

Supplementary Table S1 Full search strategies for all databases

Databases	Search strategy
PubMed	<p>#1 "Chronic Pain"[Mesh]</p>
	<p>#2 ((((((((chronic pain[Title/Abstract]) OR (persistent pain[Title/Abstract])) OR (fibromyalgia[Title/Abstract])) OR (musculoskeletal pain[Title/Abstract])) OR (neuropathic pain[Title/Abstract])) OR (complex regional pain[Title/Abstract])) OR (low back pain[Title/Abstract])) OR (back pain[Title/Abstract])) OR (neck pain[Title/Abstract])) OR (shoulder pain[Title/Abstract])) OR (headache[Title/Abstract])</p>
	<p>#3 #1 OR #2</p>
	<p>#4 ("Exercise"[Mesh]) OR "Exercise Therapy"[Mesh] OR "Physical Fitness"[Mesh]</p>
	<p>#5 ((((((((((((((((((((exercise[Title/Abstract]) OR (exercise therapy[Title/Abstract])) OR (physical fitness[Title/Abstract])) OR (physical activity[Title/Abstract])) OR (physical therapy[Title/Abstract])) OR (aerobic exercise[Title/Abstract])) OR (aerobic training[Title/Abstract])) OR (resistance training[Title/Abstract])) OR (endurance training[Title/Abstract])) OR (strength training[Title/Abstract])) OR (stretching[Title/Abstract])) OR (walking[Title/Abstract])) OR (running[Title/Abstract])) OR (cycling[Title/Abstract])) OR (swimming[Title/Abstract])) OR (yoga[Title/Abstract])) OR ("tai chi"[Title/Abstract])) OR (qigong[Title/Abstract])) OR (pilates[Title/Abstract])</p>
	<p>#6 #4 OR #5</p>
	<p>#7 ("Cognitive Behavioral Therapy"[Mesh]) OR "Acceptance and Commitment Therapy"[Mesh]</p>

Continued Supplementary Table S1 Full search strategies for all databases

Databases	Search strategy
PubMed	<p>#8</p> <p>(((((cognitive behavioral therapy[Title/Abstract]) OR (cognitive behavioural therapy[Title/Abstract])) OR (CBT[Title/Abstract])) OR ("acceptance and commitment therapy"[Title/Abstract])) OR (ACT[Title/Abstract])) OR (dialectical behavior therapy[Title/Abstract])) OR (DBT[Title/Abstract])) OR (mindfulness-based cognitive therapy[Title/Abstract])) OR (MBCT[Title/Abstract])) OR (exposure therapy[Title/Abstract])) OR (behavioral activation[Title/Abstract])) OR (problem-solving therapy[Title/Abstract])</p>
	<p>#9</p> <p>#7 OR #8</p>
	<p>#10</p> <p>#3 AND #6 AND #9</p>
	<p>Filters: English, Humans</p>
Embase	<p>#1</p> <p>'chronic pain'/exp</p>
	<p>#2</p> <p>"chronic pain":ti,ab,kw OR "persistent pain":ti,ab,kw OR fibromyalgia:ti,ab,kw OR "musculoskeletal pain":ti,ab,kw OR "neuropathic pain":ti,ab,kw OR "complex regional pain":ti,ab,kw OR "low back pain":ti,ab,kw OR "back pain":ti,ab,kw OR "neck pain":ti,ab,kw OR "shoulder pain":ti,ab,kw OR headache:ti,ab,kw</p>
	<p>#3</p> <p>#1 OR #2</p>
	<p>#4</p> <p>'exercise'/exp OR 'kinesiotherapy'/exp OR 'physical activity'/exp</p>
	<p>#5</p> <p>exercise:ti,ab,kw OR kinesiotherapy:ti,ab,kw OR 'physical activity':ti,ab,kw OR 'aerobic exercise':ti,ab,kw OR 'aerobic training':ti,ab,kw OR 'resistance training':ti,ab,kw OR 'strength training':ti,ab,kw OR stretching:ti,ab,kw OR walking:ti,ab,kw OR cycling:ti,ab,kw OR yoga:ti,ab,kw OR 'tai chi':ti,ab,kw OR qigong:ti,ab,kw OR pilates:ti,ab,kw</p>

Continued Supplementary Table S1 Full search strategies for all databases

Databases	Search strategy
Embase	#6 #4 OR #5
	#7 'cognitive behavioral therapy'/exp OR 'acceptance and commitment therapy'/exp
	#8 "cognitive behavioral therapy":ti,ab,kw OR "cognitive behavioural therapy":ti,ab,kw OR CBT:ti,ab,kw OR "acceptance and commitment therapy":ti,ab,kw OR ACT:ti,ab,kw OR "dialectical behavior therapy":ti,ab,kw OR DBT:ti,ab,kw OR "mindfulness-based cognitive therapy":ti,ab,kw OR MBCT:ti,ab,kw OR "exposure therapy":ti,ab,kw OR "behavioral activation":ti,ab,kw OR "problem-solving therapy":ti,ab,kw
	#9 #7 OR #8
	#10 #3 AND #6 AND #9
	Filters: human
	Web of Science
#2 ((((((((((TS=(exercise)) OR TS=(exercise therapy)) OR TS=(physical activity)) OR TS=(aerobic training)) OR TS=(resistance training)) OR TS=(strength training)) OR TS=(stretching)) OR TS=(yoga)) OR TS=("tai chi")) OR TS=(qigong)) OR TS=(pilates))	
#3 ((((((((((TS=(cognitive behavioral therapy)) OR TS=(cognitive behavioural therapy)) OR TS=(CBT)) OR TS=(acceptance and commitment therapy)) OR TS=(ACT)) OR TS=(dialectical behavior therapy)) OR TS=(DBT)) OR TS=(mindfulness-based cognitive therapy)) OR TS=(MBCT)) OR TS=(exposure therapy)) OR TS=(behavioral activation) OR TS=(problem-solving therapy))	

