

Effectiveness of virtual reality in patients with neck pain: systematic review and meta-analysis

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Aim

(1) To summarize the evidence from randomized controlled trials (RCTs) controlled trials (CTs) and that examined the effectiveness of active VR used in the treatment of patients with NP,

(2) To determine clinical the effectiveness and the magnitude of the effect of active VR in the management of NP.

Methods

Design: Systematic review with metaanalysis.

Searches: Medline (Ovid), Embase (Ovid), CINAHL (EBSCOhost), Cochrane Library Trials, Web of Science, and Scopus.

Inclusion Criteria: RCTs and CT with adults (>18 years old) with NP, that evaluated the effectiveness of active VR or augmented VR. VR could be implemented by using off-the-shelf or custom-made devices in combination with a display, allowing a multisensory experience and active interaction with the virtual world.

Risk of Bias (RoB): Revised Cochrane of Risk of Bias (RoB-2).

Overall quality/certainty of evidence: GRADE system.

Outcomes Meta-analyses: Pain, Neck disability, neck range of motion, quality of life and neck performance.

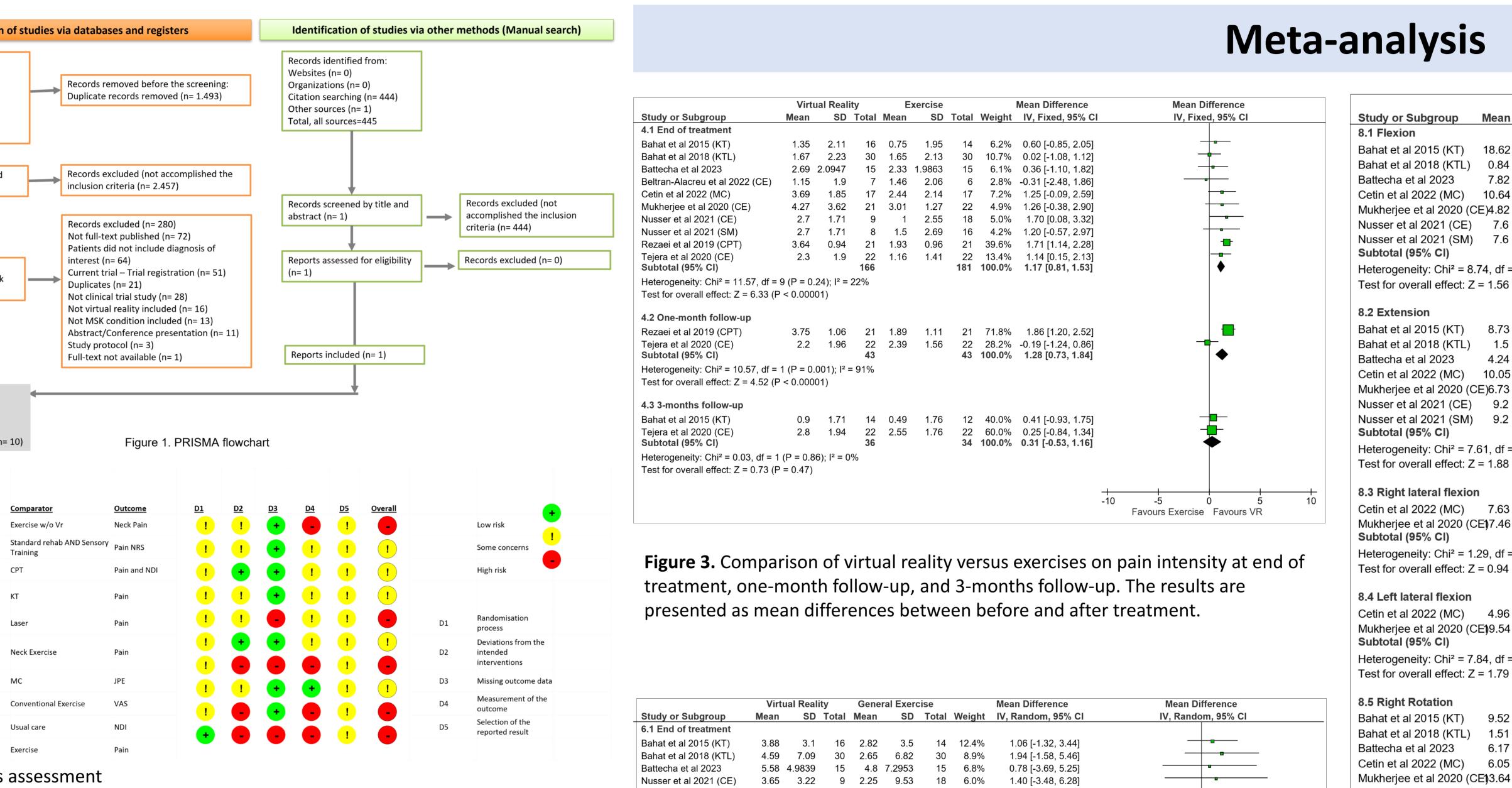
	Identification
Identification	Records identified from: Databases (n= 4.239) 1362 Embase 1026 Scopus 823 CENTRAL 647 MEDLINE 381 CINAHL
Screening	Records screened by title and abstract (n= 2.746)
	Full-text screening (Reports assessed for eligibility for neck pain) (n= 289)
Included	Total studies included from Databases=9 Total studies included in the
	review (n= 10) Studies included in the MA (n

