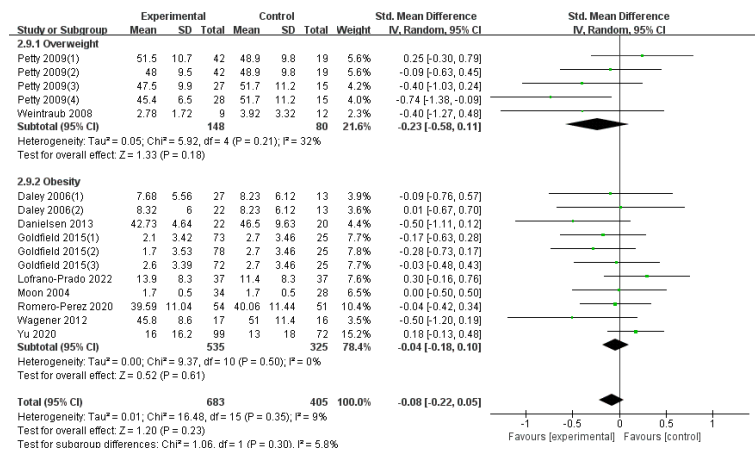


Figure S18.10. Forest plot of subgroup analyses by sex

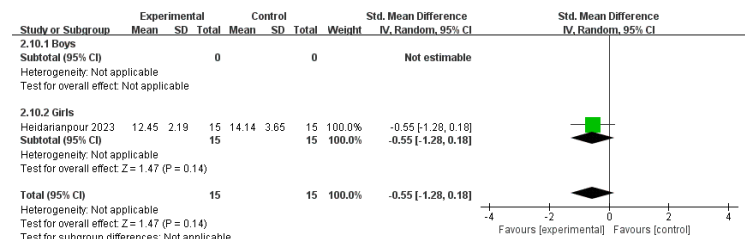


Figure S19. Forest plots of subgroup analyses for Anxiety in children and adolescents with overweight or obesity

Figure S19.1. Forest plot of subgroup analyses by type of exercise

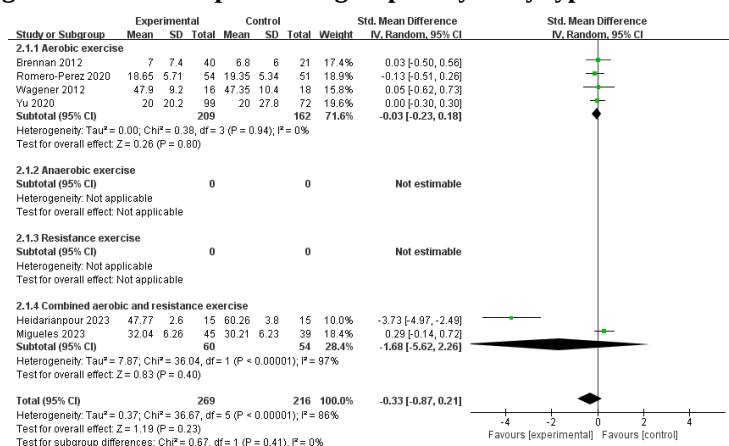


Figure S19.2. Forest plot of subgroup analyses by exercise intensity

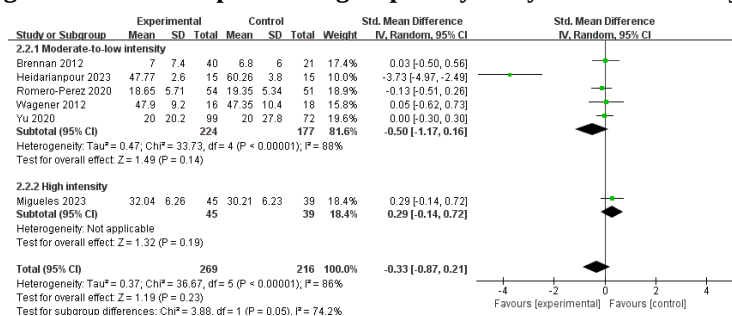


Figure S19.3. Forest plot of subgroup analyses by duration per session

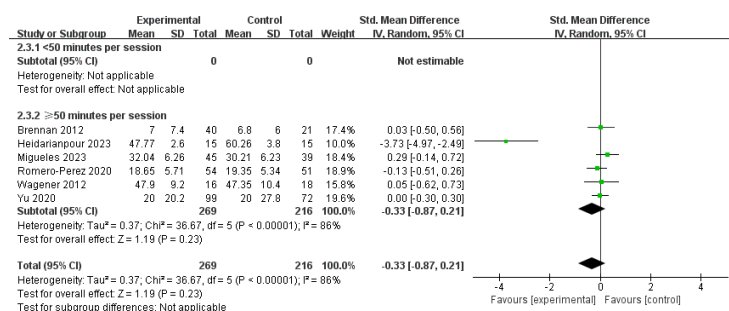


Figure S19.4. Forest plot of subgroup analyses by exercise frequency

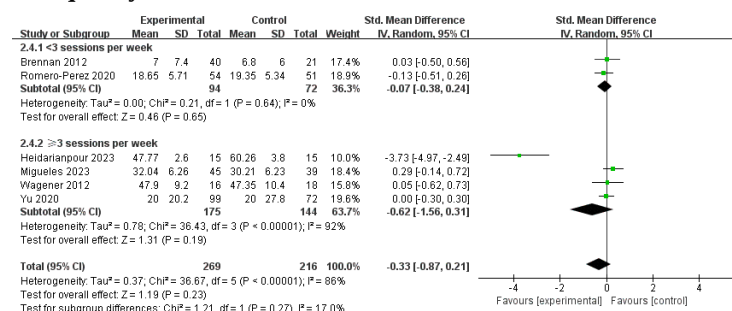


Figure S19.5. Forest plot of subgroup analyses by weekly exercise duration

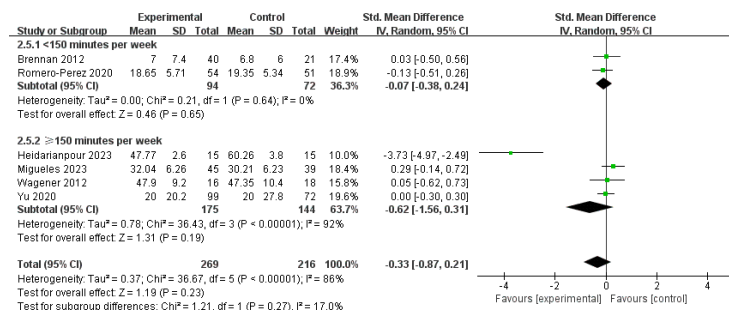


Figure S19.6. Forest plot of subgroup analyses by intervention duration

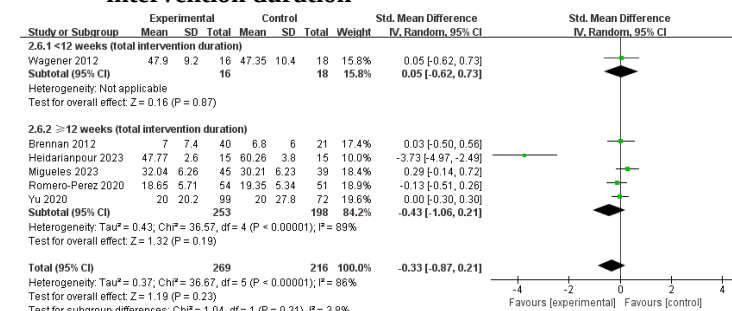


Figure S19.7. Forest plot of subgroup analyses by region

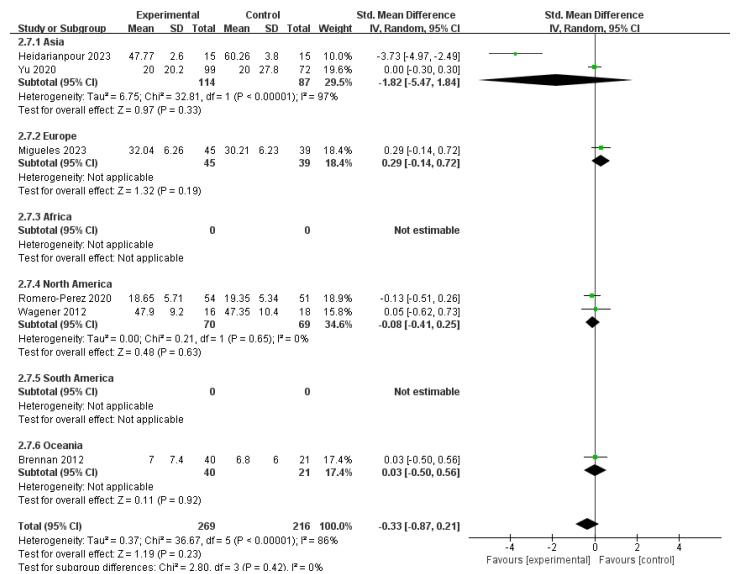


Figure S19.8. Forest plot of subgroup analyses by economic status

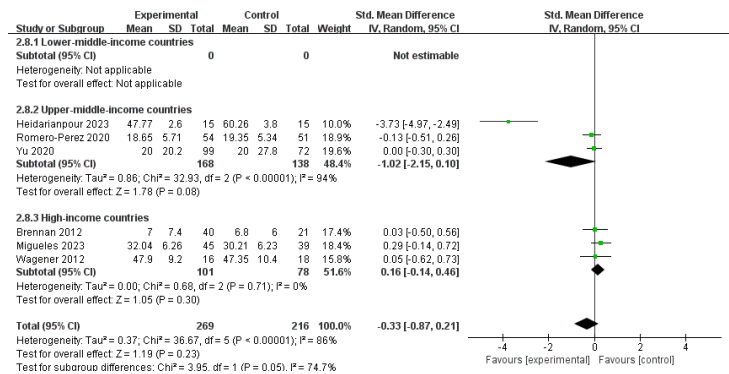


Figure S19.9. Forest plot of subgroup analyses by weight status

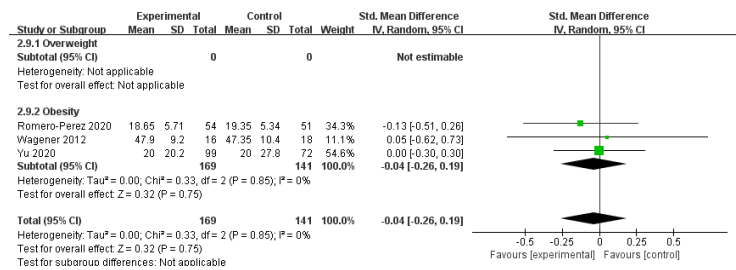


Figure S19.10. Forest plot of subgroup analyses by sex

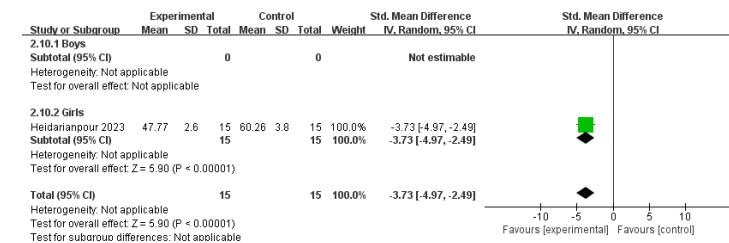


Figure S20. Forest plots of subgroup analyses for Self-esteem in children and adolescents with overweight or obesity

