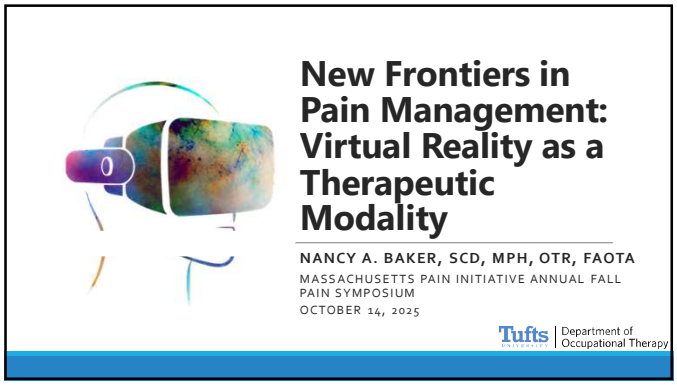
New Frontiers in Pain Management: Virtual Reality as a Therapeutic Modality
NANCY A. BAKER, SCD, MPH, OTR, FAOTA
MASSACHUSETTS PAIN INITIATIVE ANNUAL FALL PAIN SYMPOSIUM
OCTOBER 14, 2025
Tufts Department of Occupational Therapy

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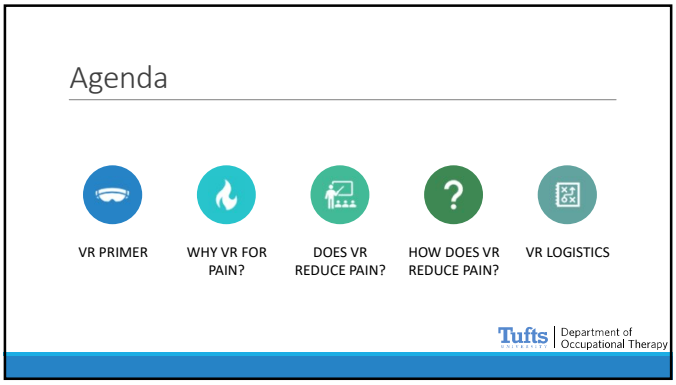
Agenda
VR PRIMER
WHY VR FOR PAIN?
DOES VR REDUCE PAIN?
HOW DOES VR REDUCE PAIN?
VR LOGISTICS
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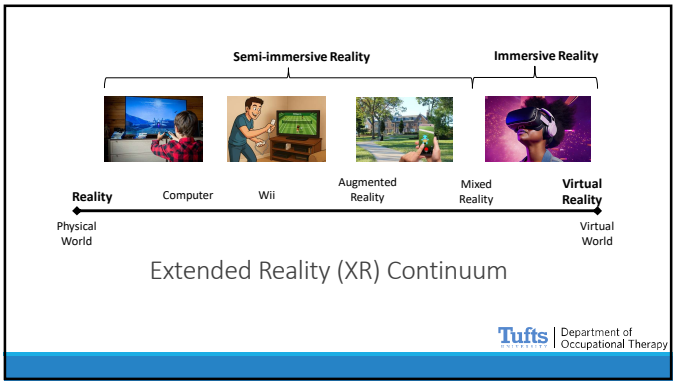
2


Virtual Reality: A Primer

3


Semi-immersive Reality
Immersive Reality
Reality
Computer
Wii
Augmented Reality
Mixed Reality
Virtual Reality
Physical World
Virtual World
Extended Reality (XR) Continuum
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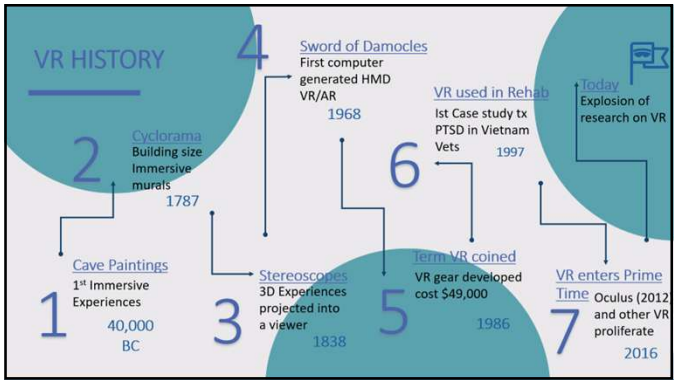
4