Study ID	Experimental
Mukherjee 2020	VR
Nusser 2021	VR
Rezaei 2019	VR
Sarig Bahat 2015	VR KT
Sarig Bahat 2018	VR
Tejera 2020	VR
Cetin et al 2022	VR + MC
Beltran-Alacreu et al 2022	VR (serious game)
Bahat et al 2020	VR
Bettecha et al 2023	VR + Exercise

Figure 2. Risk of bias assessment

Virtual reality vs Exerci	Virtual reality vs Control				
Outcomes	End of	One-month	Three-months	End of	Six-months
	treatment	follow-up	follow-up	treatment	follow-up
Pain intensity	\bigcirc	\bigcirc	\otimes	\otimes	\bigcirc
Neck disability	\bigcirc	\otimes	\otimes	\otimes	\otimes
Flexion neck movement	\otimes	?	\otimes	?	?
Extension neck movement	\otimes	?	\otimes	?	?
Lateral flexion neck movement	\otimes	?	?	?	?
Rotation neck movement	\otimes	?	\bigcirc	?	?
Flexion - JPSE	\bigcirc	?	?	?	?
Extension - JPSE	\bigcirc	?	?	?	?
Lateral flexion - JPSE	\otimes	?	?	?	?
Rotation - JPSE	\bigcirc	?	?	?	?
Flexors strength	\otimes	?	?	?	?
Extensors strength	\otimes	?	?	?	?
Endurance	\otimes	?	?	?	?
Quality of life	\otimes	?	?	\otimes	\otimes
PPT: Trapezius	\otimes	?	?	?	?
PPT: C1-C2	\otimes	?	?	?	?
PPT: C5 – C6	\bigcirc	?	?	?	?
PPT: Tibialis	\otimes	?	?	?	?
Kinesiophobia	\otimes	\otimes	\bigcirc	?	?
Balance	\otimes	\otimes	\otimes	?	?

Figure 6. Summary of the results



Rezaei et al 2019 (CPT) Tejera et al 2020 (CE) ubtotal (95% CI) Test for overall effect: Z = 2.23 (P = 0.03)