Continued Supplementary Table S1 Full search strategies for all databases

Databases	Search strategy
Web of Science	<p>#4</p> <p>(((((TS=(random*)) OR TS=(randomized controlled trial)) OR TS=(randomised controlled trial)) OR TS=(controlled clinical trial)) OR TS=(clinical trial)) OR TS=(randomly allocated)</p>
	<p>#5</p> <p>#1 AND #2 AND #3 AND #4</p>
Cochrane Library	<p>#1</p> <p>MeSH descriptor: [Chronic Pain] explode all trees</p>
	<p>#2</p> <p>#1 OR (chronic pain):ti,ab,kw OR (persistent pain):ti,ab,kw OR (fibromyalgia):ti,ab,kw OR (musculoskeletal pain):ti,ab,kw OR (neuropathic pain):ti,ab,kw OR (complex regional pain):ti,ab,kw OR (low back pain):ti,ab,kw OR (back pain):ti,ab,kw OR (neck pain):ti,ab,kw OR (shoulder pain):ti,ab,kw OR (headache):ti,ab,kw</p>
	<p>#3</p> <p>MeSH descriptor: [Exercise] explode all trees</p>
	<p>#4</p> <p>MeSH descriptor: [Exercise Therapy] explode all trees</p>
	<p>#5</p> <p>MeSH descriptor: [Physical Fitness] explode all trees</p>
	<p>#6</p> <p>#3 OR #4 OR #5 OR (exercise):ti,ab,kw OR (exercise therapy):ti,ab,kw OR (physical fitness):ti,ab,kw OR (physical activity):ti,ab,kw OR (physical therapy):ti,ab,kw OR (aerobic exercise):ti,ab,kw OR (aerobic training):ti,ab,kw OR (resistance training):ti,ab,kw OR (endurance training):ti,ab,kw OR (strength training):ti,ab,kw OR (stretching):ti,ab,kw OR (walking):ti,ab,kw OR (running):ti,ab,kw OR (cycling):ti,ab,kw OR (swimming):ti,ab,kw OR (yoga):ti,ab,kw OR ("tai chi"):ti,ab,kw OR (qigong):ti,ab,kw OR (pilates):ti,ab,kw</p>
	<p>#7</p> <p>MeSH descriptor: [Cognitive Behavioral Therapy] explode all trees</p>

Continued Supplementary Table S1 Full search strategies for all databases

Databases	Search strategy
Cochrane Library	<p>#8 MeSH descriptor: [Acceptance and Commitment Therapy] explode all trees</p>
	<p>#9 #7 OR #8 OR (cognitive behavioral therapy):ti,ab,kw OR (cognitive behavioural therapy):ti,ab,kw OR (CBT):ti,ab,kw OR (acceptance and commitment therapy):ti,ab,kw OR (ACT):ti,ab,kw OR (dialectical behavior therapy):ti,ab,kw OR (DBT):ti,ab,kw OR (mindfulness-based cognitive therapy):ti,ab,kw OR (MBCT):ti,ab,kw OR (exposure therapy):ti,ab,kw OR (behavioral activation):ti,ab,kw OR (problem-solving therapy):ti,ab,kw</p>
	<p>#10 #2 AND #6 AND #9</p>
	<p>#11 Filters: Trials, English</p>
PsycINFO	<p>#1 SU (Chronic Pain)</p>
	<p>#2 AB (chronic pain) OR AB (persistent pain) OR AB (fibromyalgia) OR AB (musculoskeletal pain) OR AB (neuropathic pain) OR AB (complex regional pain) OR AB (low back pain) OR AB (back pain) OR AB (neck pain) OR AB (shoulder pain) OR AB (headache)</p>
	<p>#3 #1 OR #2</p>
	<p>#4 SU (Exercise) OR SU (Exercise Therapy) OR SU (Physical Activity)</p>
	<p>#5 AB (exercise) OR AB (exercise therapy) OR AB (physical fitness) OR AB (physical activity) OR AB (physical therapy) OR AB (aerobic exercise) OR AB (aerobic training) OR AB (resistance training) OR AB (endurance training) OR AB (strength training) OR AB (stretching) OR AB (walking) OR AB (running) OR AB (cycling) OR AB (swimming) OR AB (yoga) OR AB ("tai chi") OR AB (qigong) OR AB (pilates)</p>

Continued Supplementary Table S1 Full search strategies for all databases

Databases	Search strategy
PsycINFO	#6 #4 OR #5
	#7 SU (Cognitive Behavioral Therapy) OR SU ("Acceptance and Commitment Therapy")
	#8 AB (cognitive behavioral therapy) OR AB (cognitive behavioural therapy) OR AB (CBT) OR AB ("acceptance and commitment therapy") OR AB (ACT) OR AB (dialectical behavior therapy) OR AB (DBT) OR AB (mindfulness-based cognitive therapy) OR AB (MBCT) OR AB (exposure therapy) OR AB (behavioral activation) OR AB (problem-solving therapy)
	#9 #7 OR #8
	#10 #3 AND #6 AND #9

Abbreviations: ab, abstract; exp, explode; kw, keyword; ti, title; AB, abstract; MeSH, Medical Subject Headings; SU, subject heading; TS, topic.

Notes: # indicates the sequential search sets or steps used within each database search strategy; * indicates truncation and retrieves words with different endings.