VR HISTORY
1 Cave Paintings
1st Immersive Experiences
40,000 BC
2 Cyclorama
Building size Immersive murals
1787
3 Stereoscopes
3D Experiences projected into a viewer
1838
4 Sword of Damocles
First computer generated HMD VR/AR
1968
5 Term VR coined
VR gear developed cost $49,000
1986
6 VR used in Rehab
Ist Case study tx PTSD in Vietnam Vets
1997
7 VR enters Prime Time
Oculus (2012 and other VR proliferate
2016
Today
Explosion of research on VR

5


User is immersed into life-sized, three-dimensional, multi-sensory computer-mediated environment interacted via a computer headset and controllers
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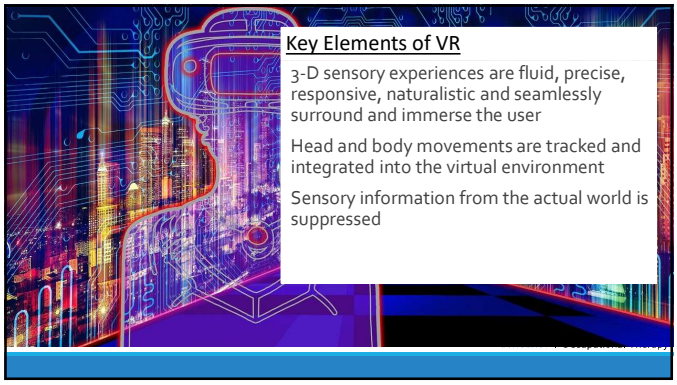
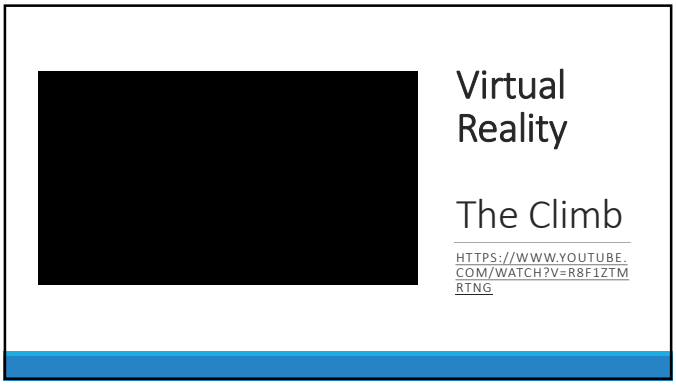
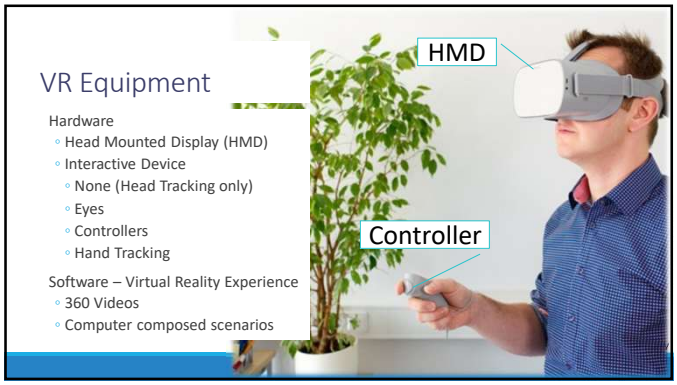
6


Key Elements of VR
3-D sensory experiences are fluid, precise, responsive, naturalistic and seamlessly surround and immerse the user
Head and body movements are tracked and integrated into the virtual environment
Sensory information from the actual world is suppressed