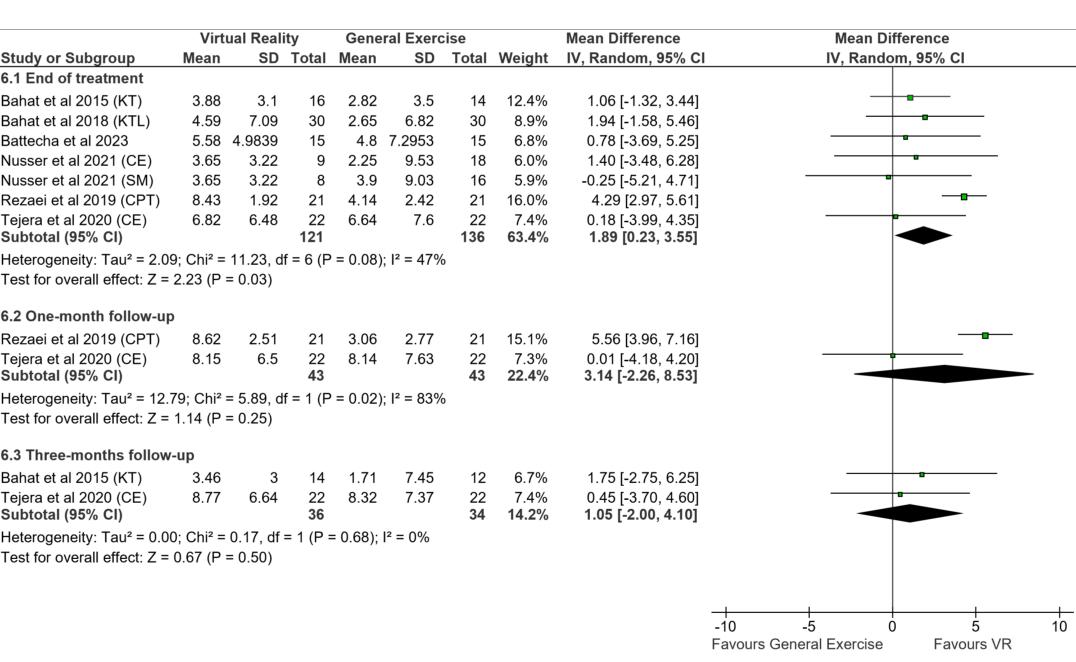
6.2 One-month follow-up Rezaei et al 2019 (CPT) 8.62 2.51 21 Tejera et al 2020 (CE) Subtotal (95% CI) Test for overall effect: Z = 1.14 (P = 0.25)

6.3 Three-months follow-up Bahat et al 2015 (KT) Subtotal (95% CI) Test for overall effect: Z = 0.67 (P = 0.50)

Figure 4. Comparison of virtual reality versus exercises on neck disability index at end of treatment, one-month follow-up, and 3-months follow-up. The results are presented as mean differences between before and after treatment.

Although the evidence is still limited for the VR treatment in patients with NP, the results found in this SR bring an important indication that the implementation of VR in existing rehabilitation for patients with neck pain appears to be a potentially safe and promising treatment approach to relieve pain and could be an alternative more effective to conventional exercise treatments that normally are employed in clinical practice.

Results



Study or Subgroup Mean Bahat et al 2015 (KT) 18.62

7.82 Cetin et al 2022 (MC) 10.64 Mukherjee et al 2020 (CE)4.82 Nusser et al 2021 (CE) 7.6 Nusser et al 2021 (SM) 7.6 Heterogeneity: Chi² = 8.74, df = Test for overall effect: Z = 1.56

Bahat et al 2015 (KT) 8.73 Bahat et al 2018 (KTL) 1.5 Battecha et al 2023 4.24 Cetin et al 2022 (MC) 10.05 Mukherjee et al 2020 (CE)6.73 Nusser et al 2021 (CE) 9.2 Nusser et al 2021 (SM) 9.2 Heterogeneity: Chi² = 7.61, df = Test for overall effect: Z = 1.88

Cetin et al 2022 (MC) 7.63 Mukherjee et al 2020 (CE)7.46 Heterogeneity: Chi² = 1.29, df = Test for overall effect: Z = 0.94

Cetin et al 2022 (MC) 4.96 Mukherjee et al 2020 (CE)9.54 Heterogeneity: Chi² = 7.84, df =

Bahat et al 2015 (KT) 9.52 Bahat et al 2018 (KTL) 1.51 Battecha et al 2023 6.17 Cetin et al 2022 (MC) 6.05 Mukherjee et al 2020 (CE)3.64 Nusser et al 2021 (CE) 3.9 Nusser et al 2021 (SM) 3.9 Subtotal (95% CI) Heterogeneity: Chi² = 11.36, df Test for overall effect: Z = 0.17

8.6 Left Rotation Bahat et al 2015 (KT) 19.16 Bahat et al 2018 (KTL) 0.57 Battecha et al 2023 6.3 Cetin et al 2022 (MC) 7.35 Mukherjee et al 2020 (CE1)1.87 Nusser et al 2021 (CE) 7.8 Nusser et al 2021 (SM) 7.8 Subtotal (95% Cl) Heterogeneity: Chi² = 3.96, df = Test for overall effect: Z = 1.09

Figure 5. Figure 8. Comparison of virtual reality versus exercise on range of motion at end of treatment. The results are presented as mean differences between before and after treatment.