Supplementary Table S2 Outcomes and measurement tools used in the included studies

Study	Pain intensity	Functional disability	Catastrophizing	Pain self-efficacy	Fear of movement	Anxiety	Depression	Quality of life	Physical performance
Aliyu et al 2018 ²⁷	VAS	ODI	—	—	—	—	—	—	—
Andersen et al 2021 ²⁸	NRS	NDI	PCS	PSEQ	TSK	DASS-21	DASS-21	SF-12	—
Casey et al 2022 ²⁹	BPI	—	PCS	PSEQ	TSK	GAD-7	PHQ-9	—	—
Cheng et al 2022 ³⁰	CPGQ	CPGQ	PCS-7	CPSS-11	—	—	CESD-10	SF-12	—
Hirase et al 2018 ³¹	NRS	—	PCS	—	—	—	GDS-15	—	TUG
Hrkac et al 2022 ³²	VAS	RMDQ	—	—	—	HADS	HADS	SF-12	—
Kang et al 2024 ³³	NRS	ODI	PCS	—	—	—	PHQ-9	—	—
Lera et al 2009 ³⁴	—	—	—	—	—	—	—	SF-36	—
Liu et al 2025 ³⁵	NRS	RMDQ	—	—	—	DASS-21	DASS-21	—	TUG; 6MWT

Continued Supplementary Table S2 Outcomes and measurement tools used in the included studies

Study	Pain intensity	Functional disability	Catastrophizing	Pain self-efficacy	Fear of movement	Anxiety	Depression	Quality of life	Physical performance
McBeth et al 2012 ³⁶	—	—	—	—	TSK	—	—	SF-36	—
Monticone et al 2012 ³⁷	NRS	NPDS	—	—	—	—	—	—	—
Monticone et al 2014 ³⁸	NRS	ODI	PCS	—	TSK	—	—	—	6MWT
van Koulik et al 2010 ³⁹	NRS	IRGL	IRGL	—	—	—	—	—	—

Abbreviations: BPI, Brief Pain Inventory; CESD-10, Center for Epidemiologic Studies Depression Scale-10; CPGQ, Chronic Pain Grade Questionnaire; CPSS-11, Chronic Pain Self-Efficacy Scale-11; DASS-21, Depression Anxiety Stress Scales-21; GAD-7, Generalized Anxiety Disorder-7; GDS-15, Geriatric Depression Scale-15; HADS, Hospital Anxiety and Depression Scale; IRGL, Impact of Rheumatic Diseases on General Health and Lifestyle; NDI, Neck Disability Index; NPDS, Neck Pain and Disability Scale; NRS, Numerical Rating Scale; ODI, Oswestry Disability Index; PCS, Pain Catastrophizing Scale; PCS-7, Pain Catastrophizing Scale-7; PHQ-9, Patient Health Questionnaire-9; PSEQ, Pain Self-Efficacy Questionnaire; RMDQ, Roland-Morris Disability Questionnaire; SF-12, 12-Item Short Form Health Survey; SF-36, 36-Item Short Form Health Survey; TSK, Tampa Scale for Kinesiophobia; TUG, Timed Up and Go Test; VAS, Visual Analog Scale; 6MWT, 6-Minute Walk Test.

Supplementary Table S3 Detailed characteristics of the combined interventions

Study	CBT provider	Intervention frequency	Intervention details	
			T	C
Aliyu et al 2018 ²⁷	Physiotherapist	CBT: 6 weeks, 2 sessions/week. Exercise: 6 weeks, 3 sessions/week, 30 mins/session.	<p>CBT + exercise</p> <p>CBT: Based on the CBT manual, including assessment, pain education, pacing, relaxation training, pleasant activities, cognitive coping, sleep strategies and discharge planning in 12 sessions.</p> <p>Exercise: Same as control group.</p>	<p>Exercise</p> <p>Exercise: Based on the protocol, including cat-camel, curl-up, side-bridge and bird-dog exercises.</p>
Andersen et al 2021 ²⁸	Psychologist	CBT: 10 weeks, 1 session/week, 60-90 mins/session. Exercise: 10 sessions in 6 weeks.	<p>CBT + exercise</p> <p>CBT: Comprised trauma-focused psychoeducation, progressive muscle relaxation, cognitive restructuring, exposure, relapse prevention, and home exercises.</p> <p>Exercise: Individually tailored exercises targeting movement, strength, endurance, and coordination, with progressive loading and guided return to general aerobic and normal daily activities.</p>	<p>Supportive therapy + exercise</p> <p>ST: Psychoeducation, discussion of current issues, general problem-solving skills, and home diary exercises, avoiding exposure, cognitive restructuring, and anxiety-management techniques.</p> <p>Exercise: Same as experimental group.</p>
Casey et al 2022 ²⁹	Psychologist	ACT: 8 weeks, 1 session/week, 2 h/session. Exercise: 8 weeks, 1 session/week, 1.5 h/session.	<p>ACT + supervised exercise</p> <p>ACT: The ACT intervention was designed to promote psychological flexibility and reduce pain-avoidant behaviours, delivered in group discussions, experiential exercises, and mindfulness practice.</p> <p>Exercise: Same as control group.</p>	<p>Supervised exercise</p> <p>Exercise: Consisted of education and advice (goal setting, understanding pain, pacing and graded exposure, and problem solving) and exercises delivered in the gym and hydrotherapy pool, including aerobic, strengthening, buoyancy-assisted, and graded exercises.</p>

Continued Supplementary Table S3 Detailed characteristics of the combined interventions

Study	CBT provider	Intervention frequency	Intervention details	
			T	C
Cheng et al 2022 ³⁰	Research assistant	CBT-informed: 10 weeks, 1 session/week, 45 mins/session. Exercise: 10 weeks, 1 session/week, 45 mins/session.	<p>CBT-informed + physical exercise</p> <p>CBT-informed: Cognitive-behavioral concepts and techniques, including relaxation, stress management, goal setting, assertive communication, self-compassion, and positive self-statements, based on existing manuals.</p> <p>Exercise: Consisted of stretching, strengthening, and balancing exercises.</p>	<p>Pain education</p> <p>Pain education: The program is based on a brochure to promote self-management of pain.</p>
Hirase et al 2018 ³¹	Physical therapist	CBT-informed: 12 weeks. Exercise: 12 weeks, 1 session/week, 60 mins/session.	<p>CBT-informed + exercise training</p> <p>CBT-informed: Received self-management education and cognitive behavioural therapy to change participants' focus on pain.</p> <p>Exercise: Same as control group.</p>	<p>Exercise training</p> <p>Exercise: Strength and balance training.</p>
Hrkac et al 2022 ³²	Physical therapist	CBT-informed: Integrated within exercise sessions. Exercise: 4 weeks, 2 sessions/week, 60 mins/session.	<p>CBT-informed + graded activity + education</p> <p>CBT-informed: Face-to-face, group-based graded activity incorporating cognitive-behavioral principles, including time-contingent progression, pacing/quotas, goal setting, and reinforcement of positive activity behaviors.</p> <p>Exercise: Combined aerobic, stretching, flexibility, core stabilization, resistance, balance, coordination, and breathing exercises delivered in an individually tailored, quota-based and time-contingent manner as part of the graded activity program.</p>	<p>C1: Supervised exercise + education</p> <p>Exercise: Supervised group-based exercise therapy, including aerobic exercise, stretching and flexibility training, core stabilization, motor control, resistance training, balance and coordination, and breathing exercises.</p> <p>C2: Usual care</p> <p>Usual care: Received usual care only, without supervised exercise or biopsychosocial components.</p>