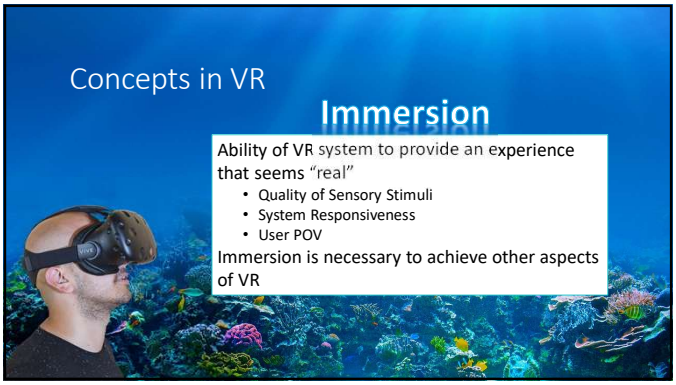
7


Virtual Reality
The Climb
HTTPS://WWW.YOUTUBE.COM/WATCH?V=R8F1ZTMRTNG

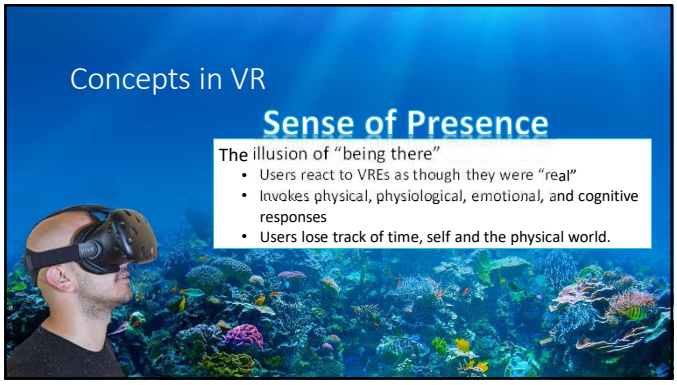
8


VR Equipment
Hardware
Head Mounted Display (HMD)
Interactive Device
None (Head Tracking only)
Eyes
Controllers
Hand Tracking
Software – Virtual Reality Experience
360 Videos
Computer composed scenarios
HMD
Controller

9


Concepts in VR
Immersion
Ability of VR system to provide an experience that seems "real"
Quality of Sensory Stimuli
System Responsiveness
User POV
Immersion is necessary to achieve other aspects of VR

10


Concepts in VR
Sense of Presence
The illusion of "being there"
Users react to VREs as though they were "real"
Invokes physical, physiological, emotional, and cognitive responses
Users lose track of time, self and the physical world.

11


Concepts in VR
Authenticity
The feeling that the VRE is genuine
Plausible - Faithfully replicate rules consistent with the environment
Believable - Aligns with users' expectations and allows the users to maintain a willing suspension of disbelief

12

Concepts in VR

Sense of Embodiment

Users perceive experiences happening to their virtual body as if it were their actual body.

Manipulation of the virtual body leads to psychological, emotional and physiological reactions that are similar to those experienced if the actual body were receiving the stimuli

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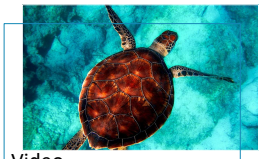
Types of Virtual Reality Experiences



Video

Programmed

https://www.meta.com/experiences/ocean-rift/

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Some Genres of VRE

- Exercise/Sports
- Meditation/Zen
- Training/Educational
- VR Exposure Therapy
- Virtual Embodiment
- Simulation
- Explore/Travel
- Arcade
- Puzzle

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Why VR for Pain

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Why Virtual Reality for Pain?