Figure S20.1. Forest plot of subgroup analyses by type of exercise

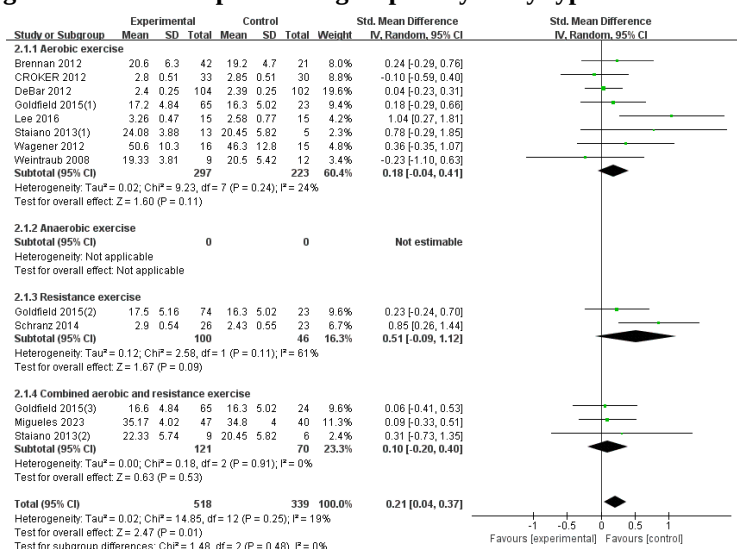


Figure S20.2. Forest plot of subgroup analyses by exercise intensity

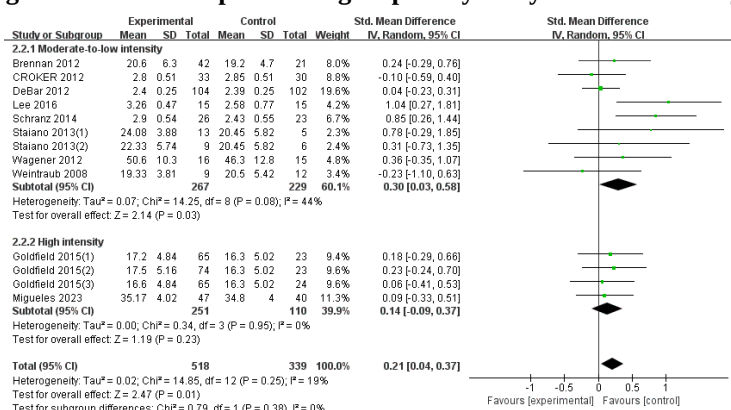


Figure S20.3. Forest plot of subgroup analyses by duration per session

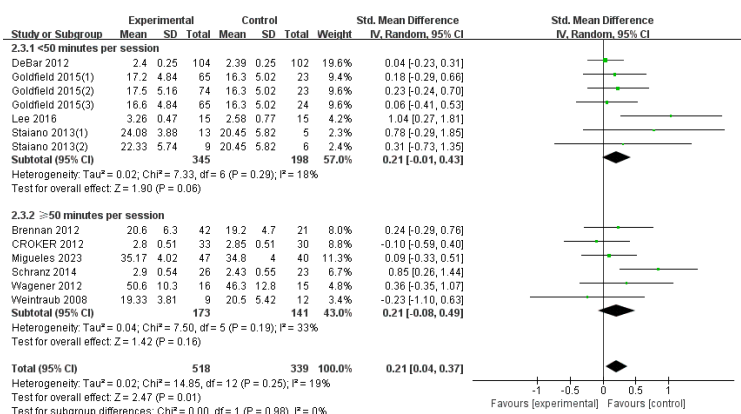


Figure S20.4. Forest plot of subgroup analyses by exercise frequency

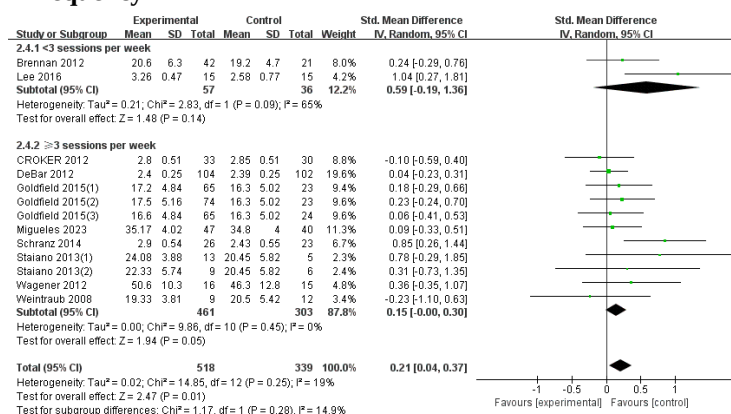


Figure S20.5. Forest plot of subgroup analyses by weekly exercise duration

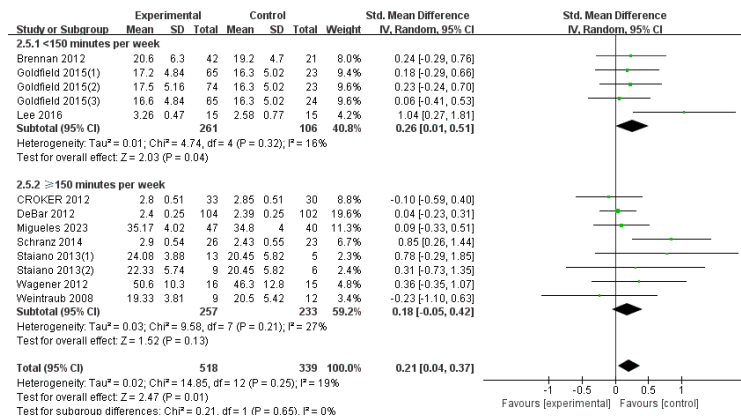


Figure S20.7. Forest plot of subgroup analyses by region

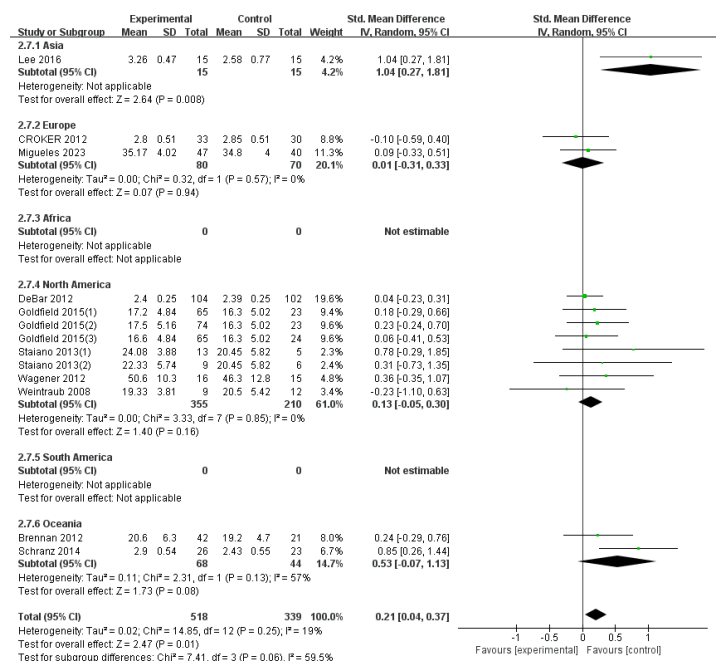


Figure S20.8. Forest plot of subgroup analyses by economic status

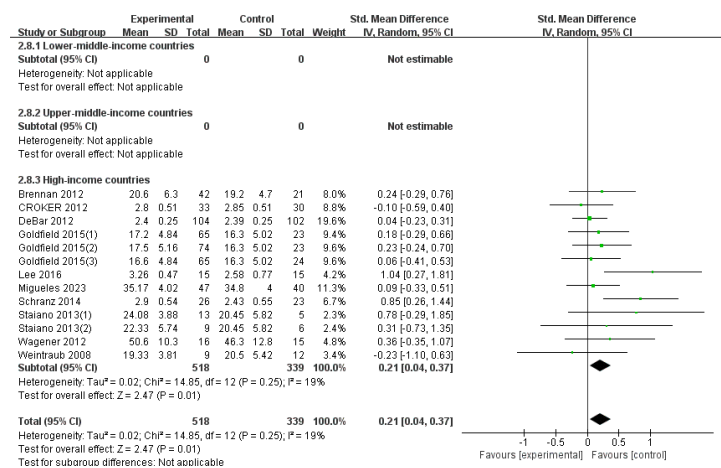


Figure S20.9. Forest plot of subgroup analyses by weight status

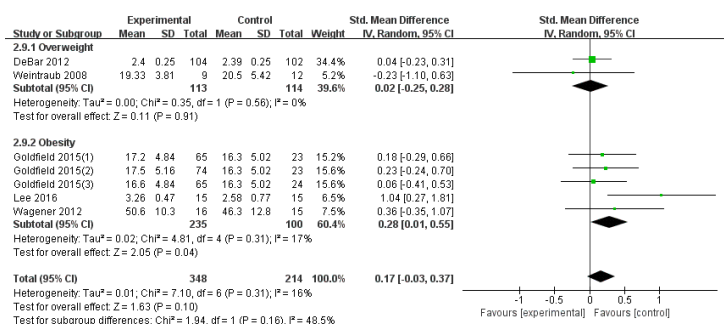


Figure S20.10. Forest plot of subgroup analyses by sex

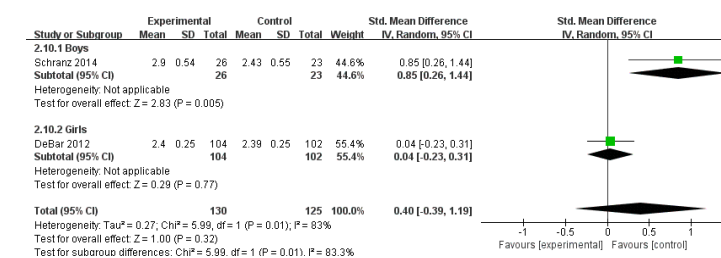


Figure S21. Forest plots of subgroup analyses for Self-worth in children and adolescents with overweight or obesity

Figure S21.1. Forest plot of subgroup analyses by type of exercise

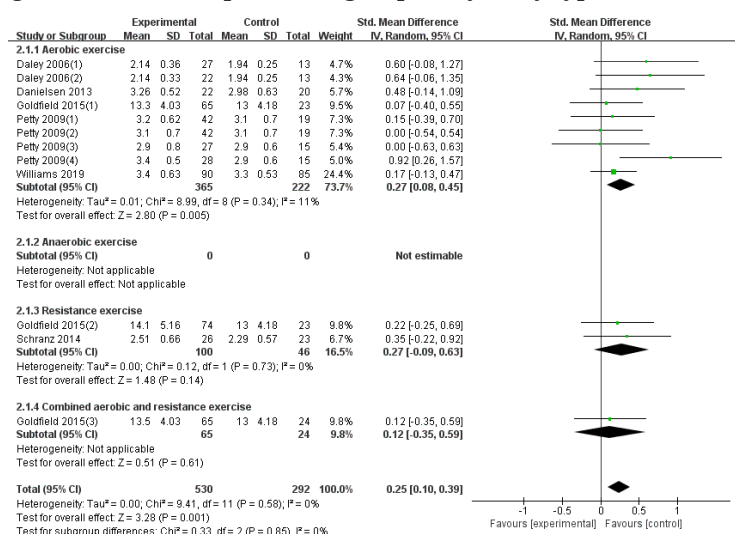


Figure S21.2. Forest plot of subgroup analyses by exercise intensity

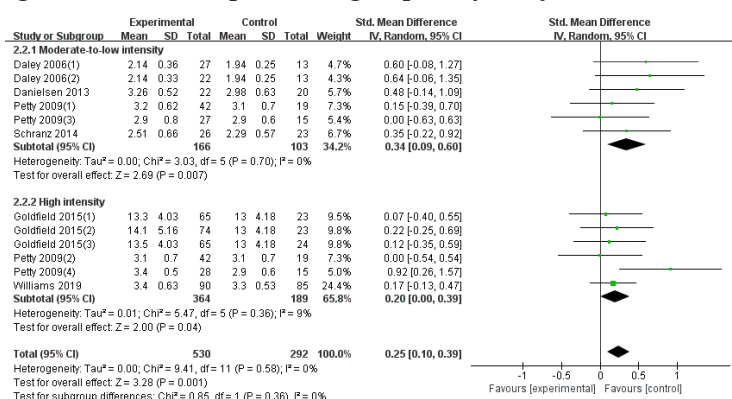


Figure S21.3. Forest plot of subgroup analyses by duration per session

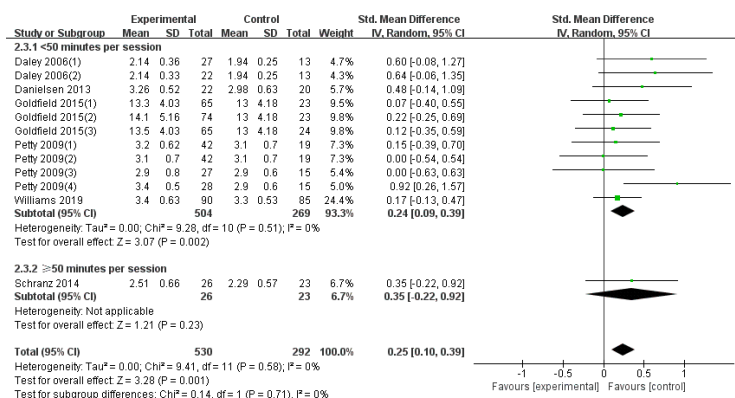


Figure S21.4. Forest plot of subgroup analyses by exercise frequency

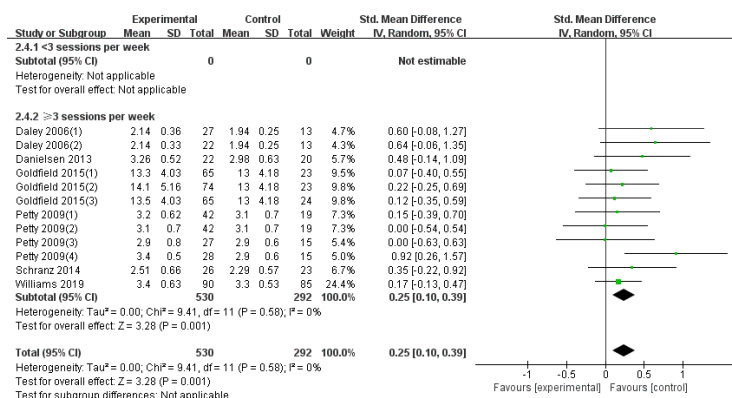


Figure S21.5. Forest plot of subgroup analyses by weekly exercise duration

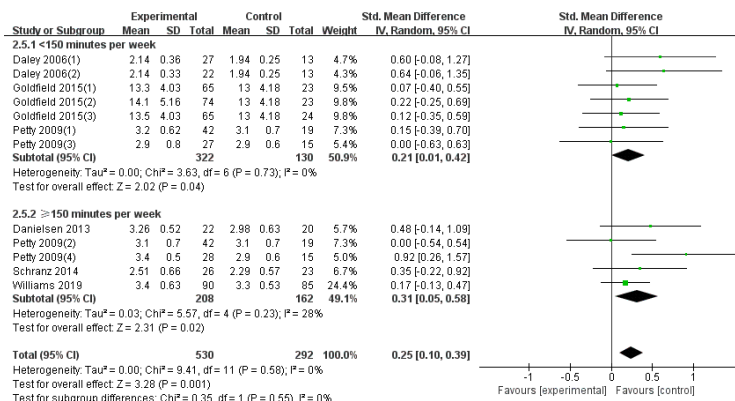


Figure S21.6. Forest plot of subgroup analyses by intervention duration

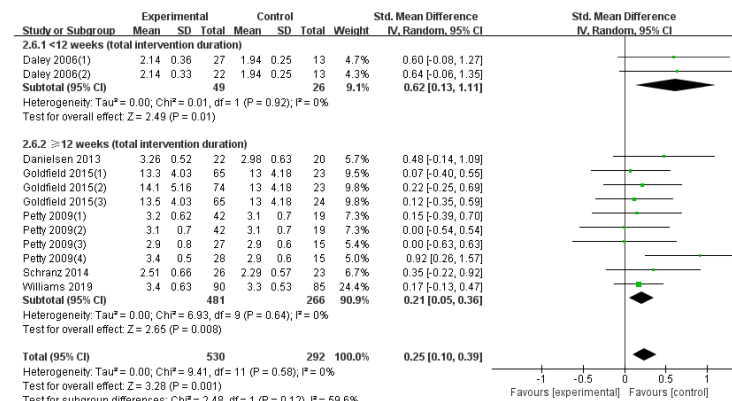


Figure S21.7. Forest plot of subgroup analyses by region

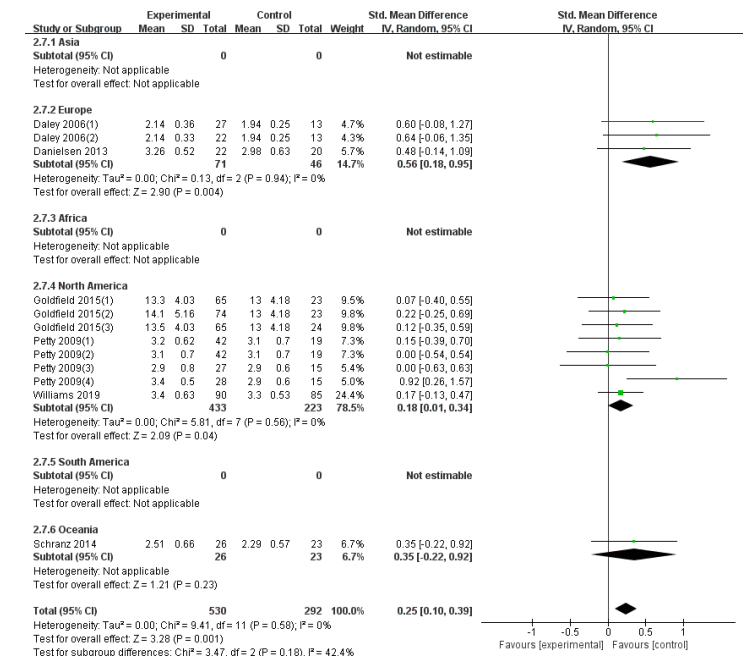


Figure S21.8. Forest plot of subgroup analyses by economic status

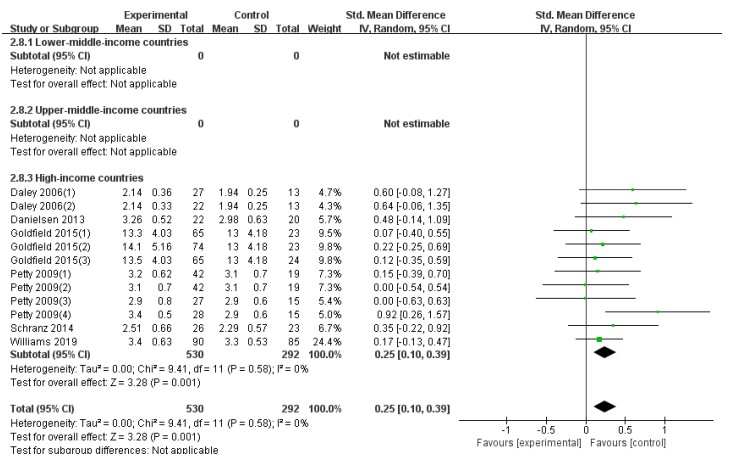


Figure S21.9. Forest plot of subgroup analyses by weight status

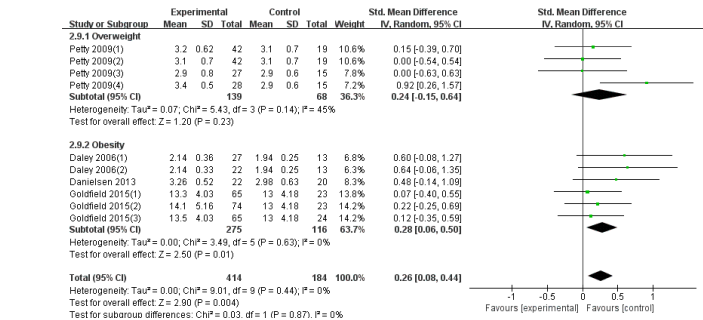


Figure S21.10. Forest plot of subgroup analyses by sex

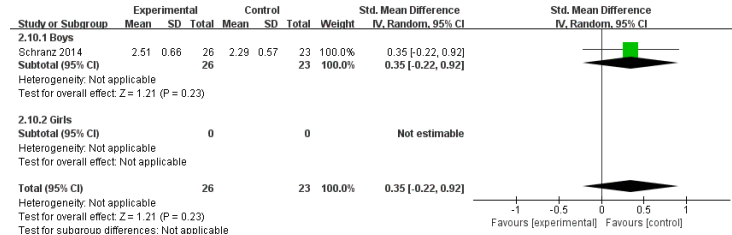


Figure S22. Funnel plots of meta-analysis results for 20 outcome indicators in children and adolescents with overweight or obesity