Continued Supplementary Table S3 Detailed characteristics of the combined interventions

Study	CBT provider	Intervention frequency	Intervention details	
			T	C
Kang et al 2024 ³³	Smartphone app	<p>CBT-informed: 8 weeks, 1 session/week.</p> <p>Exercise: 8 weeks, 6 sessions/week.</p>	<p>CBT-informed + exercise therapy</p> <p>CBT-informed: Smartphone-delivered CBT targeting pain-related negative emotions, coping and relaxation skills, and self-management via cognitive restructuring, positive self-talk, and setback strategies.</p> <p>Exercise: AI-guided, patient-tailored exercise focusing on core and lower-limb strengthening with stretching, adjusted by pain levels using progressive overload.</p>	<p>Exercise therapy</p> <p>Exercise: Conventional exercise with controlled intensity and self-directed home exercises based on educational materials.</p>
Lera et al 2009 ³⁴	Psychologist	<p>CBT: 15 weeks, 1 session/week, 90 mins/session.</p> <p>Exercise: 10 sessions in 4 months, 40 mins/session.</p>	<p>CBT + physical exercise + education</p> <p>CBT: Structured program including pain education, mind–body techniques, sleep-related behavioral strategies, activity planning, cognitive restructuring, coping and assertiveness training.</p> <p>Exercise: Same as control group.</p>	<p>Physical exercise + education</p> <p>Exercise: Consisted of aerobic exercises (static bicycle or fast walking) combined with muscle stretching and restoration exercises.</p>
Liu et al 2025 ³⁵	Psychologist	<p>ACT: 8 weeks, 1 session/week, 60 mins/session.</p> <p>Exercise: 8 weeks, 1 supervised session/week (30 mins) + 2 home sessions/week (30 mins each).</p>	<p>ACT + exercise</p> <p>ACT: Strategies targeting cognitive defusion, acceptance, present-moment awareness, self-as-context, values clarification, and committed action.</p> <p>Exercise: Same as control group.</p>	<p>Exercise + education</p> <p>Exercise: Strengthening exercises and specific back stretching designed to improve core stability, motor control, and reduce lumbar muscle tightness.</p>

Continued Supplementary Table S3 Detailed characteristics of the combined interventions

Study	CBT provider	Intervention frequency	Intervention details	
			T	C
McBeth et al 2012 ³⁶	Therapist	<p>CBT: 1 initial assessment + 7 weeks, 1 session/week, 30-45 mins/session + 2 booster sessions at 3 and 6 months.</p> <p>Exercise: ≥ 2 sessions/week, 20-60 mins/session, with 6 monthly instructor-led reassessment.</p>	<p>CBT + graded exercise</p> <p>CBT: Telephone-delivered CBT including patient-centered assessment, goal setting, and CBT manual such as behavioral activation, cognitive restructuring, lifestyle self-management, and relapse prevention.</p> <p>Exercise: A facility-based exercise program consistent with ACSM guidelines and designed to improve cardiorespiratory fitness, with individually negotiated exercise intensity and instructor-led supervision.</p>	<p>C1: Graded exercise Exercise: Same as experimental group.</p> <p>C2: CBT CBT: Same as experimental group.</p> <p>C3: Usual care Usual care: Received the usual care from their family physician.</p>
Monticone et al 2012 ³⁷	Physiotherapist	<p>CBT: Integrated within exercise sessions.</p> <p>Exercise: 8-12 weeks, 1-2 sessions/week, up to 12 sessions, 45-50 mins/session.</p>	<p>CBT-informed + exercise</p> <p>CBT-informed: Individual cognitive-behavioural therapy focusing on patients' beliefs, negative automatic thoughts and behaviours, combined with graded activities, graded exposure, and the development of coping strategies and pacing skills.</p> <p>Exercise: Same as control group.</p>	<p>Exercise</p> <p>Exercise: Individualized physiotherapy including passive and active neck mobilization, postural control exercises, strengthening and stretching.</p>
Monticone et al 2014 ³⁸	Psychologist	<p>CBT: 8 weeks, 1 session/week, 60 mins/session.</p> <p>Exercise: 8 weeks, 2 sessions/week, 60 mins/session.</p>	<p>CBT + exercise</p> <p>CBT: Individual CBT targeting fear of movement and catastrophizing, including explanation of the fear-avoidance model, cognitive reconditioning, and graded exposure to feared activities.</p> <p>Exercise: Individualized spinal stabilization exercises, in addition to usual care rehabilitation, based on assessment of lumbar movement dysfunction and aimed at improving dynamic trunk stabilization.</p>	<p>Usual care</p> <p>Usual care: Usual care including passive spinal mobilisation and basic functional rehabilitation.</p>

Continued Supplementary Table S3 Detailed characteristics of the combined interventions