PERSONALIZED TREATMENTS

EMOTIONAL & PSYCHOLOGICAL WELL BEING

HEALTH LITERACY

ACQUISITION OF SKILLS

MOTIVATING

ENGAGING

PROVIDES ESCAPE

DISTRACTING

FUN

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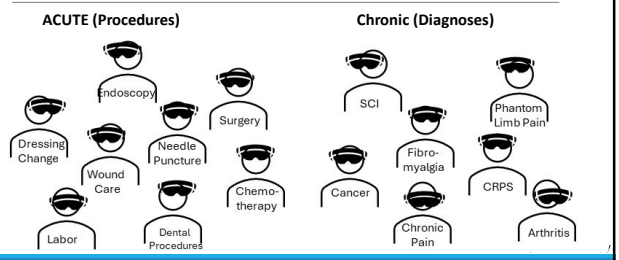
Used by many Pain Populations



18

Used at many Clinical Sites

- ICU
- Acute Rehab
- Outpatient
- Inpatient
- Home
- Nursing Homes
- Schools
- Dental Clinics

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Used across the lifespan

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VR has many benefits
It can be used by many populations and in many settings

21

Does VR Reduce Pain?

STATE OF THE SCIENCE

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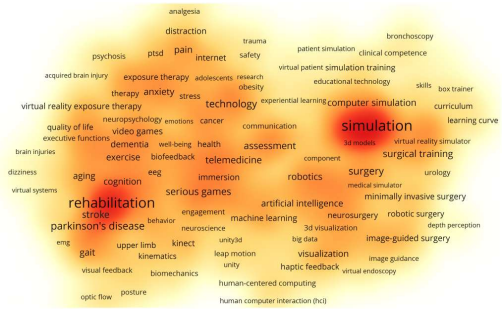
Density map showing author keywords of the publications in virtual reality research in medicine.



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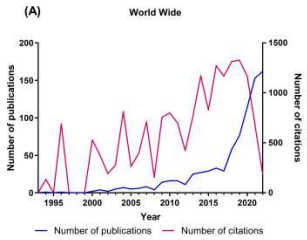
Yeung, 2021 *Journal of Medical Internet Research*

23

Bibliometric Analysis of Research Articles on Virtual Reality in the Field of Pain Medicine Published from 1993 to 2022



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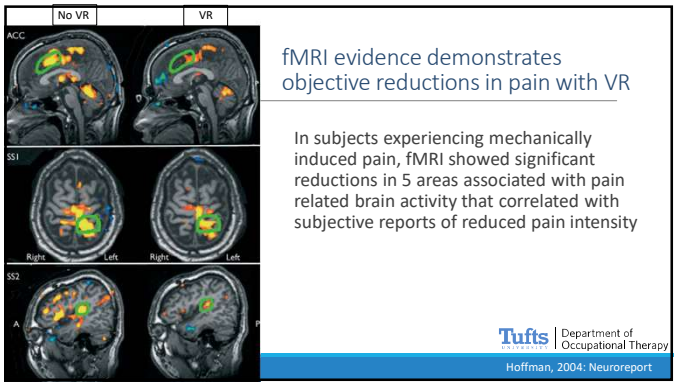
Kim, 2023: *J Pain Res*

24



fMRI evidence demonstrates objective reductions in pain with VR

In subjects experiencing mechanically induced pain, fMRI showed significant reductions in 5 areas associated with pain related brain activity that correlated with subjective reports of reduced pain intensity

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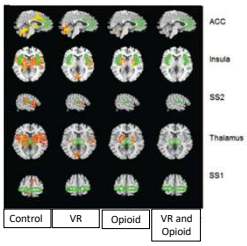
Hoffman, 2004: Neuroreport

25

VR pain reduction is similar to opioids and enhances opioid effects



Compared to control for subjects receiving thermal pain stimuli

- VR significantly reduced pain signals in the Insula, SS2 and Thalamus
- Opioids significantly reduced pain signals in the Insula and Thalmus
- VR + Opioids significantly reduced pain in the ACC, Insula, SS2, and Thalamus

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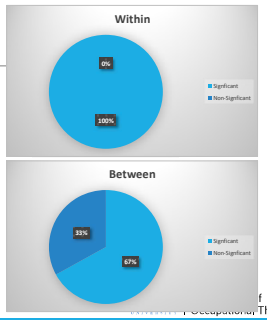
Hoffman, Anesth Analg: 2007