Figure S22.1. Funnel plot of the effect of exercise on BMI

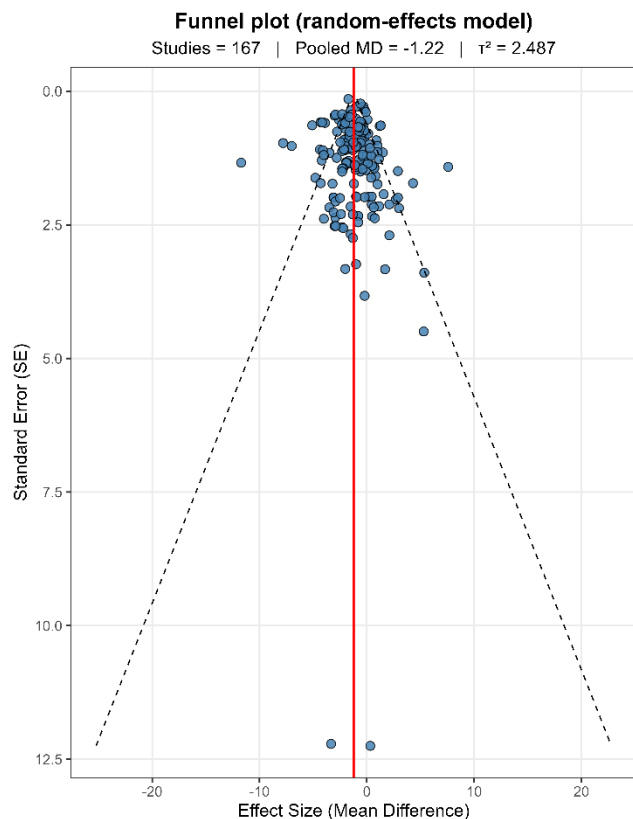


Figure S22.2. Funnel plot of the effect of exercise on WC

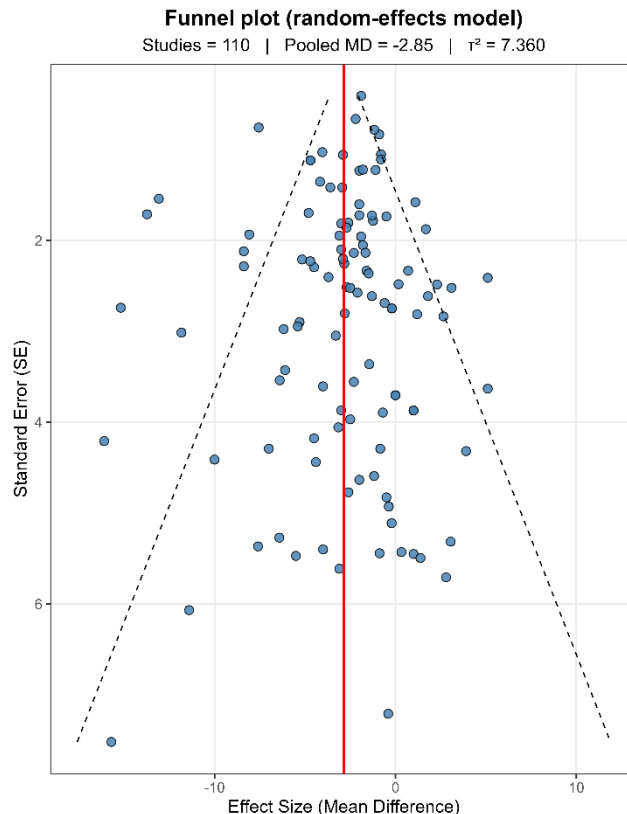


Figure S22.3. Funnel plot of the effect of exercise on BF%

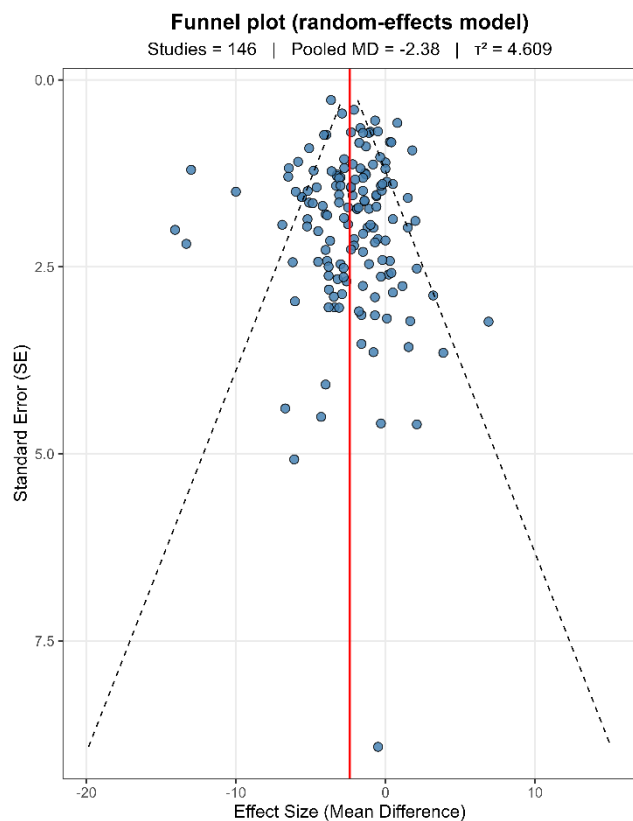


Figure S22.4. Funnel plot of the effect of exercise on VO₂max

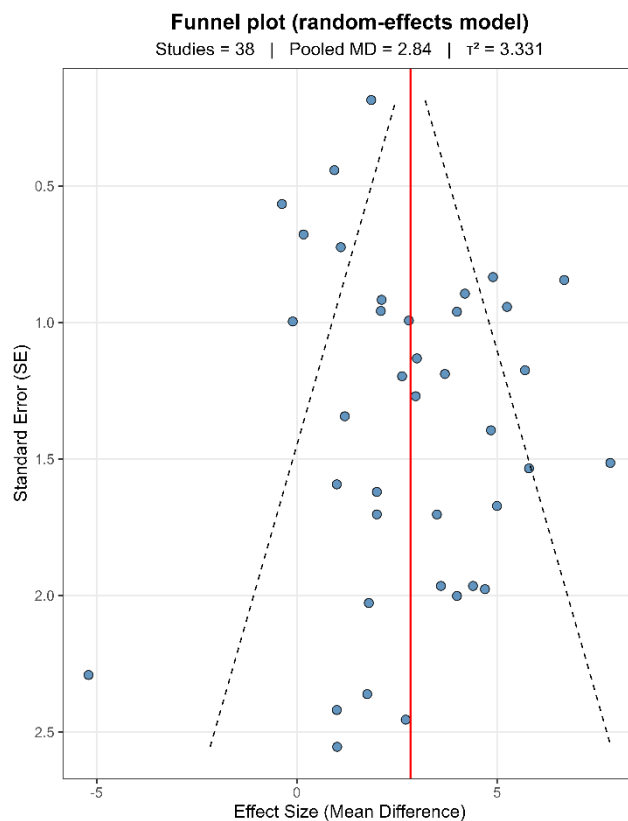


Figure S22.5. Funnel plot of the effect of exercise on VO₂peak

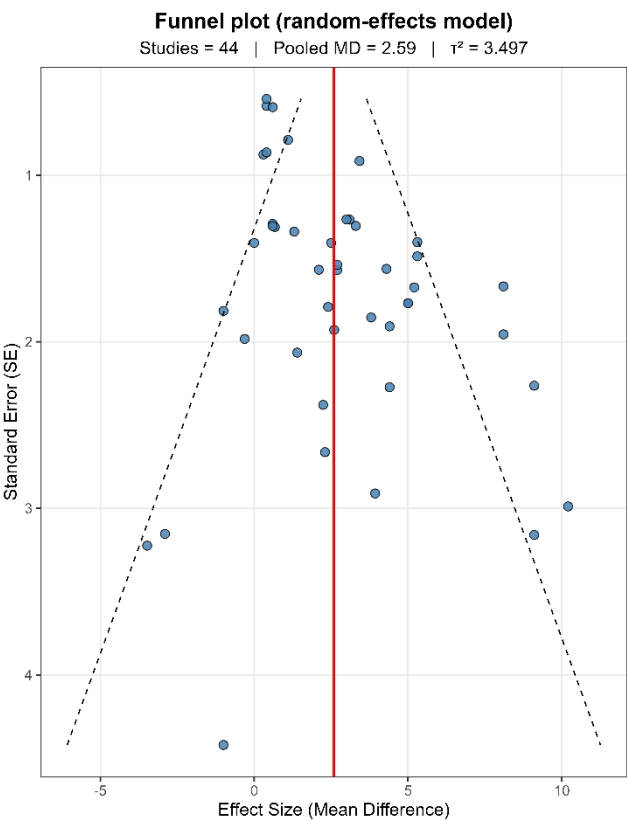


Figure S22.6. Funnel plot of the effect of exercise on HRmax

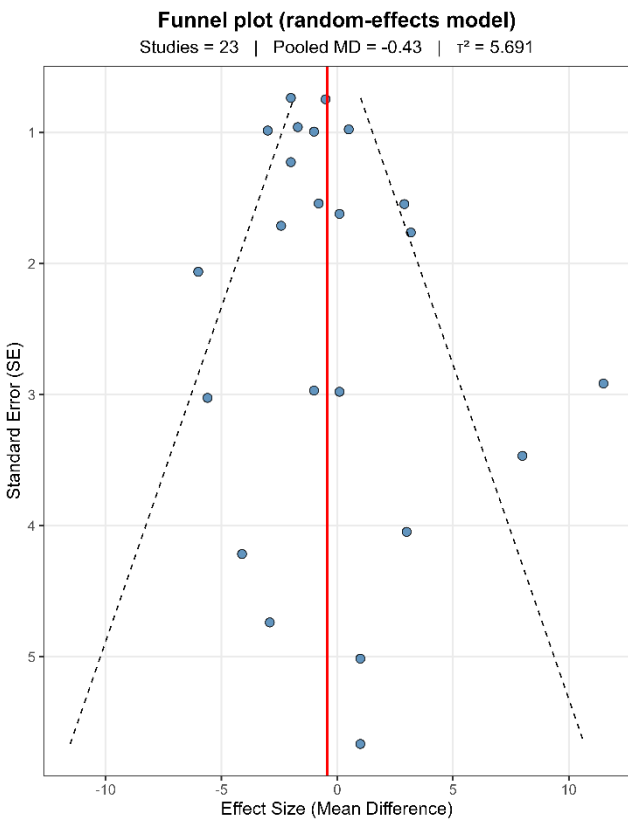


Figure S22.7. Funnel plot of the effect of exercise on HRrest

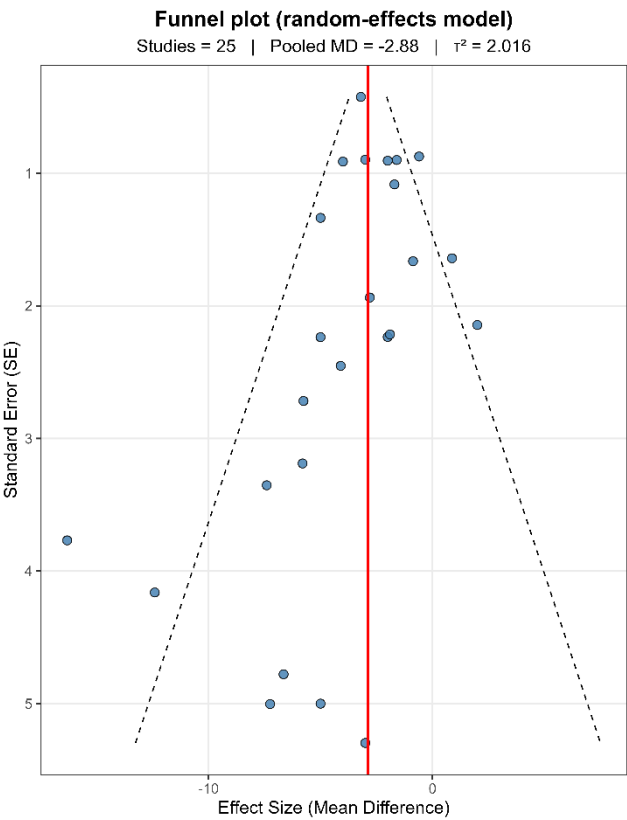


Figure S22.8. Funnel plot of the effect of exercise on SBP

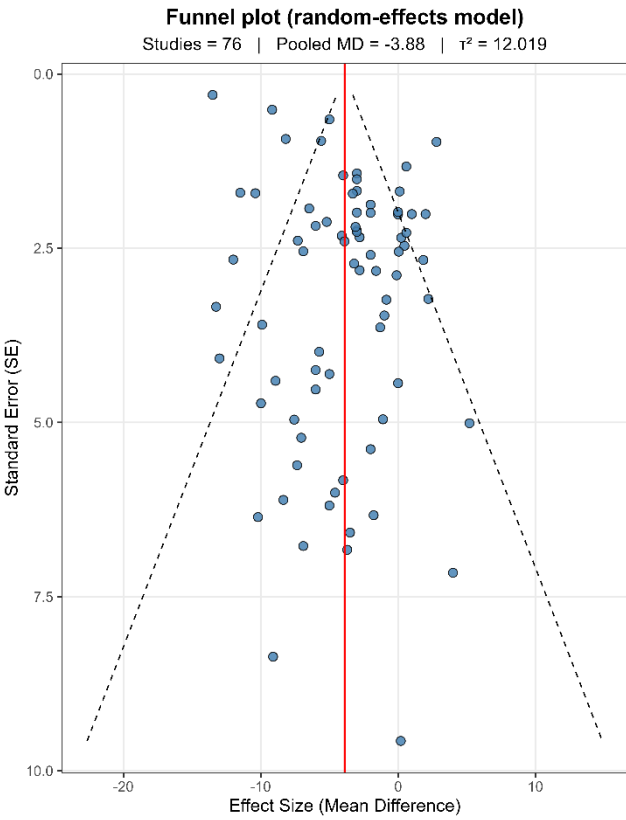


Figure S22.9. Funnel plot of the effect of exercise on DBP

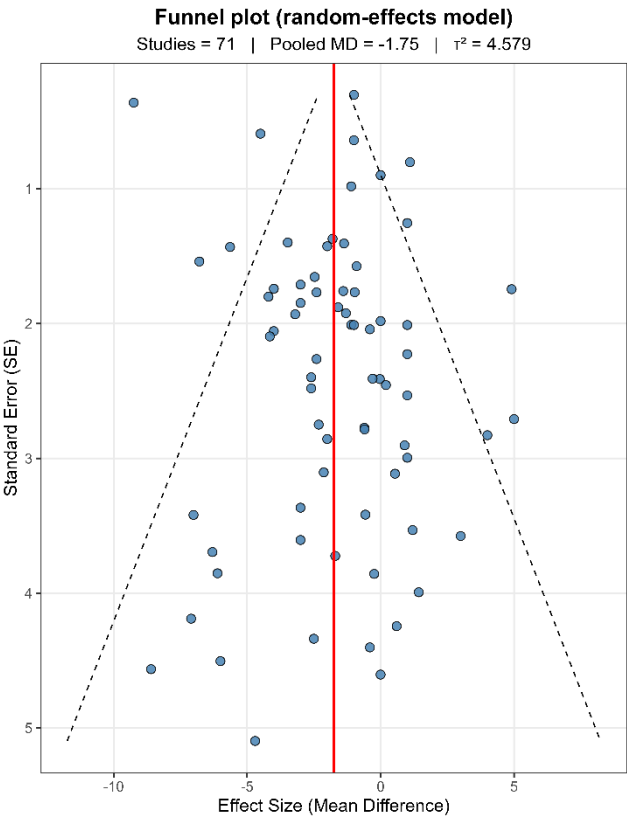


Figure S22.10. Funnel plot of the effect of exercise on TC

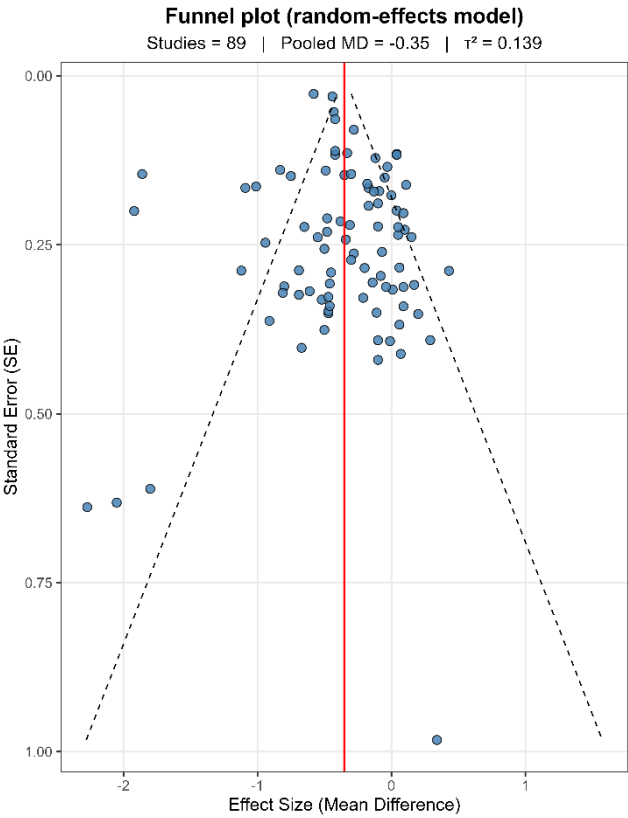


Figure S22.11. Funnel plot of the effect of exercise on TG

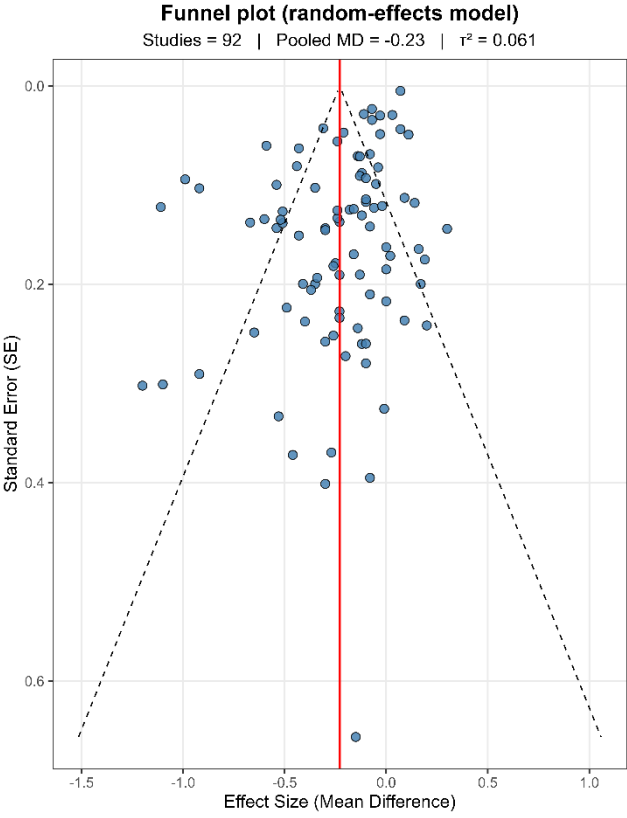


Figure S22.12. Funnel plot of the effect of exercise on HDL-C

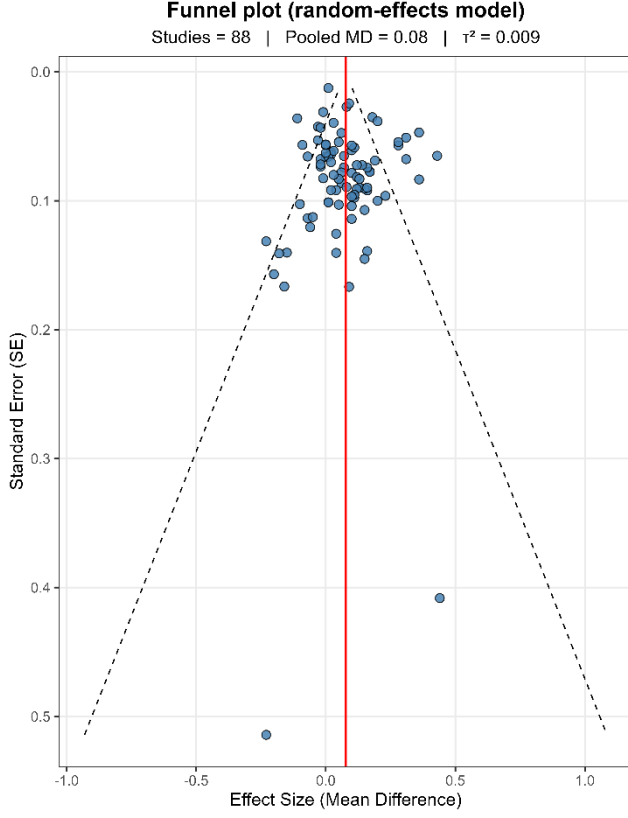


Figure S22.13. Funnel plot of the effect of exercise on LDL-C

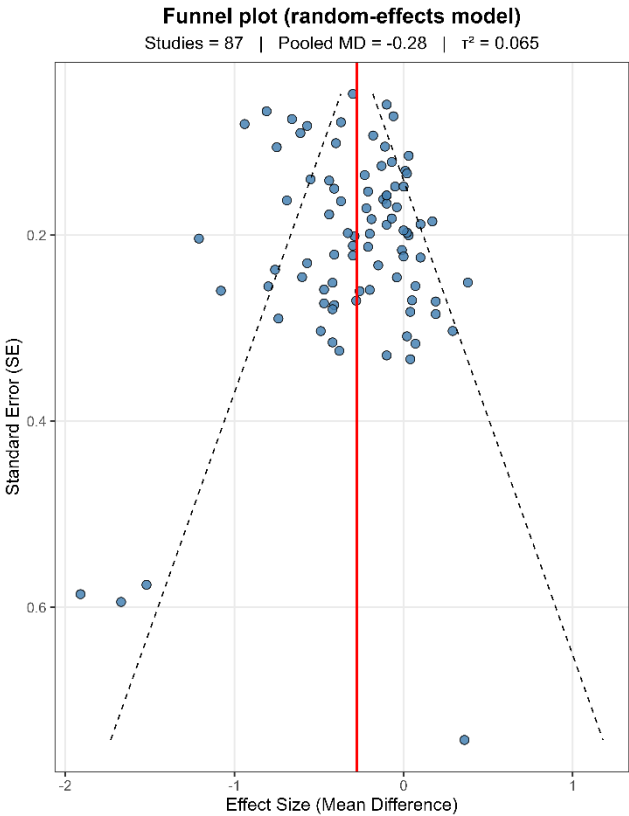


Figure S22.14. Funnel plot of the effect of exercise on FPG

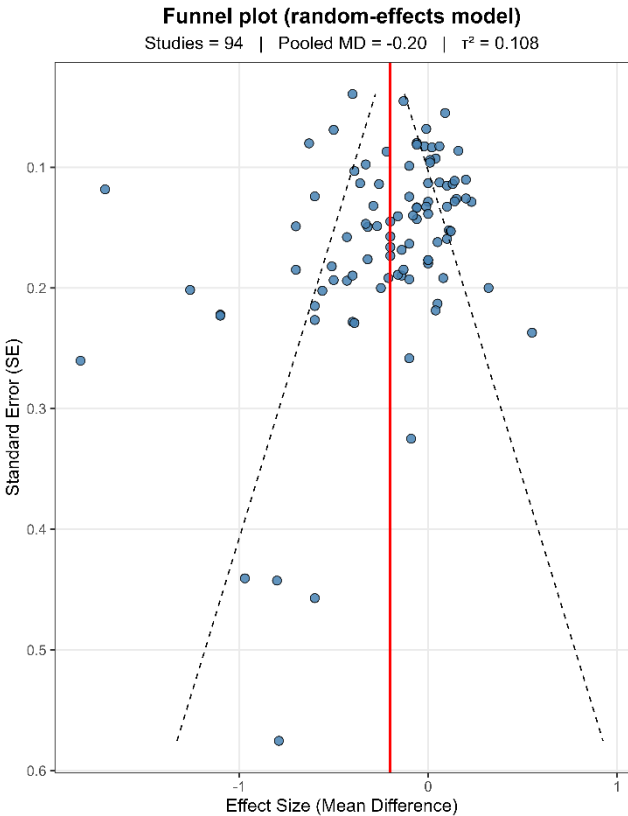


Figure S22.15. Funnel plot of the effect of exercise on HbA1c

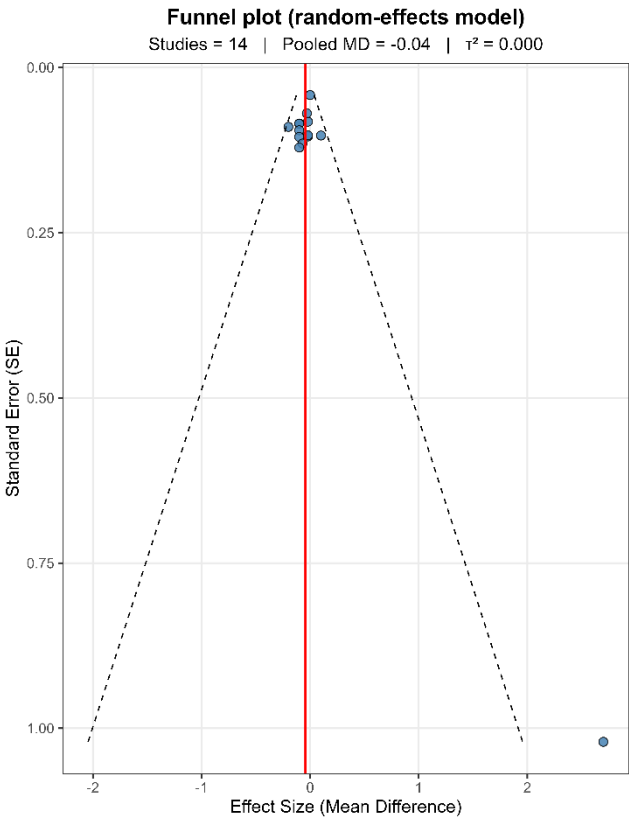


Figure S22.16. Funnel plot of the effect of exercise on FINS

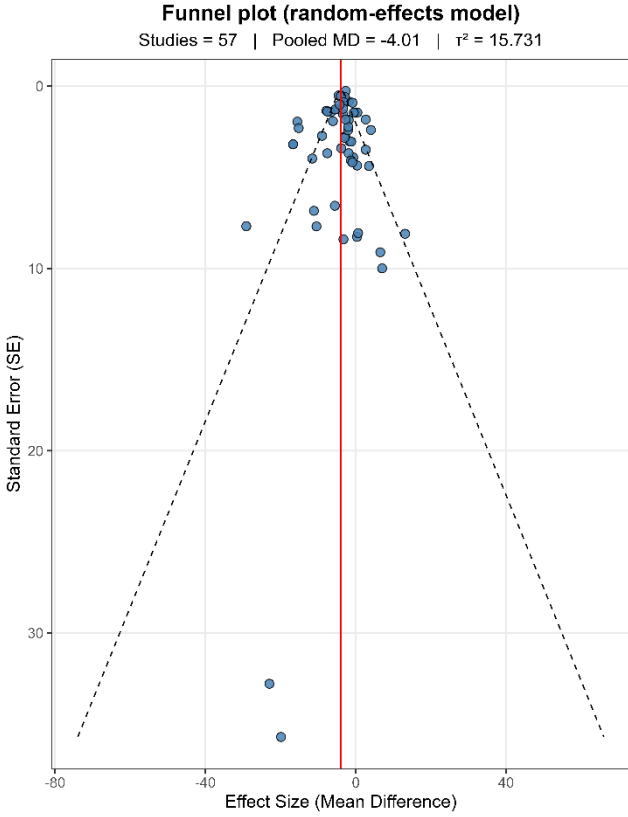


Figure S22.17. Funnel plot of the effect of exercise on Depression

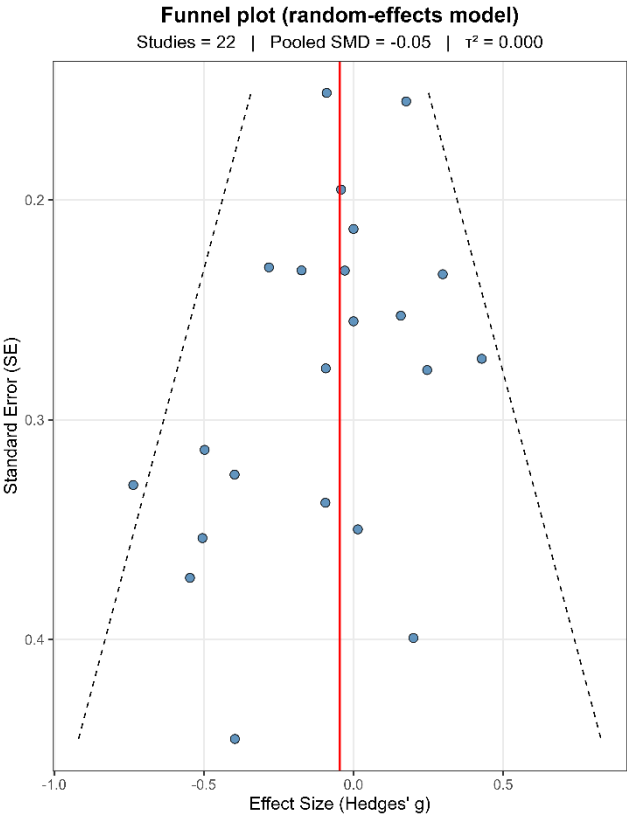


Figure S22.18. Funnel plot of the effect of exercise on Anxiety

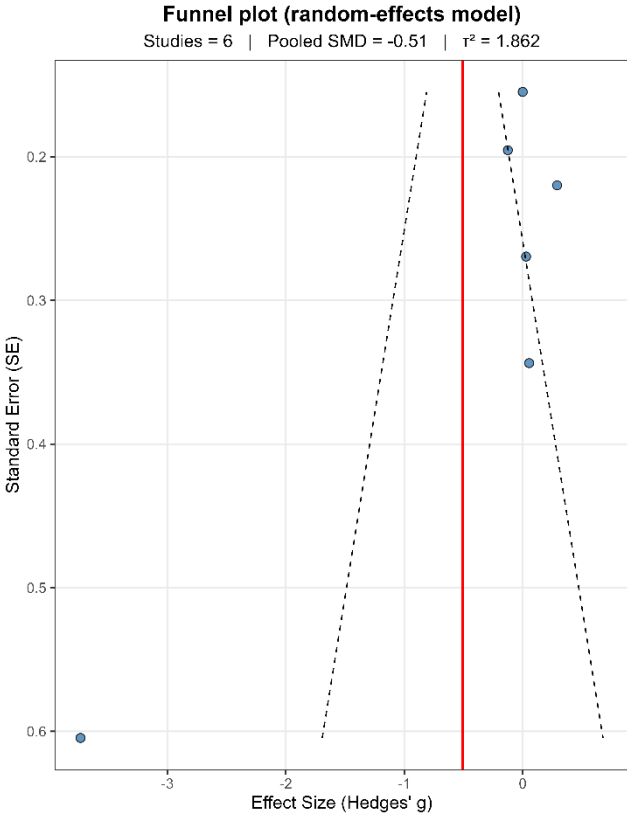


Figure S22.19. Funnel plot of the effect of exercise on Self-esteem

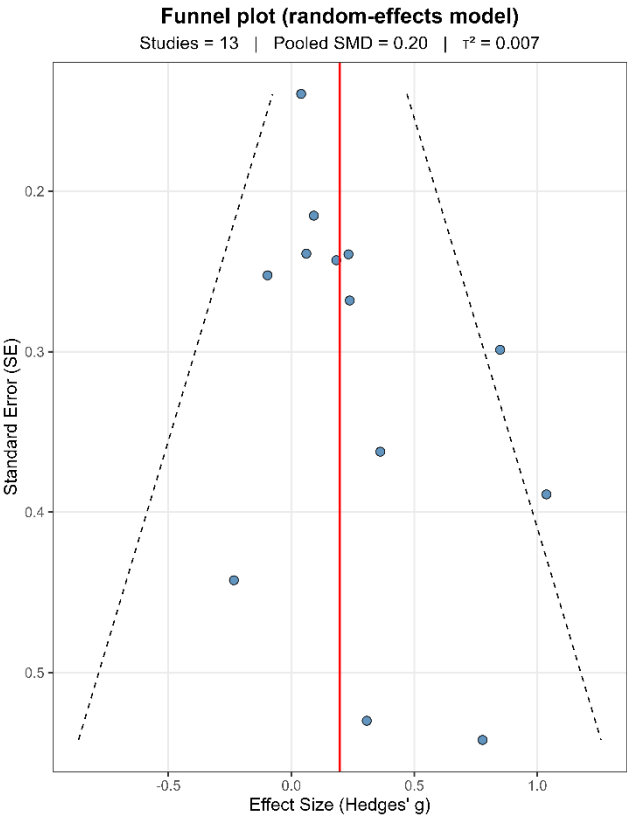


Figure S22.20. Funnel plot of the effect of exercise on Self-worth

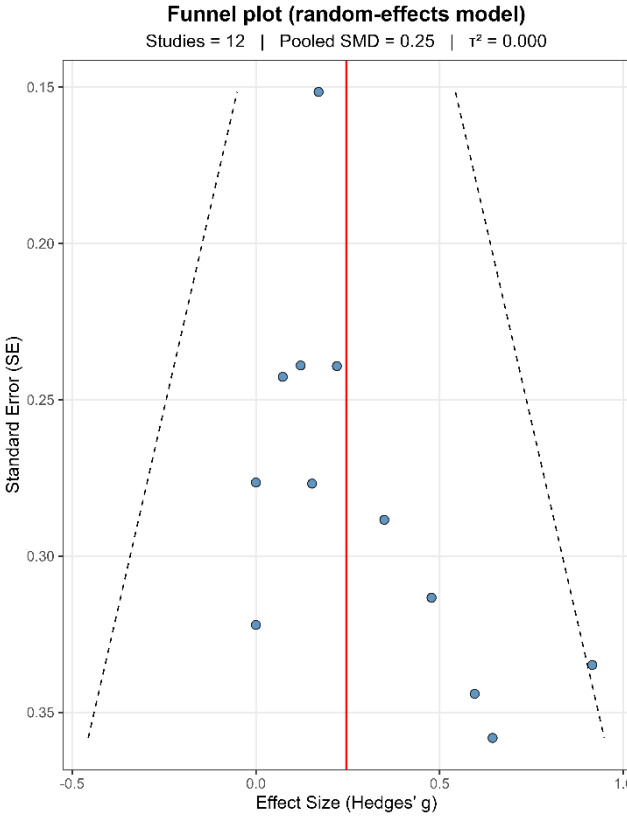


Table S3. Certainty of assessment using GRADE for RCTs

Outcome	Initial rating	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Quality of the evidence
BMI	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
WC	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
BF%	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
VO ₂ max	High	No serious concern	Serious concern ^b	No serious concern	No serious concern	No serious concern	Moderate
VO ₂ peak	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
