

Supplementary S1. Search strategy

Databases searched: PubMed, Web of Science, Cochrane Library, Embase, CNKI, Wanfang

PubMed (Title/Abstract)

Search #	Query	Results
#1	("virtual reality" OR "head-mounted display" OR VR OR "augmented reality" OR "immersive virtual reality" OR "mixed reality" OR "virtual reality environment" OR "virtual reality technology")	36,748
#2	("exercise" OR "physical activity" OR sports OR bike OR treadmill OR exergame OR "active video game" OR Wii OR Kinect)	575,479
#3	("mental illness" OR "mental disorders" OR "mental health" OR depression OR anxiety OR "depressive disorder" OR tristimania OR "negative emotion")	915,427
#4	(female OR women OR woman OR girls OR pregnancy OR gravida)	10,963,939
#5	#1 AND #2 AND #3 AND #4	99

The database searches were conducted in June 2025.

Web of Science (Abstract)

Search #	Query	Results
#1	("virtual reality" OR "head-mounted display" OR VR OR "augmented reality" OR "immersive virtual reality" OR "mixed reality" OR "virtual reality environment" OR "virtual reality technology")	307,317
#2	("exercise" OR "physical activity" OR sports OR bike OR treadmill OR exergame OR "active video game" OR Wii OR Kinect)	1,244,322
#3	("mental illness" OR "mental disorders" OR "mental health" OR depression OR anxiety OR "depressive disorder" OR tristimania OR "negative emotion")	1,460,891
#4	(female OR women OR woman OR girls OR pregnancy OR gravida)	15,085,661
#5	#1 AND #2 AND #3 AND #4	118

The database searches were conducted in June 2025.

Cochrane Library (Title/Abstract/Keyword)

Search #	Query	Results
#1	("virtual reality" OR "head-mounted display" OR VR OR "augmented reality" OR "immersive virtual reality" OR "mixed reality" OR "virtual reality environment" OR "virtual reality technology")	10,470
#2	("exercise" OR "physical activity" OR sports OR bike OR treadmill OR exergame OR "active video game" OR Wii OR Kinect)	191,045
#3	("mental illness" OR "mental disorders" OR "mental health" OR depression OR anxiety OR "depressive disorder" OR tristimania OR "negative emotion")	192,088
#4	(female OR women OR woman OR girls OR pregnancy OR gravida)	1,085,829
#5	#1 AND #2 AND #3 AND #4	169

The database searches were conducted in June 2025.

EMBASE:160 (Subject)

("virtual reality" OR "head-mounted display" OR "VR" OR "augmented reality" OR "immersive virtual reality" OR "mixed reality" OR "virtual reality environment" OR "virtual reality technology") AND ("exercise" OR "physical activity" OR "sports" OR "bike" OR "treadmill" OR "exergame" OR "active video game" OR "Wii" OR "Kinect") AND ("mental illness" OR "mental disorders" OR "mental health" OR "depression" OR "anxiety" OR "depressive disorder" OR "tristimania" OR "negative emotion") AND ("female" OR "women" OR "woman" OR "girls" OR "pregnancy" OR "gravida")

The database searches were conducted in June 2025.

CNKI: 16 (Subject)

("virtual reality" OR "head-mounted display" OR "VR" OR "augmented reality" OR "immersive virtual reality" OR "mixed reality" OR "virtual reality environment" OR "virtual reality technology") AND ("exercise" OR "physical activity" OR "sports" OR "bike" OR "treadmill" OR "exergame" OR "active video game" OR "Wii" OR "Kinect") AND ("mental illness" OR "mental disorders" OR "mental health" OR "depression" OR "anxiety" OR "depressive disorder" OR "tristimania" OR "negative emotion") AND ("female" OR "women" OR "woman" OR "girls" OR "pregnancy" OR "gravida") The database searches were conducted in June 2025.

Wanfang: 3 (Subject)

("virtual reality" OR "head-mounted display" OR "VR" OR "augmented reality" OR "immersive virtual reality" OR "mixed reality" OR "virtual reality environment" OR "virtual reality technology") AND ("exercise" OR "physical activity" OR "sports" OR "bike" OR "treadmill" OR "exergame" OR "active video game" OR "Wii" OR "Kinect") AND ("mental illness" OR "mental disorders" OR "mental health" OR "depression" OR "anxiety" OR "depressive disorder" OR "tristimania" OR "negative emotion") AND ("female" OR "women" OR "woman" OR "girls" OR "pregnancy" OR "gravida") The database searches were conducted in June 2025.