Study	CBT provider	Intervention frequency	Intervention details	
			T	C
van Koulil et al 2010 ³⁹	Therapist	<p>CBT: 8 weeks, 2 sessions/week, 2 h/session + 1 booster session at 3 months.</p> <p>Exercise: 8 weeks, 2 sessions/week, 2 h/session + 1 booster session at 3 months.</p>	<p>CBT + exercise</p> <p>CBT: Tailored group-based CBT delivered according to either pain-avoidance or pain-persistence cognitive-behavioral patterns, including structured goal setting, cognitive restructuring, graded activity/exposure, pacing strategies, partner involvement, and relapse-prevention components.</p> <p>Exercise: Relaxation training, aerobic exercises (cycling and gymnastic activities), and hydrotherapy or anaerobic exercises, including strength, flexibility, and functional walking training.</p>	Wait-list
<p>Abbreviations: h, hour; mins, minutes; ACSM, American College of Sports Medicine; ACT, acceptance and commitment therapy; AI, artificial intelligence; CBT, cognitive behavioral therapy; CBT-informed, cognitive behavioral therapy-informed; ST, supportive therapy.</p> <p>Notes: T indicates the treatment group; C indicates the control group; C1, C2, and C3 indicate control subgroup 1, control subgroup 2, and control subgroup 3, respectively.</p>				

Supplementary Table S4 Detailed GRADE assessment for post-intervention outcomes

Outcome	No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	CBT + exercise (n)	Control (n)	Effect estimate	Certainty of evidence
Pain intensity	11	Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	472	547	SMD = -0.44, 95% CI: [-0.72, -0.16]	Moderate
Functional disability	9	Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	341	421	SMD = -0.41, 95% CI: [-0.68, -0.15]	Moderate
Pain catastrophizing	6	Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	270	267	MD = -4.35, 95% CI: [-7.13, -1.56]	Moderate
Pain self-efficacy	3	Randomized trials	Not serious	Not serious	Not serious	Not serious	None	182	175	SMD = 0.30, 95% CI: [0.09, 0.51]	High
Depression	7	Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	343	400	SMD = -0.27, 95% CI: [-0.42, -0.12]	Moderate

Abbreviations: CBT, cognitive behavioral therapy; CI, confidence interval; GRADE, Grading of Recommendations Assessment, Development and Evaluation; MD, mean difference; SMD, standardized mean difference.

Notes: Evidence from randomized controlled trials started as high-certainty evidence and was downgraded when concerns were identified in GRADE domains. ^a Some included studies had concerns regarding the randomization process and outcome measurement.

Supplementary Table S5 Detailed GRADE assessment for 3-, 6-, and 12-month follow-up outcomes of pain intensity and functional disability

Outcome	No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	CBT + exercise (n)	Control (n)	Effect estimate	Certainty of evidence
Pain intensity (3-month follow-up)	4	Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	212	259	SMD = -0.59, 95% CI: [-1.00, -0.17]	Moderate
Pain intensity (6-month follow-up)	5	Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	239	304	SMD = -0.50, 95% CI: [-0.83, -0.17]	Moderate
Pain intensity (12-month follow-up)	3	Randomized trials	Serious ^b	Not serious	Not serious	Not serious	None	118	117	SMD = -0.11, 95% CI: [-0.37, 0.15]	Moderate
Functional disability (3-month follow-up)	3	Randomized trials	Not serious	Not serious	Not serious	Not serious	None	143	189	SMD = -0.71, 95% CI: [-1.16, -0.26]	High
Functional disability (6-month follow-up)	5	Randomized trials	Serious ^c	Not serious	Not serious	Not serious	None	240	305	SMD = -0.48, 95% CI: [-0.84, -0.13]	Moderate
Functional disability (12-month follow-up)	2	Randomized trials	Not serious	Not serious	Not serious	Not serious	None	76	78	SMD = -0.15, 95% CI: [-0.67, 0.37]	High

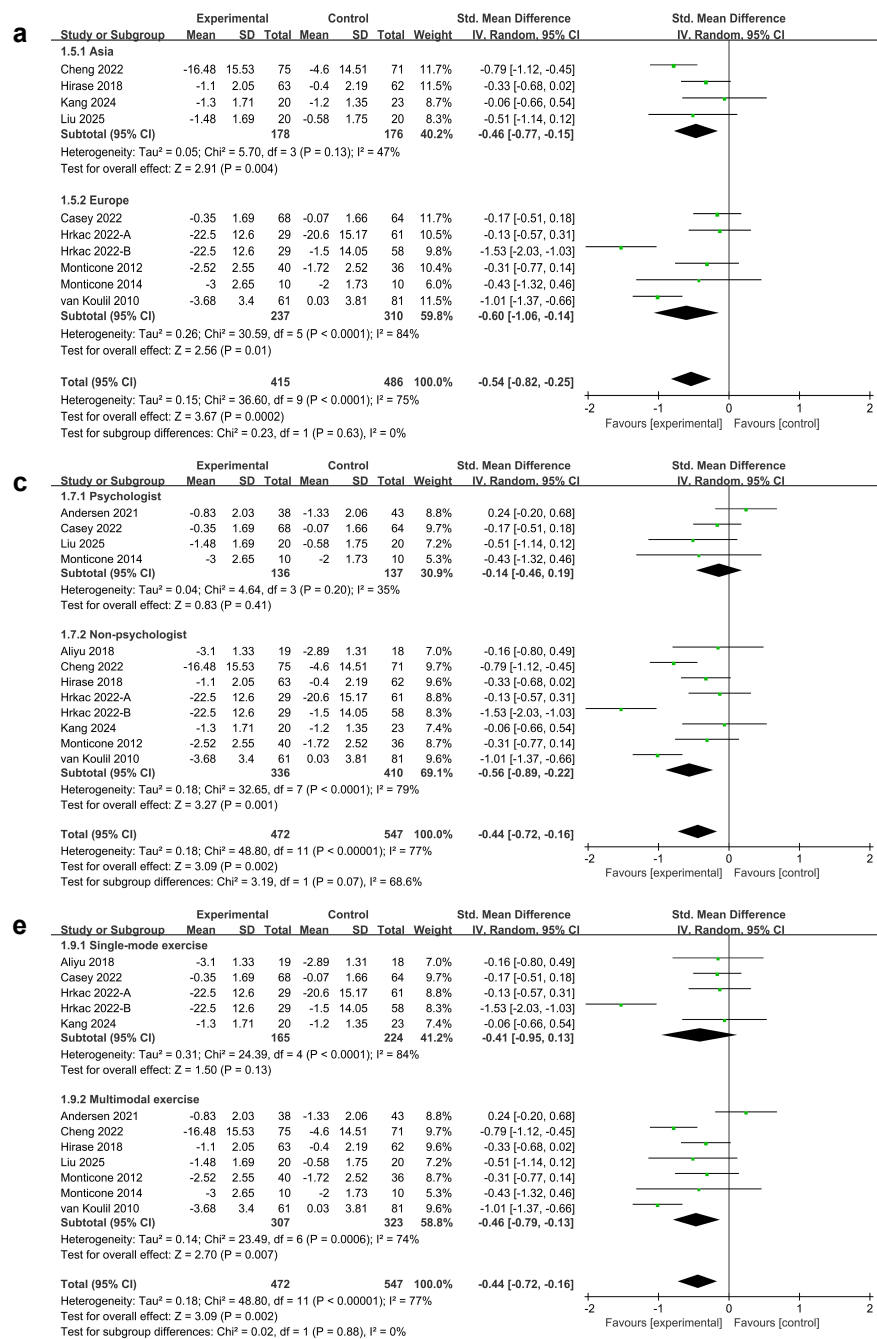
Abbreviations: CBT, cognitive behavioral therapy; CI, confidence interval; GRADE, Grading of Recommendations Assessment, Development and Evaluation; SMD, standardized mean difference.