HRmax	High	No serious concern	Serious concern ^b	No serious concern	Serious concern ^c	No serious concern	Low
HRrest	High	No serious concern	No serious concern	No serious concern	No serious concern	No serious concern	High
SBP	High	No serious concern	No serious concern	No serious concern	No serious concern	No serious concern	High
DBP	High	No serious concern	Serious concern ^b	No serious concern	No serious concern	No serious concern	Moderate
TC	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
TG	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
HDL-C	High	Serious concern ^a	Serious concern ^b	No serious concern	No serious concern	No serious concern	Low
LDL-C	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
FPG	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
HbA1c	High	No serious concern	No serious concern	No serious concern	Serious concern ^c	No serious concern	Moderate
FINS	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
Depression	High	No serious concern	No serious concern	No serious concern	Serious concern ^c	No serious concern	Moderate
Anxiety	High	No serious concern	Serious concern ^b	No serious concern	Serious concern ^c	Serious concern ^d	Very Low
Self-esteem	High	Serious concern ^a	No serious concern	No serious concern	No serious concern	No serious concern	Moderate
Self-worth	High	No serious concern	No serious concern	No serious concern	No serious concern	No serious concern	High

Note: BMI, body mass index; WC, waist circumference; BF%, percentage of body fat; VO₂max, maximal oxygen consumption; VO₂peak, peak oxygen uptake; HRmax, max heart rate; HRrest, resting heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FPG, fasting plasma glucose; HbA1c, hemoglobin A1c; FINS, fasting insulin

RCTs, randomised controlled trials; GRADE, the Grading of Recommendations, Assessment, Development and Evaluations.

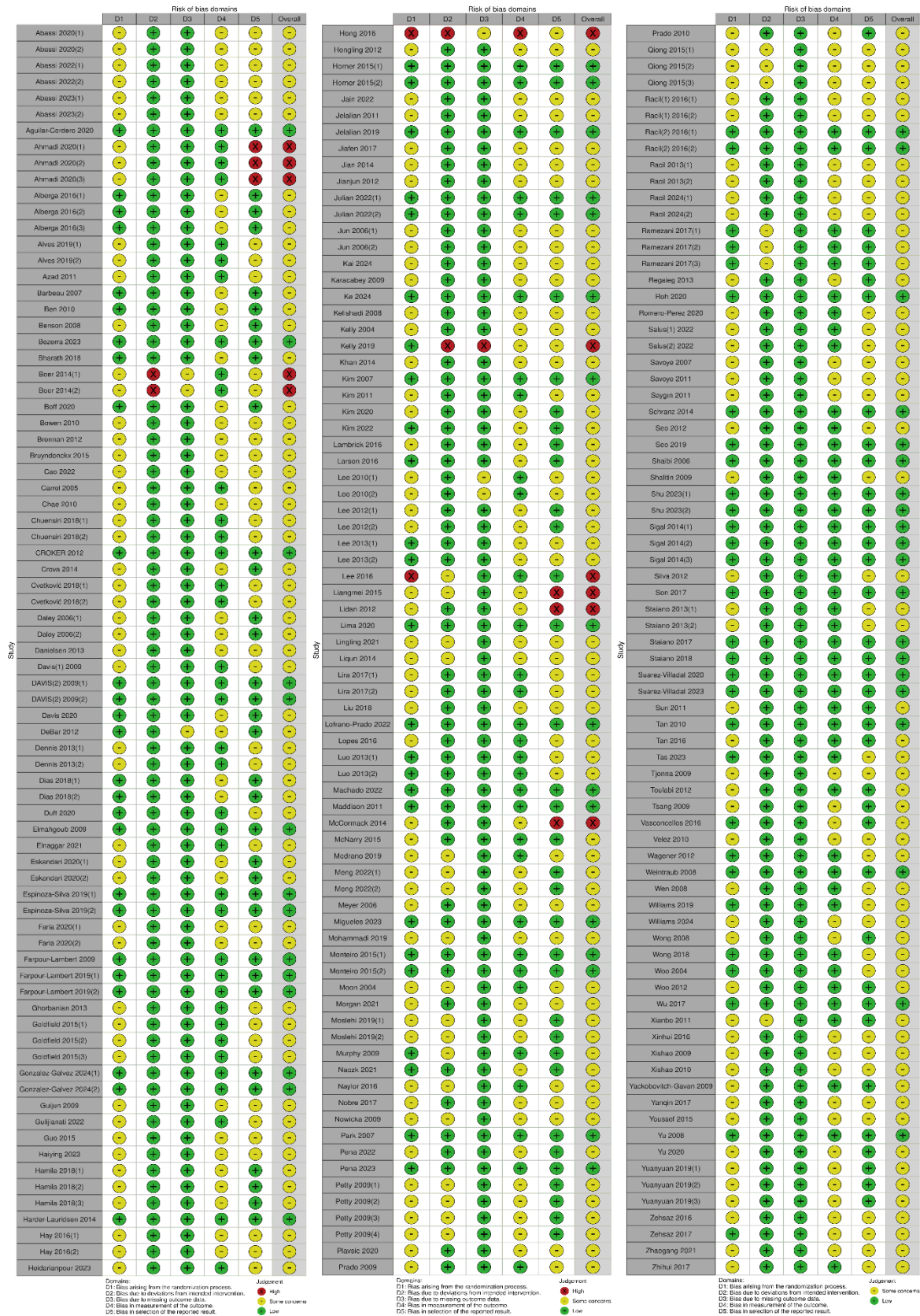
a: Downgraded one level due to some concerns about risk of bias

c: Downgraded one level due to wide confidence interval crossing the line of no effect

b: Downgraded one level due to unexplained heterogeneity

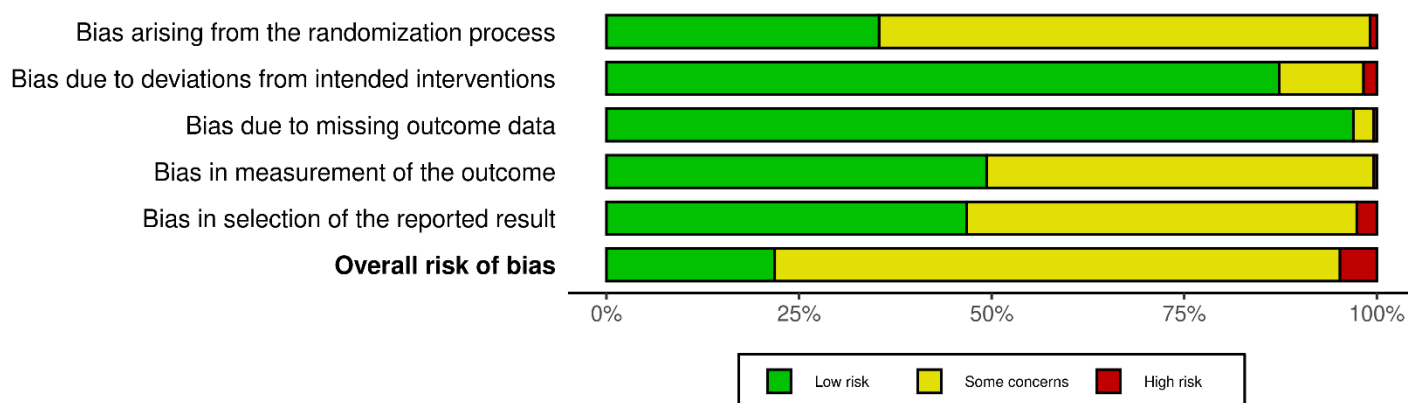
d: Downgraded one level due to suspected publication bias

Figure S23. Revised Cochrane Risk-of-Bias Tool for Randomised Trials summary and author judgments of low, some concerns, and high risk of bias across all included RCTs (K=229)



Note: RCT, randomised controlled trial. N indicated the number of the intervention groups.

Figure S24. Review judgment of risk bias for each domain: percentages across all included RCTs (K=229)



Note: RCTs, randomised controlled trials. N indicated the number of the intervention groups.