26

VR and Acute Pain

- Scoping review of 44 studies
- Evaluated improvements in pain intensity in within and between designs

100% of within studies reported significantly improved pain with VR
67% of between studies reported VR was significantly more effective at reducing pain than control



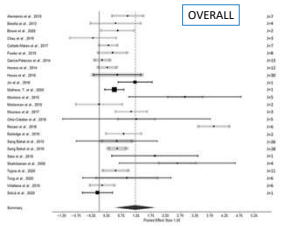
Baker, 2022: Clin J Pain

27

VR and Chronic Pain

- Meta Analysis of 41 studies
- Assessed effect of VR on multiple outcomes (e.g. pain, psychological variables, function, etc)

Effect sizes (95% CI)
Overall = 1.22 (0.55 to 1.89)
Pain = 1.60 (0.83 to2.36)
Function = 1.40 (0.13 to 2.17)



Goudman, 2022: JMIR Serious Games,

28

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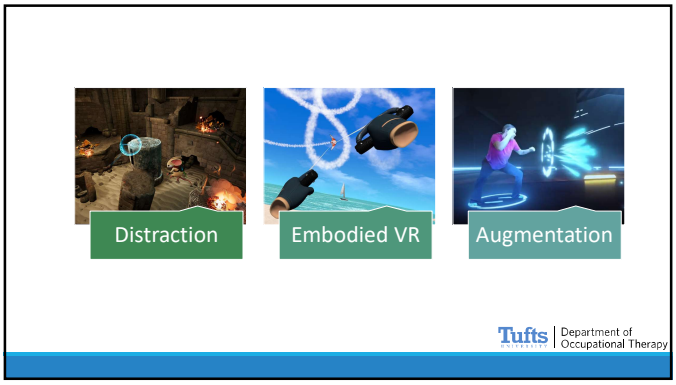

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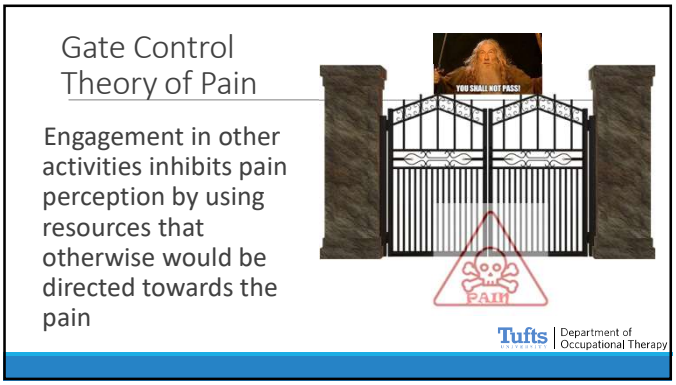

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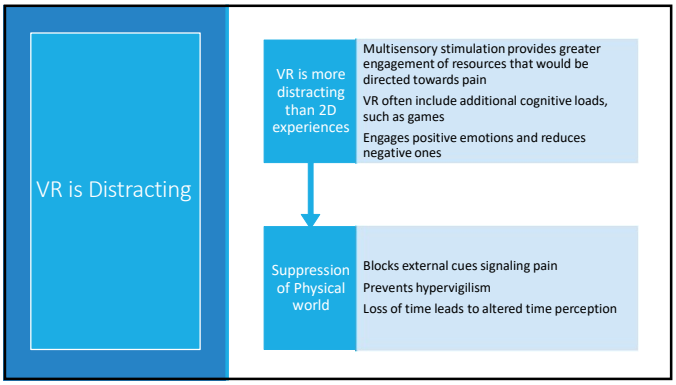