Conclusion



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VR N SD	Total		e Compa SD		Weight	Mean Difference IV, Fixed, 95% C	Mean Difference IV, Fixed, 95% CI
30	Total	Meall	30	Total	weight	TV, FIXEU, 99% C	
2 14.4	16	5.79	19.1	12	4.0%	12.83 [-0.08, 25.74]	
4 8.73	30	0.74	8.15	30	36.6%	0.10 [-4.17, 4.37]	-
2 14.030	8 15	3.66 î	16.2519	15	5.7%	4.16 [-6.71, 15.03]	
4 7.44	17	8.47	7.21	17	27.5%	2.17 [-2.75, 7.09]	
2 9.84	21	6.96	11.9	22	15.7%	-2.14 [-8.65, 4.37]	
6 13.97	79	-2.9	12.75	18	5.7%	10.50 [-0.36, 21.36]	
6 13.97	78	-1	13.56	16	4.8%	8.60 [-3.14, 20.34]	
	116			130	100.0%	2.06 [-0.53, 4.64]	◆
= 6 (P =	0.19); I	² = 31%					
δ (P = 0.1	2)						
3 16.1	16	1.68	16.2	12	6.1%	7.05 [-5.04, 19.14]	
5 11.46		2.37	13.73	30	21.9%	-0.87 [-7.27, 5.53]	_
4 14.9879			19.6648	15		-2.16 [-14.67, 10.35]	_
5 9.25		7.7	7.04	17	29.4%	2.35 [-3.18, 7.88]	— ——— ——
3 9.23 3 9.85		5.3	7.04 11.66	22		1.43 [-5.01, 7.87]	
9.60 2 12.85		-3.3	14.02	22 18	21.7% 8.0%	12.50 [1.90, 23.10]	│ _
2 12.80			14.02 13.95	16			
12.00) 8 116	-1.4	13.95		7.1% 100.0%	10.60 [-0.63, 21.83] 2.87 [-0.12, 5.87]	
= 6 (P =		² = 21%			/0	2.07 [-0.12, 0.07]	
– 0 (P – 3 (P = 0.0		۲/0 ۲					
		7.0	F A 4		07.001		
8.34		7.3	5.81	17		0.33 [-4.50, 5.16]	
5 11.7		12.19	11.78		32.1%	5.27 [-1.75, 12.29]	
- 4 / 5	38 0.000	2 - 0001		39	100.0%	1.92 [-2.06, 5.90]	
= 1 (P =		- = 23%					
4 (P = 0.3	94)						
6 7.41		4.92	5.78		71.5%	0.04 [-4.43, 4.51]	
4 8.96		7.54	14.25		28.5%	12.00 [4.92, 19.08]	
	38			39	100.0%	3.44 [-0.33, 7.22]	
= 1 (P =		l² = 87%	6				
9 (P = 0.0)7)						
2 12.8	3 16	21.18	13.2	12	9.8%	-11.66 [-21.41, -1.91]	
1 14.82	2 30	2.51	14.45	30	17.0%	-1.00 [-8.41, 6.41]	
7 12.3334	4 15	5.13 1	12.1167	15	12.2%	1.04 [-7.71, 9.79]	
5 13.6	6 17	8.52	6.06	17	18.6%	-2.47 [-9.55, 4.61]	
4 9.53		6.38	11.35	22		7.26 [1.01, 13.51]	-
12.33		2.2	10.11	18		1.70 [-7.61, 11.01]	
) 12.33			13.55			-0.10 [-10.92, 10.72]	
	116				100.0%		\bullet
f = 6 (P =		l² = 47%	6			-	
7 (P = 0.8	37)						
6 17.6	5 16	17.14	19.2	12	5.3%	2.02 [-11.85, 15.89]	
7 13.26		0.27	15.46	30	19.2%	0.30 [-6.99, 7.59]	p
3 11.177			12.225	15		-1.56 [-9.94, 6.82]	_
5 9		8.41	9.98	17	25.0%	-1.06 [-7.45, 5.33]	
7 10.35		5.95	9.90 12.78	22		5.92 [-1.02, 12.86]	
10.30 14.95		0.6	9.71	22 18	21.2% 8.8%	7.20 [-3.55, 17.95]	
3 14.95 3 14.95		0.6 4.1	9.71 16.74	16	o.o% 5.8%	3.70 [-9.51, 16.91]	
14.90	, o 116	4.1	10.74		5.8% 100.0%		
= 6 (P =		² = 0%		-		.,	
	<i>/</i> ·						
) (P = 0.2							
9 (P = 0.2							
9 (P = 0.2						_	-20 -10 0 10 20