Table S4. Egger's test and Trim-and-Fill correction analyses for publication bias across outcomes

Outcomes	Egger's test p	No. of Imputed Studies (k _o)	Original Effect	Original 95% CI	Adjusted Effect	Adjusted 95% CI
BMI (kg/m ²)	0.4447	32	-1.220	-1.527 to -0.913	-1.715	-2.041 to -1.389
WC (cm)	0.7128	21	-2.854	-3.562 to -2.146	-3.727	-4.450 to -3.004
BF (%)	0.8769	31	-2.385	-2.842 to -1.928	-3.155	-3.620 to -2.691
VO ₂ max (mL kg ⁻¹ min ⁻¹)	0.0429*	10	2.842	2.121 to 3.564	1.861	1.054 to 2.668
VO ₂ peak (mL kg ⁻¹ min ⁻¹)	0.0002*	0	2.587	1.850 to 3.323	2.587	1.850 to 3.323
HRmax (bpm)	0.2298	0	-0.428	-1.728 to 0.872	-0.428	-1.728 to 0.872
HRrest (bpm)	0.1940	6	-2.882	-3.793 to -1.971	-2.379	-3.523 to -1.236
SBP (mmHg)	0.0000*	1	-3.884	-4.911 to -2.856	-3.952	-4.979 to -2.924
DBP (mmHg)	0.0241*	11	-1.752	-2.471 to -1.034	-2.403	-3.313 to -1.492
TC (mmol/l)	0.0540	0	-0.352	-0.445 to -0.258	-0.352	-0.445 to -0.258
TG (mmol/l)	0.0000*	0	-0.229	-0.289 to -0.169	-0.229	-0.289 to -0.169
HDL-C (mmol/l)	0.1617	13	0.077	0.051 to 0.103	0.100	0.073 to 0.126
LDL-C (mmol/l)	0.1289	0	-0.276	-0.344 to -0.208	-0.276	-0.344 to -0.208
FPG (mmol/l)	0.3146	0	-0.202	-0.276 to -0.127	-0.202	-0.276 to -0.127
HbA1c (%)	0.4798	0	-0.044	-0.088 to 0.001	-0.044	-0.088 to 0.001
FINS (μU/mL)	0.2372	0	-4.008	-5.299 to -2.717	-4.008	-5.299 to -2.717
Depression	0.0758	5	-0.046	-0.151 to 0.059	0.025	-0.092 to 0.141
Anxiety	0.1278	0	-0.507	-1.629 to 0.615	-0.507	-1.629 to 0.615
Self-esteem	0.0799	4	0.197	0.045 to 0.349	0.089	-0.116 to 0.295
Self-worth	0.0870	2	0.246	0.099 to 0.393	0.190	0.050 to 0.330

Note: BMI, body mass index; WC, waist circumference; BF%, percentage of body fat; VO₂max, maximal oxygen consumption; VO₂peak, peak oxygen uptake; HRmax, max heart rate; HRrest, resting heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FPG, fasting plasma glucose; HbA1c, hemoglobin A1c; FINS, fasting insulin. To further explore and correct potential asymmetry, Duval and Tweedie's trim-and-fill procedure was applied under a random-effects model.

Egger's regression test ($SND \sim 1/SE$) was used to assess publication bias.

The Trim-and-Fill method by Duval and Tweedie was used to estimate the number of missing studies (k_0) and adjust the pooled effect size.

95% CI: 95% confidence interval.

*P values < 0.05 were considered statistically significant. *P < 0.05*

Figure S25. Trim-and-fill funnel plots of meta-analysis results for 20 outcome indicators in children and adolescents with overweight or obesity