Notes: Evidence from randomized controlled trials started as high-certainty evidence and was downgraded when concerns were identified in GRADE domains.

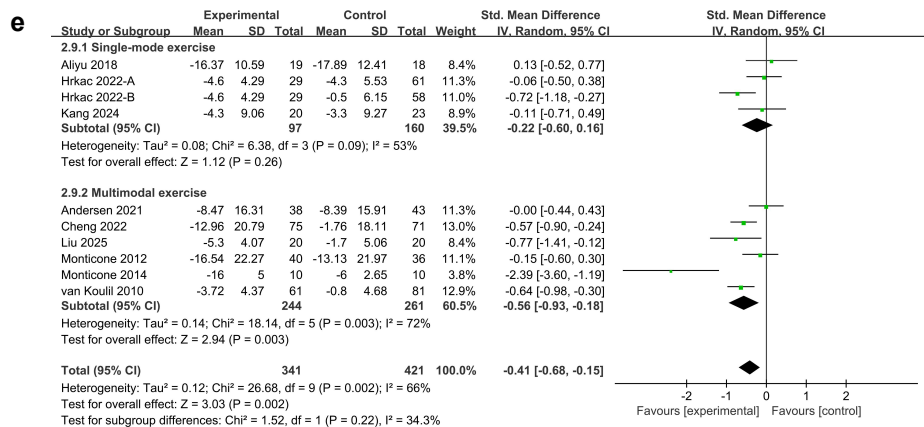
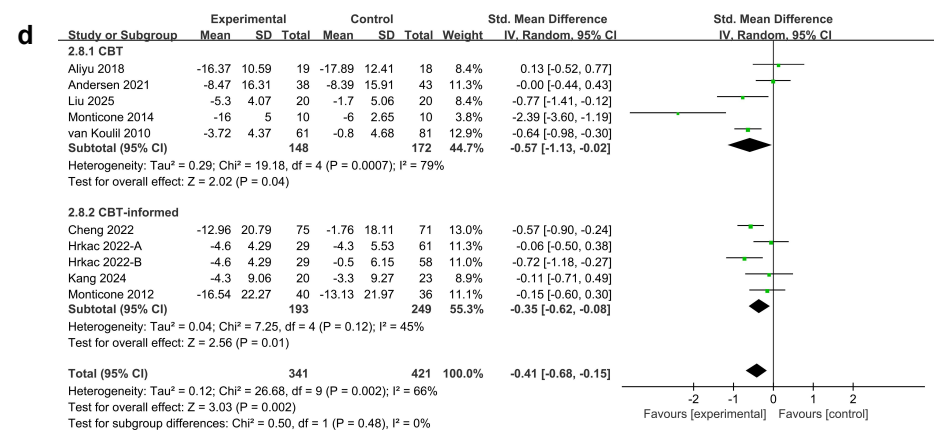
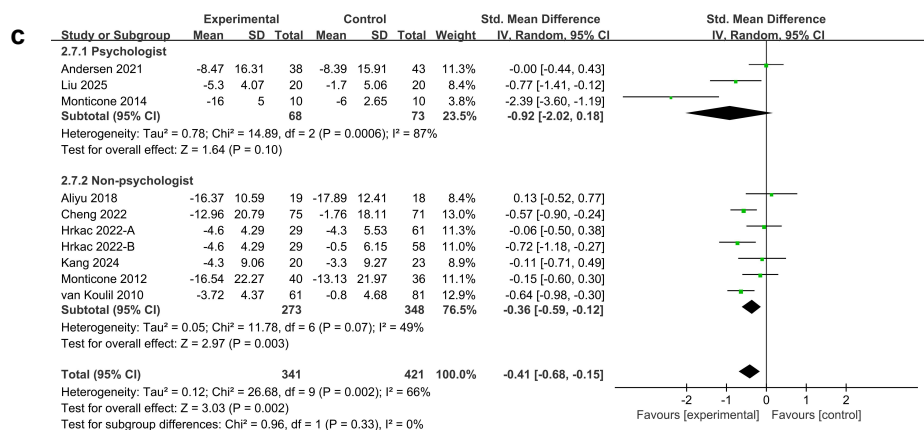
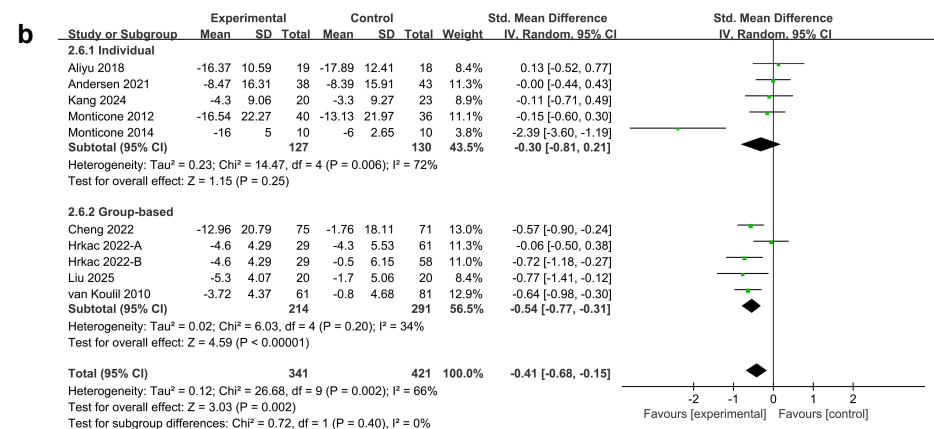
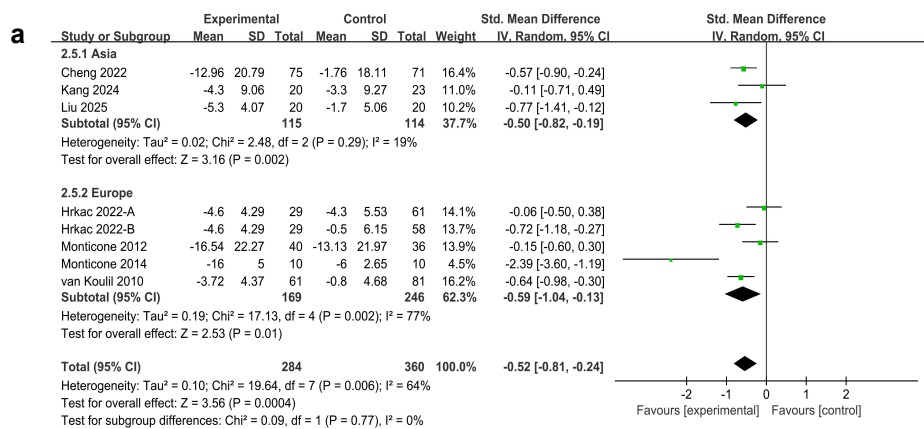
^a Some included studies had concerns regarding the randomization process.