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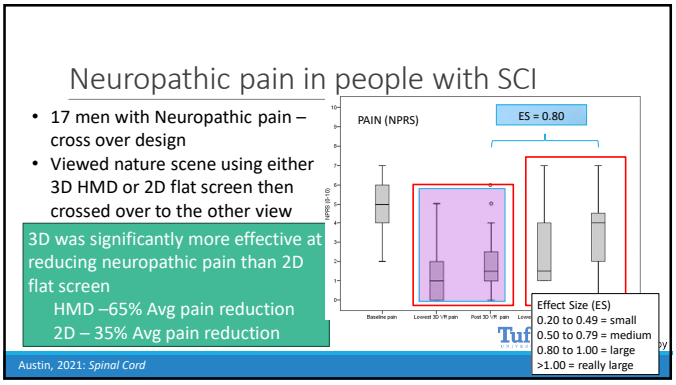

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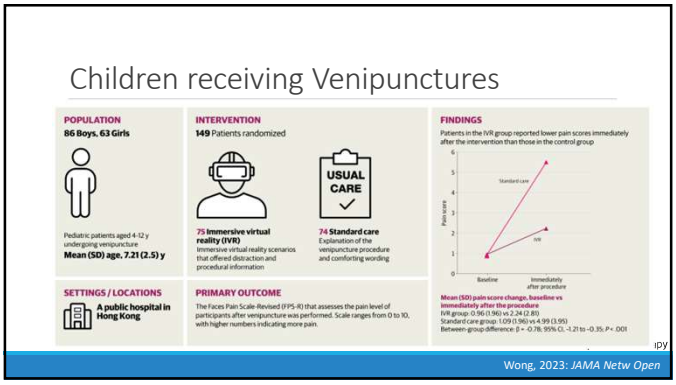
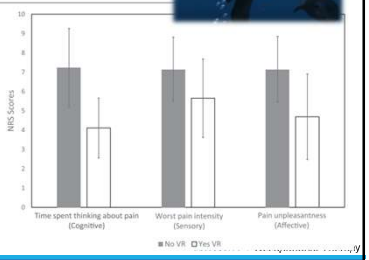


36

Women in Labor

- 14 tx; 14 cont
- Tx group watched VR Ocean Rift during active labor; Control received no VR

Women using VR reported significantly less pain intensity, less time thinking about pain and less pain unpleasantness during labor



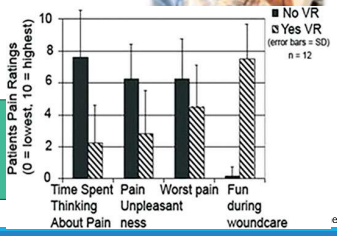
Aydin, 2019 *J Perianesth Nurs*

37

Veterans receiving burn care

- 12 male veterans – cross over
- During VR Tx patients watched SnowWorld. Both groups received appropriate analgesic medications

Veterans pain scores significantly improved during burn care
VR worked best for people with higher levels of pain



Maani, 2011: *J Trauma Acute Care Surg*

38

Embodiment

A subjective experience in which a person views a simulated body and the properties of that simulated body are processed as if they were the properties of the person's own biological body

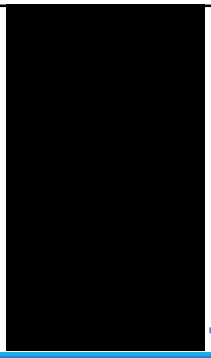
https://miro.medium.com/v2/resize:fit:864/1*5eoQkLaYLC9dO1VjkiumeQ.png

Kilteni. *Presence:* 2012

39

Embodiment

The Rubber Hand Illusion



Botvinick. *Nature:* 1998

https://www.youtube.com/watch?v=IYQLFI-hgts&t=13s

40

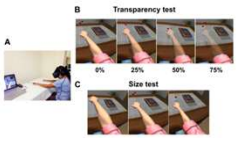
Pain and VR Embodiment

Manipulate the virtual limb from the first-person POV

Changes in the virtual body affect pain perception

May recalibrate body representation in distorted body image of people with chronic pain