Figure S25.1. Trim-and-fill funnel plot for BMI

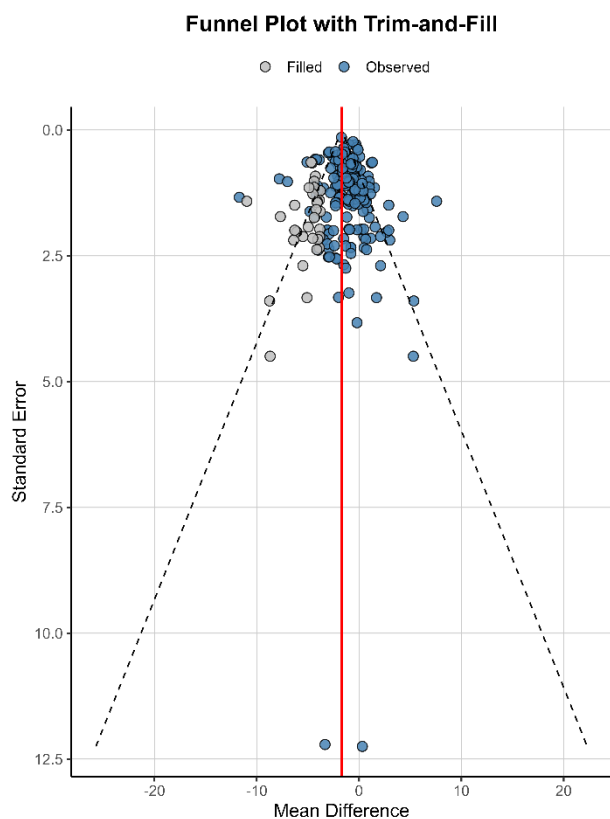


Figure S25.2. Trim-and-fill funnel plot for WC

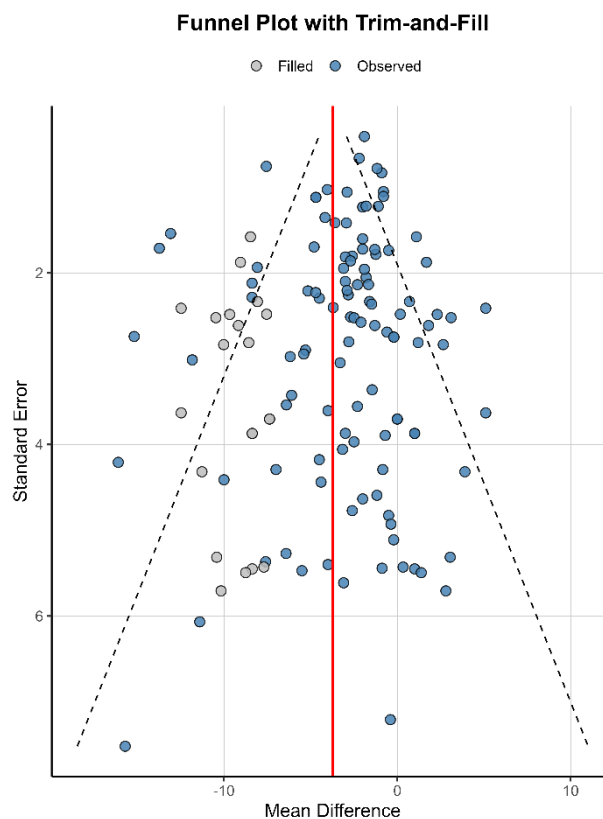


Figure S25.3. Trim-and-fill funnel plot for BF%

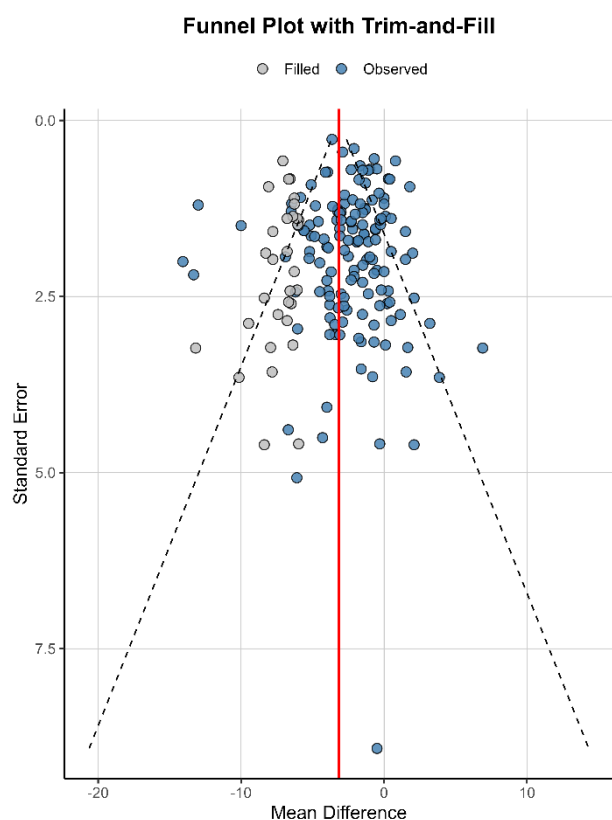


Figure S25.4. Trim-and-fill funnel plot for VO₂max

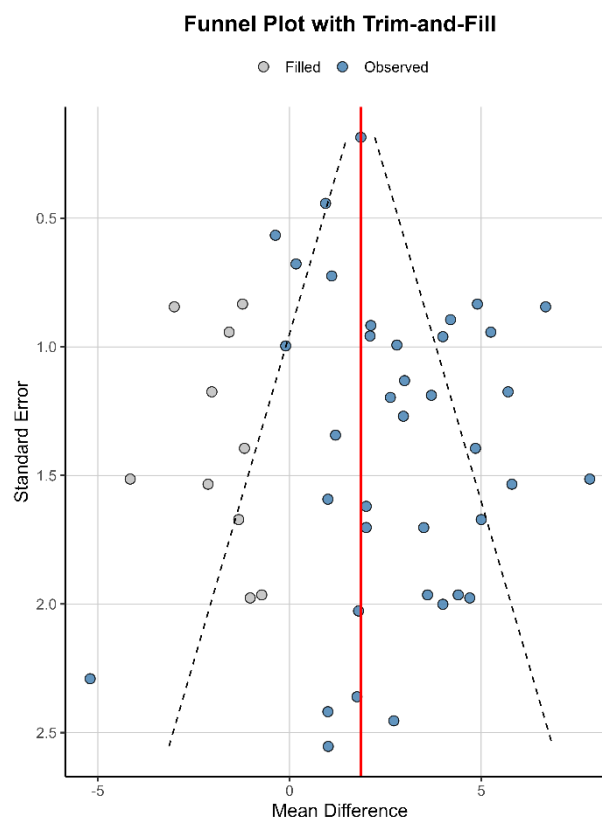


Figure S25.5. Trim-and-fill funnel plot for VO2peak

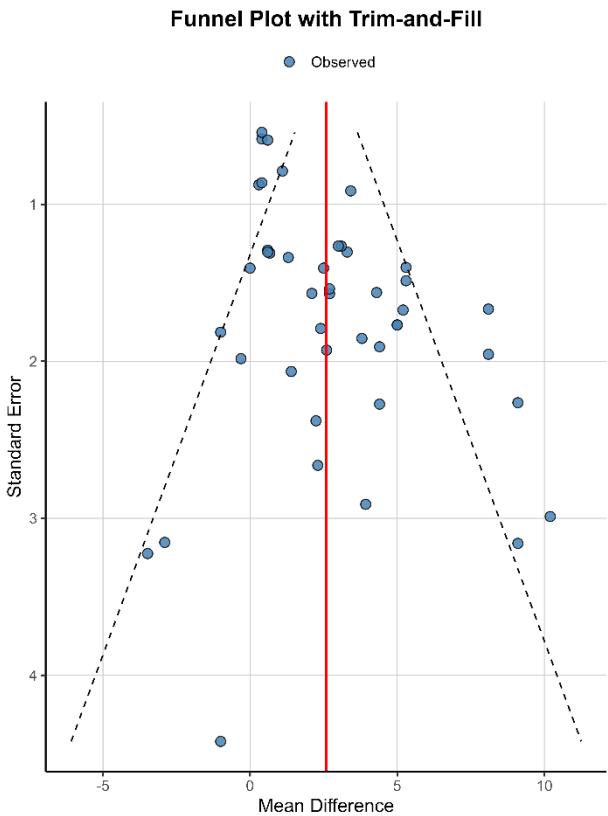


Figure S25.6. Trim-and-fill funnel plot for HRmax

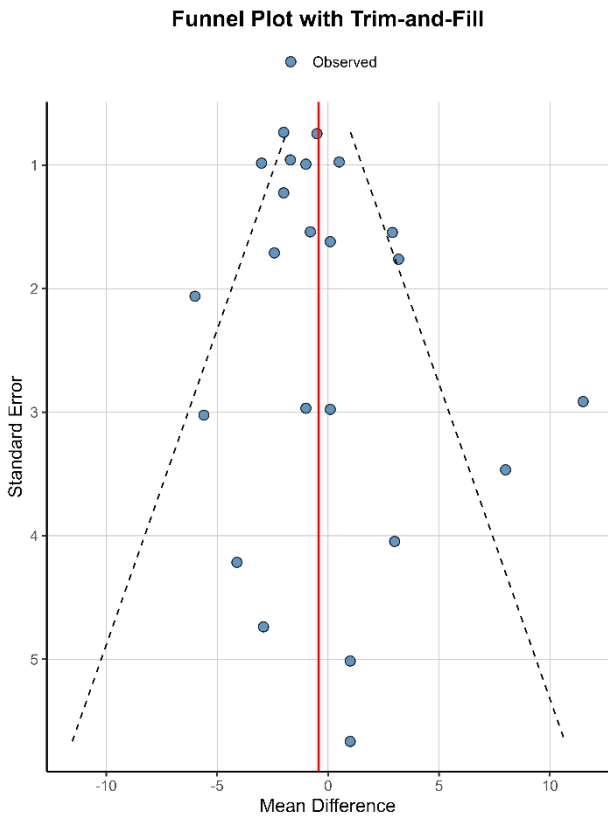


Figure S25.7. Trim-and-fill funnel plot for HRrest

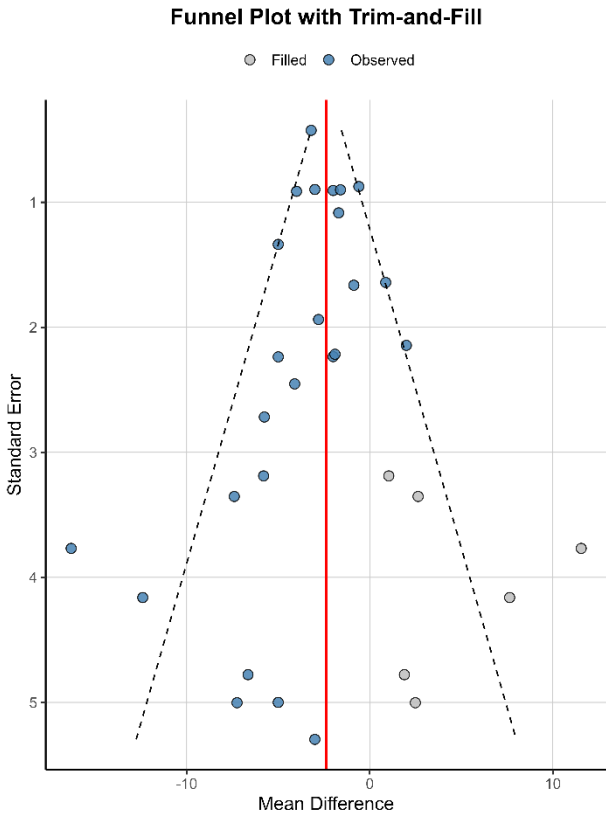


Figure S25.8. Trim-and-fill funnel plot for SBP

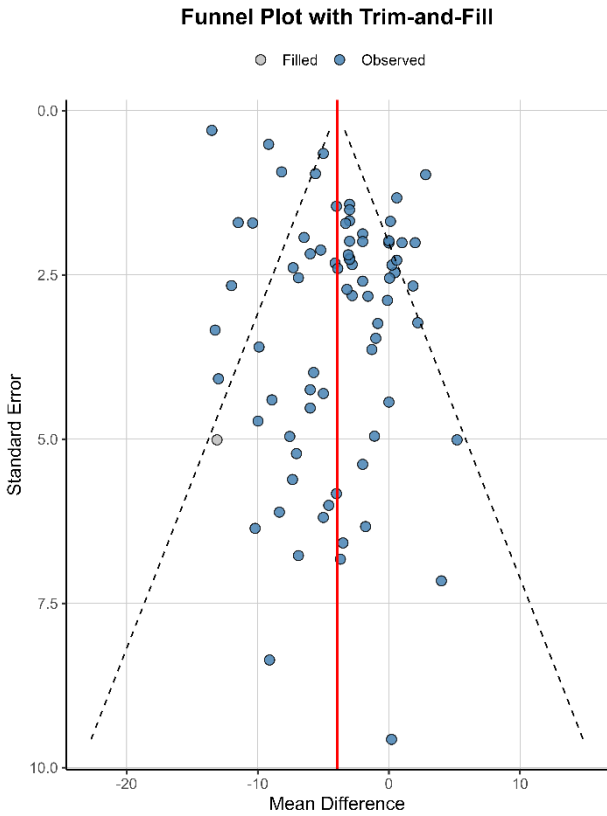


Figure S25.9. Trim-and-fill funnel plot for DBP

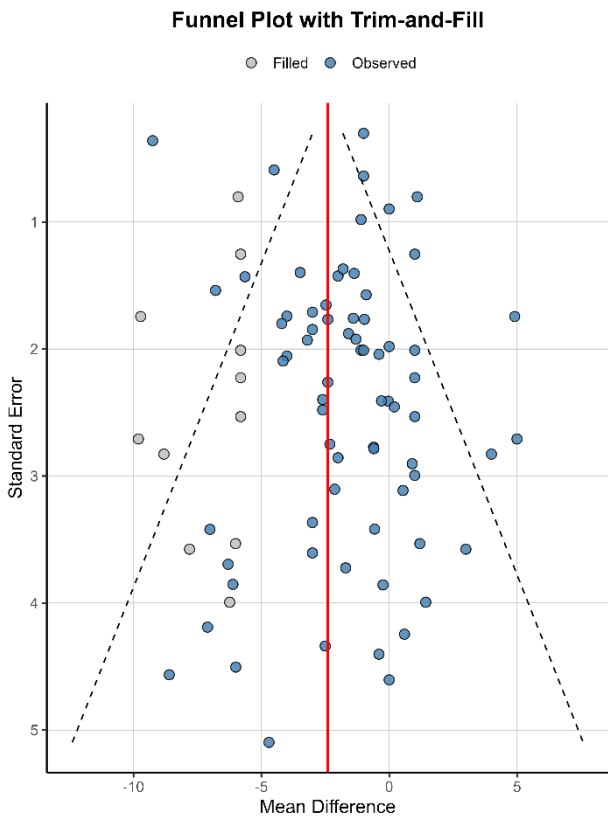


Figure S25.10. Trim-and-fill funnel plot for TC

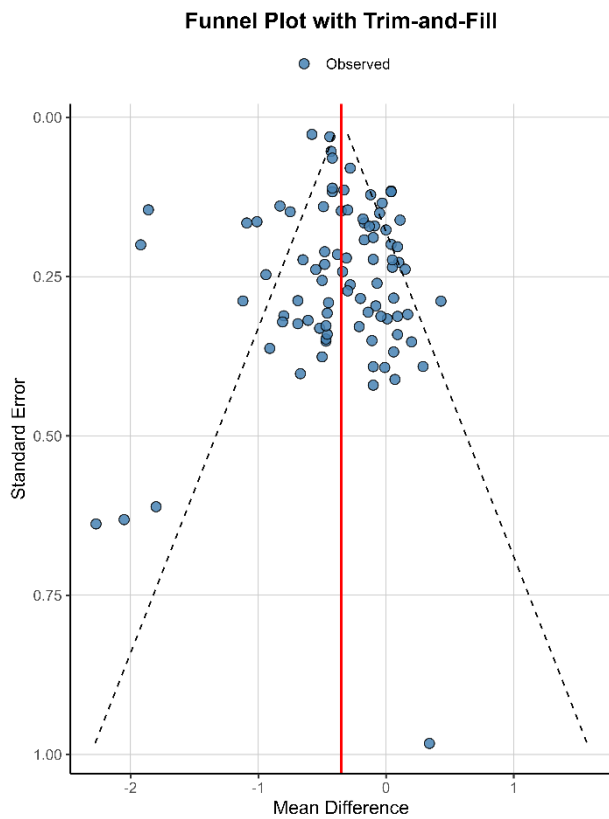


Figure S25.11. Trim-and-fill funnel plot for TG

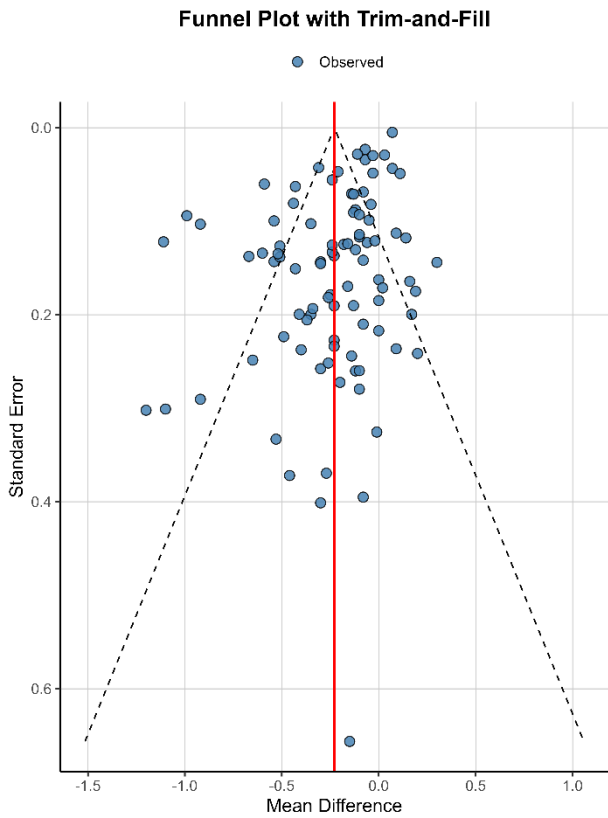


Figure S25.12. Trim-and-fill funnel plot for HDL-C

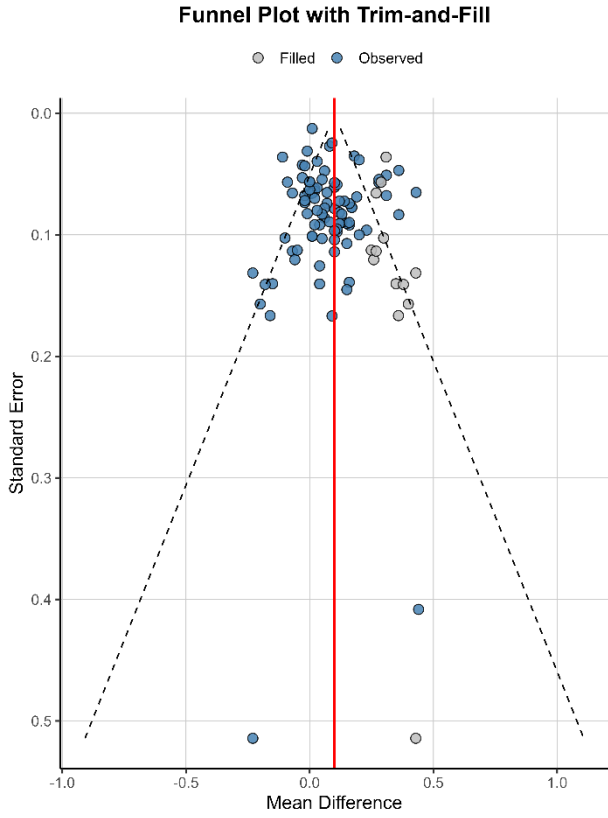


Figure S25.13. Trim-and-fill funnel plot for LDL-C

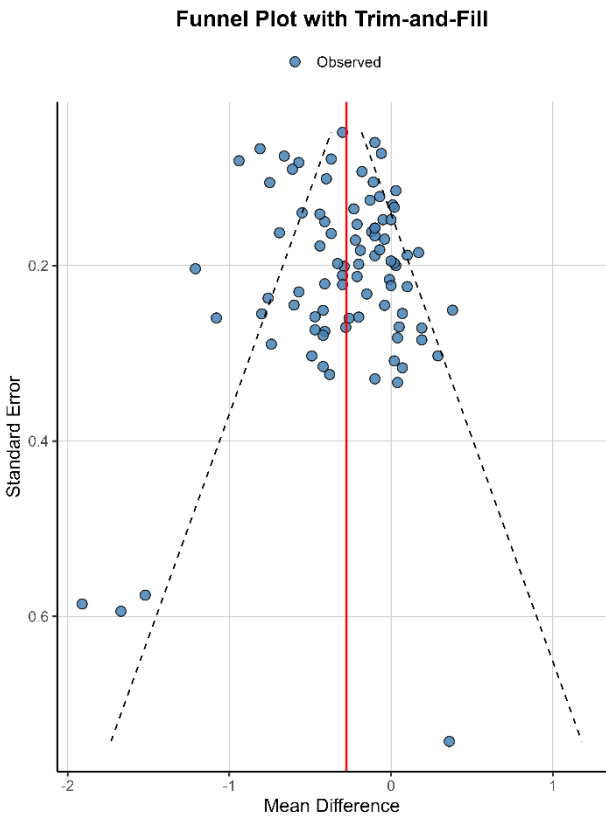


Figure S25.14. Trim-and-fill funnel plot for FPG

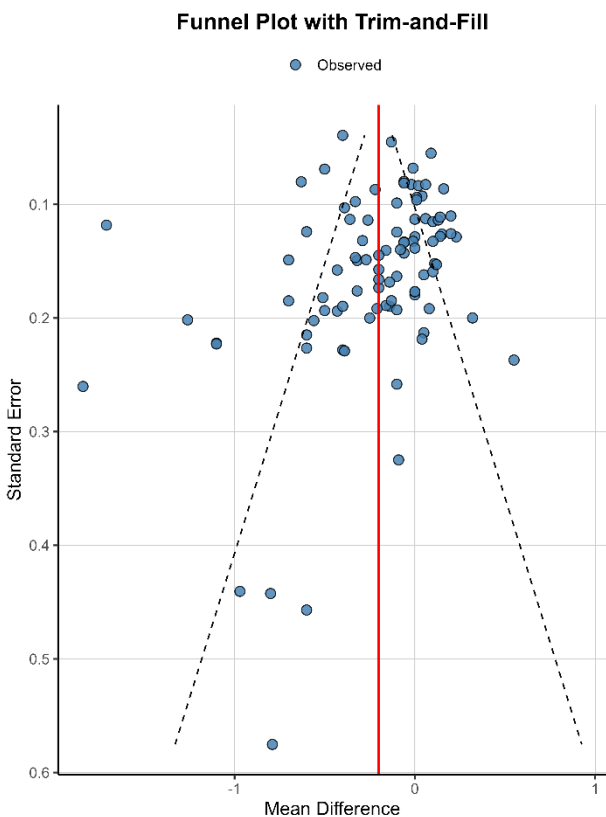


Figure S25.15. Trim-and-fill funnel plot for HbA1c

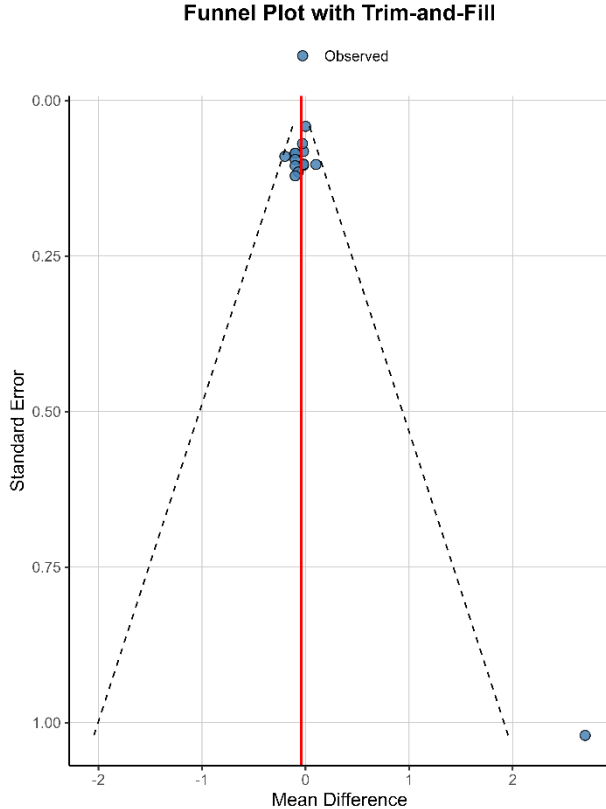


Figure S25.16. Trim-and-fill funnel plot for FINS

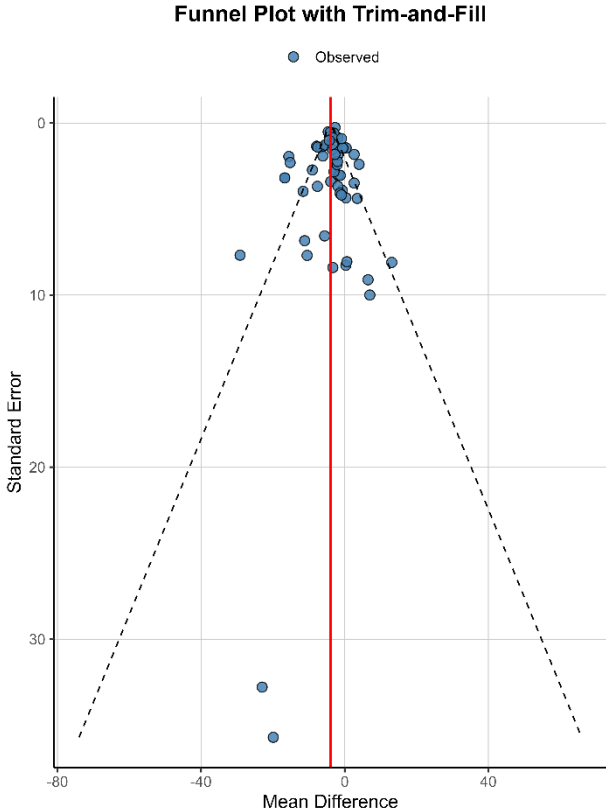


Figure S25.17. Trim-and-fill funnel plot for Depression

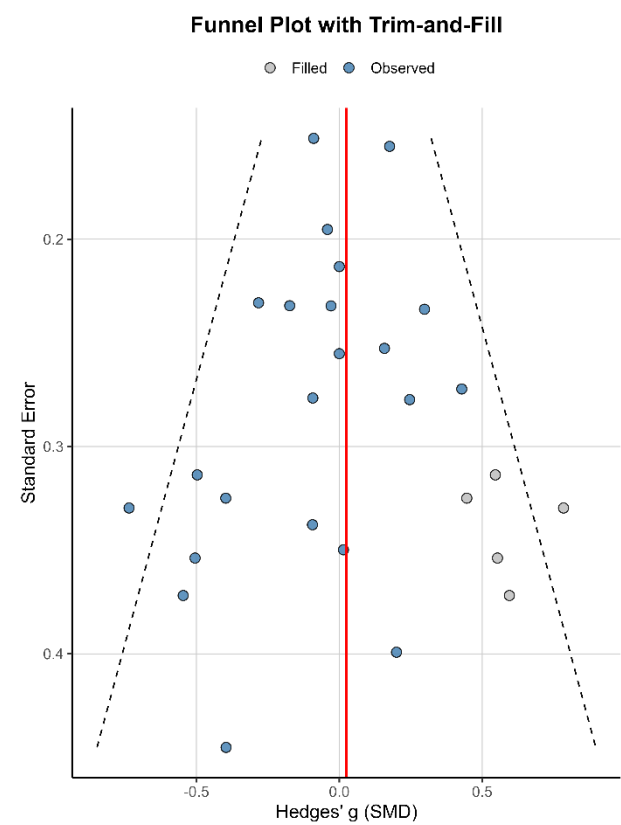


Figure S25.18. Trim-and-fill funnel plot for Anxiety

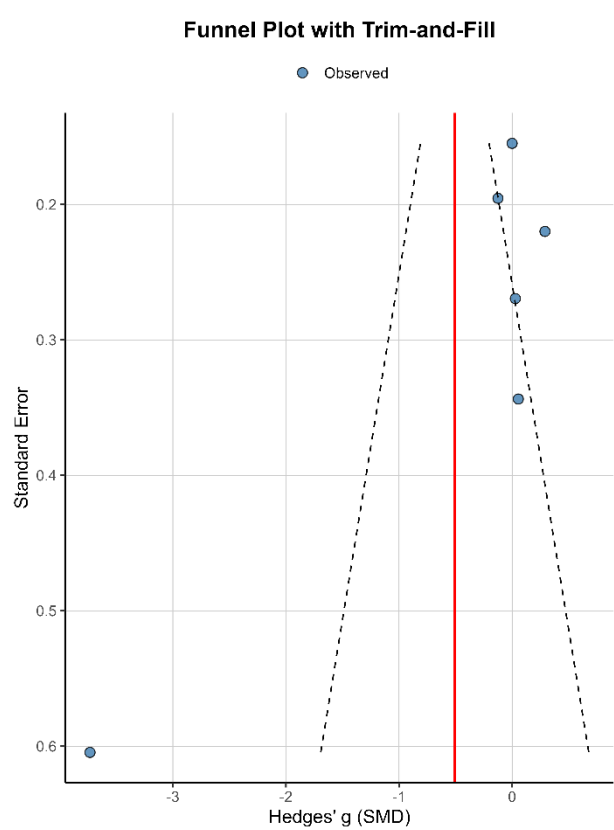


Figure S25.19. Trim-and-fill funnel plot for Self-esteem

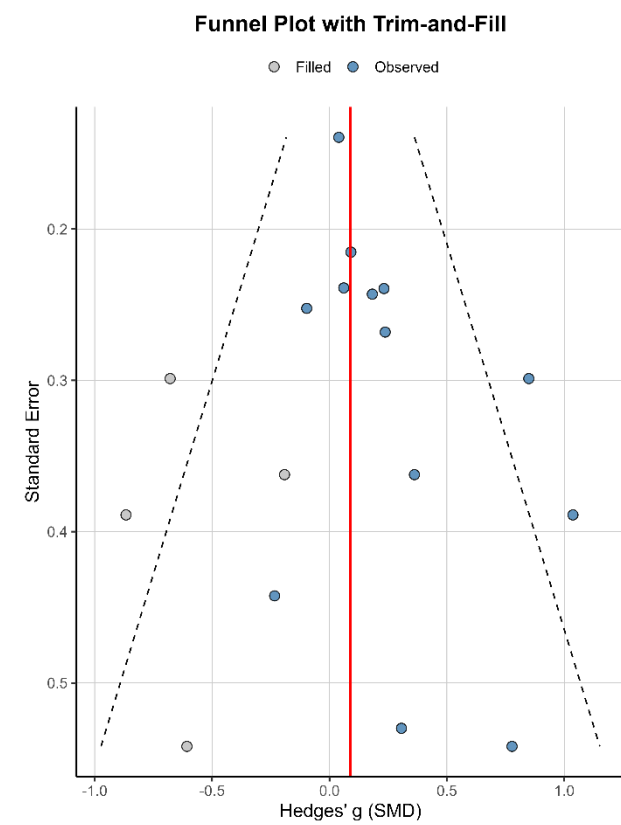
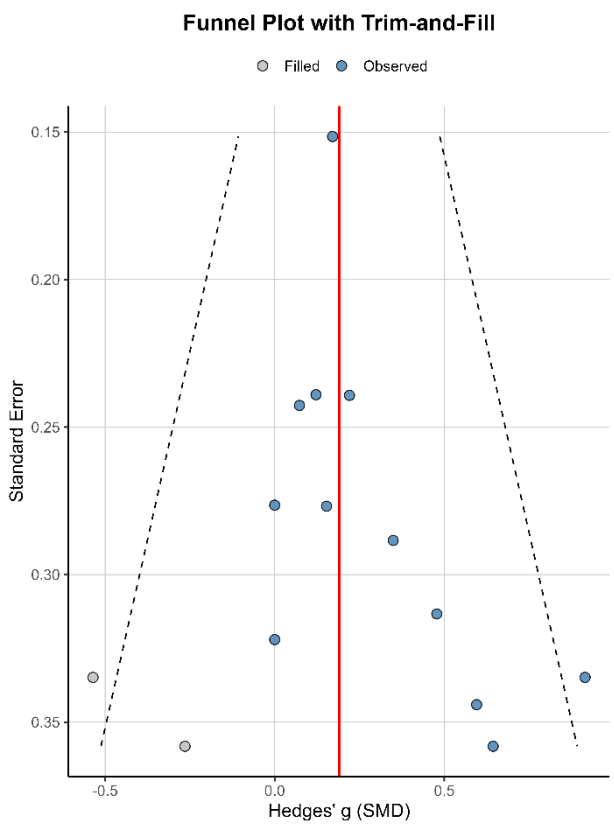


Figure S25.20. Trim-and-fill funnel plot for Self-worth



Appendix 5. List of all included studies in the meta-analysis

1. Abassi W, Ouerghi N and Feki M, et al. Effects of moderate- vs. High-intensity interval training on physical fitness, enjoyment, and affective valence in overweight/obese female adolescents: a pre-/post-test study. *Eur Rev Med Pharmacol Sci* 2023; 27: 3809-3822.
2. Abassi W, Ouerghi N and Ghouili H, et al. Greater effects of high- compared with moderate-intensity interval training on thyroid hormones in overweight/obese adolescent girls. *Horm Mol Biol Clin Investig* 2020; 41.
3. Abassi W, Ouerghi N and Nikolaidis PT, et al. Interval training with different intensities in overweight/obese adolescent females. *Int J Sports Med* 2022; 43: 434-443.
4. Ablakmu G, Minnan W and Yanhong H, et al. The effects of a low-energy balanced diet combined with aerobic exercise on body fat metabolism, insulin resistance, and oxidative stress in children with simple obesity. *Modern Biomedical Progress* 2022; 22: 3459-3462.
5. Aguilar-Cordero MJ, Rodriguez-Blanque R and Leon-Rios X, et al. Influence of physical activity on blood pressure in children with overweight/obesity: a randomized clinical trial. *Am J Hypertens* 2020; 33: 131-136.
6. Ahmadi A, Moheb-Mohammadi F and Navabi ZS, et al. The effects of aerobic training, resistance training, combined training, and healthy eating recommendations on lipid profile and body mass index in overweight and obese children and adolescents: a randomized clinical trial. *ARYA Atheroscler* 2020; 16: 226-234.
7. Alberga AS, Prud Homme D and Sigal RJ, et al. Effects of aerobic training, resistance training, or both on cardiorespiratory and musculoskeletal fitness in adolescents with obesity: the HEARTY trial. *Appl Physiol Nutr Metab* 2016; 41: 255-265.
8. Alves A, Venancio TL and Honorio S, et al. Multicomponent training with different frequencies on body composition and physical fitness in obese children. *An Acad Bras Cienc* 2019; 91: e20181264.
9. Azad A, Gharakhanlou R and Niknam A, et al. Effects of aerobic exercise on lung function in overweight and obese students. *Tanaffos* 2011; 10: 24-31.