^b Some included studies had concerns regarding deviations from intended interventions.

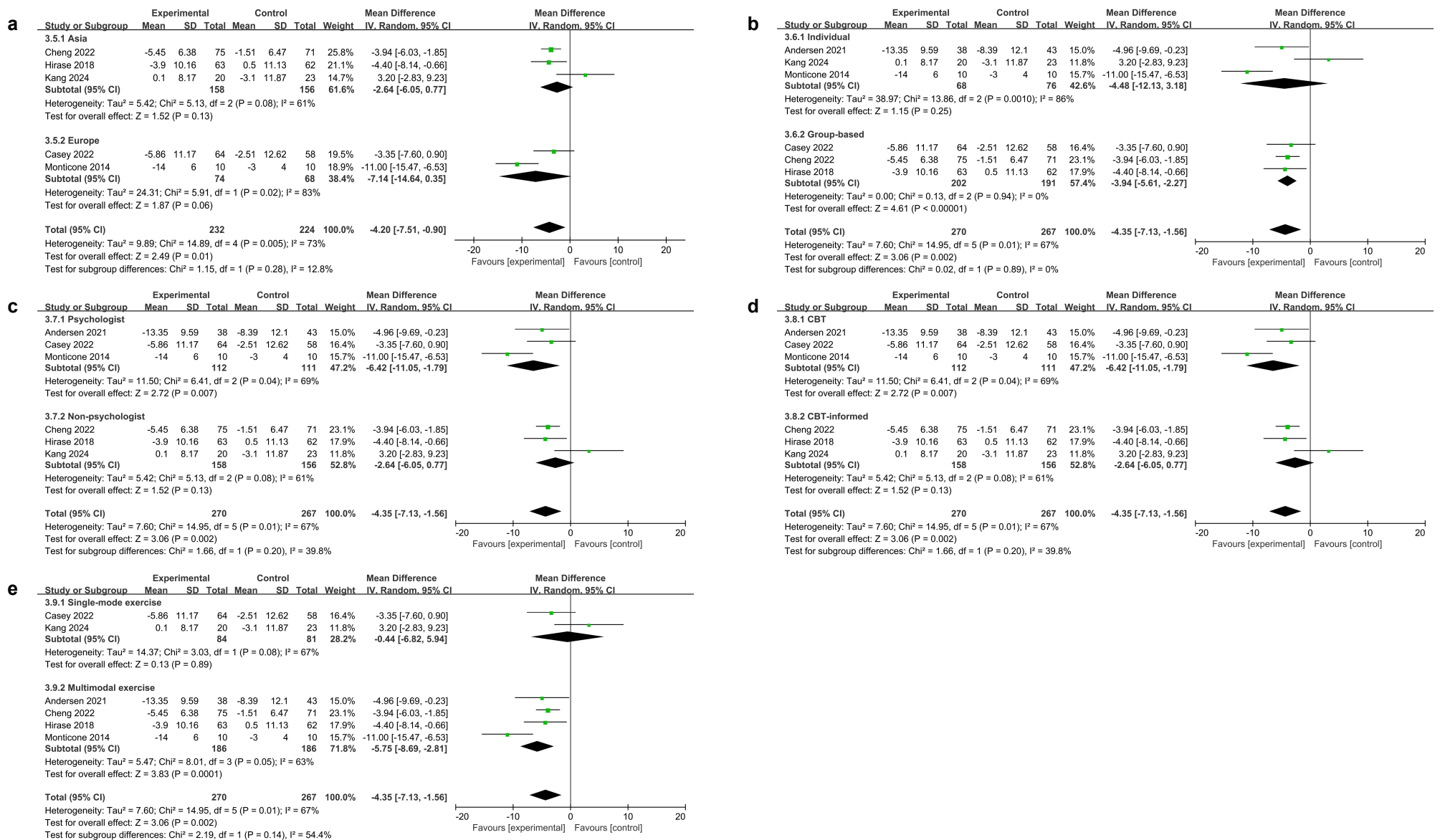
^c Some included studies had concerns regarding the randomization process and outcome measurement.