Supplementary S2. Characteristics of the studies included in the meta-analysis (Table S2, n=8)

Author	Year	Country	Condition	Sample		Intervention		Depression measure	Depression	
				VR (age)	CT (age)	VR (frequency and duration)	CT (frequency and duration)		Pre-	Post-
Jimenez-Barragan et al.	2025	Spain	pregnant women aged ≥ 18 years	35 (30.0 \pm 5.3)	35 (33.77 \pm 3.46)	Mindfulness-based techniques, conscious breathwork, and progressive muscle relaxation (14 minutes each times, 7 times/week, 6 weeks)	usual antenatal care	Edinburgh Postnatal Depression Scale (EPDS)	VR:11.32 \pm 0.96 CG:11.33 \pm 0.94	VR:7.25 \pm 1.32 CG:16.23 \pm 1.25
Lee et al.	2025	Republic of Korea	older adult women aged 65 and older	19 (78.4 \pm 4.83)	17 (78.5 \pm 3.85)	VR-based cognitive rehabilitation and physical enhancement content (3 times/week, 12 weeks, each time 30 minutes)	usual lifestyle habits	Short Geriatric Depression Scale-Korea (SGDS-K)	VR:1.61 \pm 0.09 CG:1.52 \pm 0.17	VR:1.56 \pm 0.15 CG:1.63 \pm 0.12
Polat et al.	2021	Turkey	women with Fibromyalgia Syndrome age between 18 and 65 years	20 (42.6 \pm 8.7)	20 (47.0 \pm 7.1)	virtual reality exercise (volleyball, Microsoft Xbox KinectÒ) together with cycling exercise (3 times/week, 15 minutes each time, 4 weeks)	aerobic exercise (cycling) and conventional exercises (muscle strengthening, balance and flexibility), (3 times/week, 20 minutes each times, 4 weeks)	Hospital Anxiety and Depression Scale (HADS) [(HADS-D)]	VR:8.95 \pm 2.9 CG:8.9 \pm 3.2	VR:6.4 \pm 2.8 CG:7.6 \pm 2.7
Seo et al.	2023	Republic of Korea	women 40–65 years with a body mass index of 23 kg/m ² or more	23 (47.74 \pm 5.50)	23 (48.26 \pm 7.56)	virtual reality indoor cycling (50 minutes each time, 3-5 times/week, 8 weeks)	daily activities without an exercise intervention	Korean version of the Patient Health Questionnaire-9 (PHQ-9)	VR:5.48 \pm 4.50 CG:6.00 \pm 2.84	VR:2.48 \pm 1.27 CG:5.30 \pm 3.13
Wi et al.	2013	Republic	Elderly females	20	20	hot packs and electrical stimulation	Daily care	Short Geriatric	VR:8.1 \pm	VR:6.4 \pm 1.7

		of Korea	aged 65 years or older (have degenerative osteoarthritis of the knees)	(76 ± 5.68)	(74.55 ± 4.45)	of their knees (15 mins) and exercise game (Xbox 360) (30 minutes each time, 3 times/week, 4 weeks)	(hot packs (15 mins) and electrical stimulation of their knees (15 mins)	Depression Scale (SGDS-K),	2.7 CG:7.8± 2.26	8 CG:7.6±1.9 0
Liu et al.	2024	China	female college students	25 (19.07 ± 0.20)	25 (19.20 ± 0.15)	VR cycling group (30 minutes each time, 2 times/week, 8 weeks)	Quiet rest under control conditions	Depression Scale (CES D)	VR:20.2 ±1.62 CG:20.7 ±1.67	VR:10.32± 1.53 CG:20.48± 1.53
Liu et al.	2025	China	female college students	25 (19.07 ± 0.20)	25 (19.20 ± 0.15)	VR cycling group for 30 mins	Take a quiet break for 30 minutes, and can browse through the exercise magazine provided	Beck Depression inventory (BDI-13)	VR:7.92 ±1.15 CG:8.08 ±1.2	VR:4.08±1. 08 CG:8.16±1. 40
Czech et al.	2024	Poland	patients who had not started treatment for breast cancer	17 (59.8±10.72)	16 (56.68 ±11.26)	Virtual Therapeutic Garden [8 sessions (each session duration about 15 minute), all sessions including motor tasks (tending garden and breathing exercises)], 2 weeks.	with standard-of-care procedures without additional interventions	The Hospital Anxiety and Depression Scale Modified Version (HADS-M) [(HADS-D)]	VR:5.59 ±3.83 CG:4.81 ±4.92	VR:2.53±2. 40 CG:8±2.19

Supplementary S3. Risk of bias assessment

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Byung-Sun Lee 2025	?	+	?	?	+	+	?
Elisângela Valevein Rodrigues2017	?	?	?	?	●	+	?
Eun-Young Seo2023	+	+	?	?	+	+	?
Jimenez-Barragan 2025	+	+	+	+	+	+	?
LIU Yang2025	?	?	?	+	+	+	?
LIU Zhi - he2025	+	?	?	+	+	+	?
Musa Polat 2021	+	+	+	+	+	+	?
Oliver Czech2024	+	?	?	+	+	+	?
Sam Yeol Wi2013	?	?	?	?	+	+	?