10. Barbeau P, Johnson MH and Howe CA, et al. Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls. *Obesity (Silver Spring)* 2007; 15: 2077-2085.
11. Ben OO, Elloumi M and Zouhal H, et al. Effect of individualized exercise training combined with diet restriction on inflammatory markers and IGF-1/IGFBP-3 in obese children. *Ann Nutr Metab* 2010; 56: 260-266.
12. Benson AC, Torode ME and Fiatarone SM. The effect of high-intensity progressive resistance training on adiposity in children: a randomized controlled trial. *Int J Obes (Lond)* 2008; 32: 1016-1027.
13. Bezerra TA, Souza FA and Pessoa M, et al. Effects of a multicomponent intervention on cardiovascular risk factors in overweight children: a randomized clinical trial in light of complex systems. *Int J Environ Health Res* 2023; 33: 1368-1378.
14. Bharath LP, Choi WW and Cho J, et al. Combined resistance and aerobic exercise training reduces insulin resistance and central adiposity in adolescent girls who are obese: randomized clinical trial. *Eur J Appl Physiol* 2018; 118: 1653-1660.
15. Boer P, Meeus M and Terblanche E, et al. The influence of sprint interval training on body composition, physical and metabolic fitness in adolescents and young adults with intellectual disability: a randomized controlled trial. *Clin Rehabil* 2014; 28: 221-231.
16. Boff RM, Dornelles MA and Feoli A, et al. Transtheoretical model for change in obese adolescents: MERC randomized clinical trial. *J Health Psychol* 2020; 25: 2272-2285.
17. Bowen L and Zhengzhen W. The effect of short-term exercise and nutrition on certain metabolic indicators in obese adolescents. *Chinese Journal of Rehabilitation Theory and Practice* 2010; 16: 483-485.
18. Brennan L, Wilks R and Walkley J, et al. Treatment acceptability and psychosocial outcomes of a randomised controlled trial of a cognitive behavioural lifestyle intervention for overweight and obese adolescents. *Behav Change* 2012; 29: 36-62.
19. Bruyndonckx L, Hoymans VY and De Guchteneere A, et al. Diet, exercise, and endothelial function in obese adolescents.

Pediatrics (Evanston) 2015; 135: e653.

20. Cao M, Tang Y and Zou Y. Integrating high-intensity interval training into a school setting improve body composition, cardiorespiratory fitness and physical activity in children with obesity: a randomized controlled trial. *J Clin Med* 2022; 11: 5436.
21. Carrel AL, Clark RR and Peterson SE, et al. Improvement of fitness, body composition, and insulin sensitivity in overweight children in a school-based exercise program: a randomized, controlled study. *Archives of pediatrics & adolescent medicine* 2005; 159: 963-968.
22. Chae H, Kwon Y and Rhie Y, et al. Effects of a structured exercise program on insulin resistance, inflammatory markers and physical fitness in obese korean children. *J Pediatr Endocrinol Metab* 2010; 23: 1065.
23. Chuensiri N, Suksom D and Tanaka H. Effects of high-intensity intermittent training on vascular function in obese preadolescent boys. *Child Obes* 2018; 14: 41-49.
24. Croker H, Viner RM and Nicholls D, et al. Family-based behavioural treatment of childhood obesity in a UK national health service setting: randomized controlled trial. *Int J Obes (Lond)* 2012; 36: 16-26.
25. Crova C, Struzzolino I and Marchetti R, et al. Cognitively challenging physical activity benefits executive function in overweight children. *J Sports Sci* 2014; 32: 201-211.
26. Cvetković N, Stojanović E and Stojiljković N, et al. Exercise training in overweight and obese children: recreational football and high-intensity interval training provide similar benefits to physical fitness. *Scand J Med Sci Sports* 2018; 28: 18-32.
27. Daley AJ, Copeland RJ and Wright NP, et al. Exercise therapy as a treatment for psychopathologic conditions in obese and morbidly obese adolescents: a randomized, controlled trial. *Pediatrics* 2006; 118: 2126-2134.