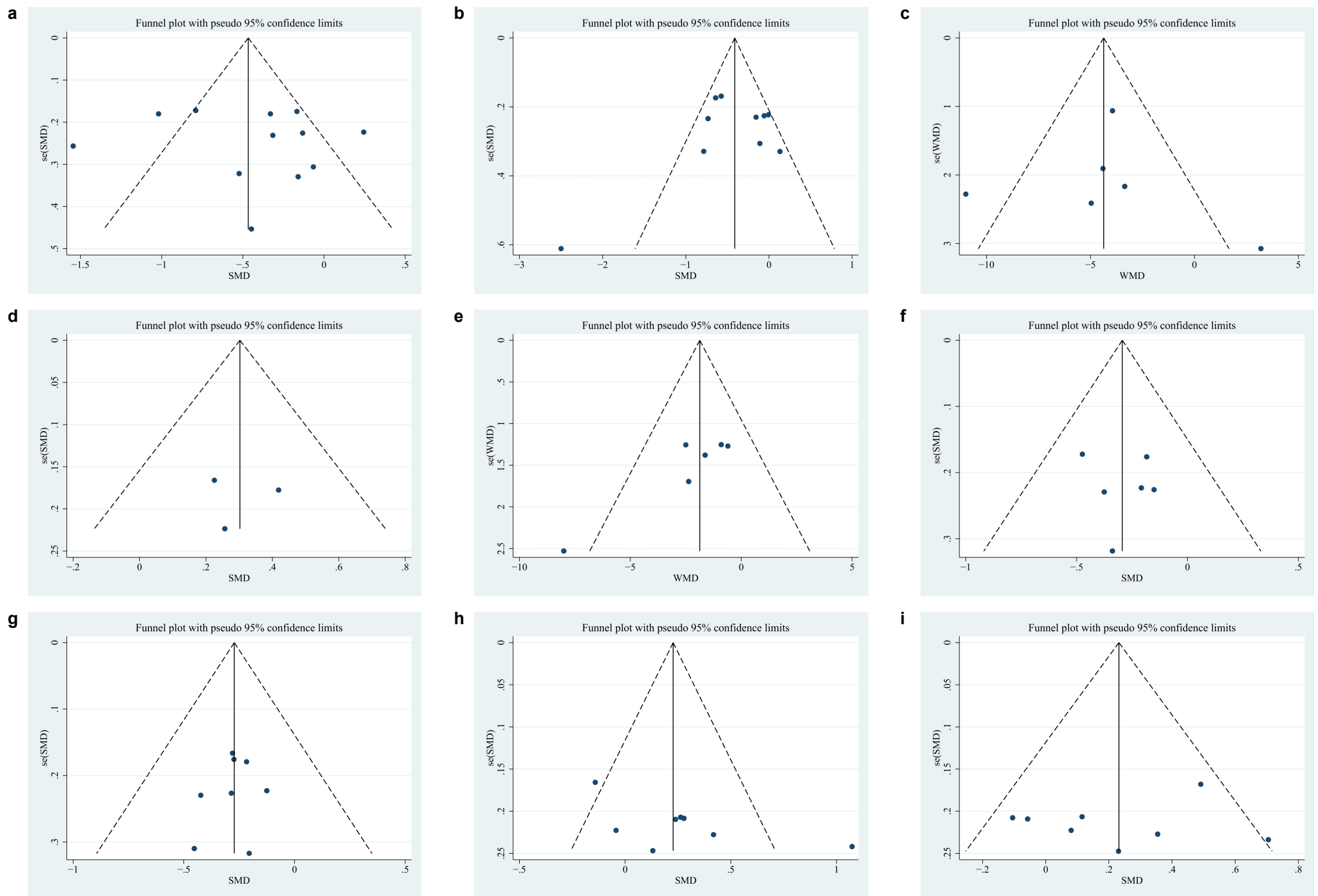
Supplementary Figure S1 Subgroup analyses of pain intensity. (a) Subgroup by region; (b) subgroup by intervention delivery format; (c) subgroup by CBT provider; (d) subgroup by CBT core elements; (e) subgroup by exercise type. $P < 0.05$ indicates a statistically significant difference between cognitive behavioral therapy combined with exercise and control groups.



Supplementary Figure S2 Subgroup analyses of functional disability. (a) subgroup by region; (b) subgroup by intervention delivery format; (c) subgroup by CBT provider; (d) subgroup by CBT core elements; (e) subgroup by exercise type. $P < 0.05$ indicates a statistically significant difference between cognitive behavioral therapy combined with exercise and control groups.



Supplementary Figure S3 Subgroup analyses of pain catastrophizing. (a) Subgroup by region; (b) subgroup by intervention delivery format; (c) subgroup by CBT provider; (d) subgroup by CBT core elements; (e) subgroup by exercise type. $P < 0.05$ indicates a statistically significant difference between cognitive behavioral therapy combined with exercise and control groups.



Supplementary Figure S4 Funnel plots for publication bias assessment across outcomes. (a) Pain intensity; (b) functional disability; (c) pain catastrophizing; (d) pain self-efficacy; (e) fear of movement; (f) anxiety; (g) depression; (h) physical component summary (PCS) of quality of life; (i) mental Component Summary (MCS) of quality of life.