28. Danielsen YS, Nordhus IH and Juliusson PB, et al. Effect of a family-based cognitive behavioural intervention on body mass index, self-esteem and symptoms of depression in children with obesity (aged 7-13): a randomised waiting list controlled trial. *Obes Res Clin Pract* 2013; 7: e116-e128.
29. Davis CL, Litwin SE and Pollock NK, et al. Exercise effects on arterial stiffness and heart health in children with excess weight: the SMART RCT. *Int J Obes (Lond)* 2020; 44: 1152-1163.
30. Davis JN, Kelly LA and Lane CJ, et al. Randomized control trial to improve adiposity and insulin resistance in overweight latino adolescents. *Obesity (Silver Spring)* 2009; 17: 1542-1548.
31. Davis JN, Tung A and Chak SS, et al. Aerobic and strength training reduces adiposity in overweight latina adolescents. *Med Sci Sports Exerc* 2009; 41: 1494-1503.
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34. Dennis BA, Ergul A and Gower BA, et al. Oxidative stress and cardiovascular risk in overweight children in an exercise intervention program. *Child Obes* 2013; 9: 15-21.
35. Dias KA, Ingul CB and Tjønnå AE, et al. Effect of high-intensity interval training on fitness, fat mass and cardiometabolic biomarkers in children with obesity: a randomised controlled trial. *Sports Med* 2018; 48: 733-746.
36. Duft RG, Castro A and Bonfante ILP, et al. Altered metabolomic profiling of overweight and obese adolescents after combined training is associated with reduced insulin resistance. *Sci Rep* 2020; 10: 16880.
37. Elmahgoub SM, Lambers S and Stegen S, et al. The influence of combined exercise training on indices of obesity, physical fitness and lipid profile in overweight and obese adolescents with mental retardation. *Eur J Pediatr* 2009; 168: 1327-1333.
38. Elnaggar RK, Shendy MA and Elfakharany MS. Effect of 8 weeks of incremental aerobic training on inflammatory mediators, cardiorespiratory indices, and functional capacity in obese children with bronchial asthma. *Pediatr Exerc Sci* 2021; 33: 23-31.
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supplementation on inflammatory adipokine, cytokine concentrations, and body composition in obese adolescent boys. *Nutrients* 2020; 12.

40. Espinoza-Silva M, Latorre-Román P and Párraga-Montilla J, et al. Response of obese schoolchildren to high-intensity interval training applied in the school context. *Endocrinología, Diabetes y Nutrición (English ed.)* 2019; 66: 611-619.
41. Faria WF, Mendonça FR and Santos GC, et al. Effects of 2 methods of combined training on cardiometabolic risk factors in adolescents: a randomized controlled trial. *Pediatr Exerc Sci* 2020; 32: 217-226.
42. Farpour-Lambert NJ, Aggoun Y and Marchand LM, et al. Physical activity reduces systemic blood pressure and improves early markers of atherosclerosis in pre-pubertal obese children. *J Am Coll Cardiol* 2009; 54: 2396-2406.
43. Farpour-Lambert NJ, Martin XE and Bucher DTS, et al. Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in pre-pubertal children. *Clin Obes* 2019; 9: e12335.
44. Ghorbanian B, Ravassi A and Reza M, et al. The effects of rope training on lymphocyte ABCA1 expression, plasma ApoA-I and HDL-c in boy adolescents. *Int J Endocrinol Metab* 2013; 11.
45. Goldfield GS, Kenny GP and Alberga AS, et al. Effects of aerobic training, resistance training, or both on psychological health in adolescents with obesity: the HEARTY randomized controlled trial. *J Consult Clin Psychol* 2015; 83: 1123-1135.
46. Gonzalez-Galvez N, Soler-Marin A and Abelleira-Lamela T, et al. Eight weeks of high-intensity interval vs. Sprint interval training effects on overweight and obese adolescents carried out during the cool-down period of physical education classes: randomized controlled trial. *Front Public Health* 2024; 12: 1394328.
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52. Hay J, Wittmeier K and Macintosh A, et al. Physical activity intensity and type 2 diabetes risk in overweight youth: a randomized trial. *Int J Obes (Lond)* 2016; 40: 607-614.
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