May promote neuroplastic changes in body awareness and pain processing



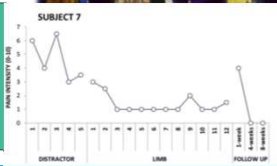
Matamala-Gomez, 2019: *Front Hum Neurosci.*

41

People with Phantom Limb Pain and virtual limb "replacement"

- 7 people with PLP
- Distractor Tx: 55 mins in VR environment followed by Limb Tx: 55 mins in embodied limb with active movement of virtual legs

People with PLP experienced significant pain relief in both txs
Distractor Tx: Mean pain score went from 54 to 39 a 28.0% reduction in pain
Limb Tx: Mean pain went from 45 to 27 a 39.6% reduction in pain

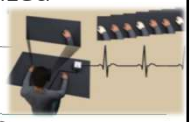


Ambron, 2021: Neurorehabil Neural Repair

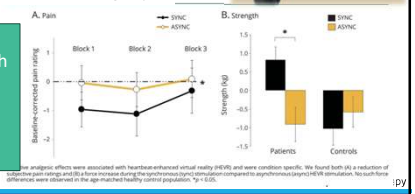
42

People with CRPS and Synchronized Heartrate

- 24 people CRPS & 24 healthy controls
- 3 blocks of either synchronous (tx) or asynchronous (cont) Heartrate in the embodied hand for each group



CRPS patients had significantly lower pain and greater strength during the synchronous trials than non-synchronous.
No significant effect for the healthy controls



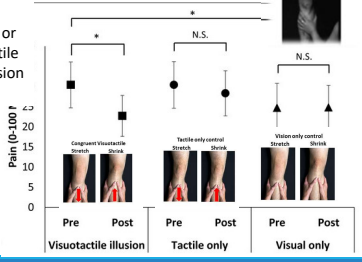
Solca 2018: *Neurology*

43

Knee OA pain and Illusory resizing

- 6 to 12 people painful knee OA
- HMD gave illusion of knee enlarging or shrinking while research applied tactile stimulation. Control conditions of vision or tactile alone.

People with OA experienced a 25% reduction in pain during visiotactile stimulation. 10 repeated applications in one session reduced pain by 40%



Stanton, 2018: *Peer J;* McIntyre, 2019: *Pain Rep*

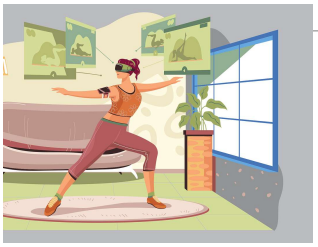
44

VR Augmented Treatment

VR used to deliver treatments already shown to be beneficial for pain

- Exercise
- Meditation/Relaxation
- Education/Skills Training

45



VR and Exercise

Superior motivation to conventional exercise

Higher exertion with lower perceived exertion

Increased enjoyment

Greater adherence to programs

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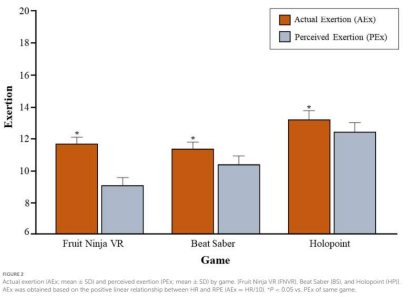

Actual vs. perceived exertion during active virtual reality game exercise

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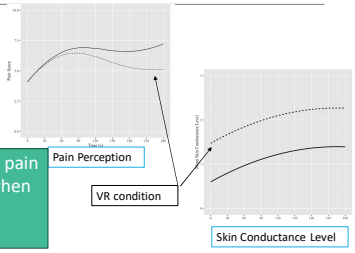
Stewart, 2022: *Front Rehab Sci*

47

VR supported exercise improves pain perception and sympathetic activity

- 41 healthy controls – cross over design
- Endured a cold pressor test while participating in a VR-facilitated or non-VR facilitated biking exercise program

People had significantly improved pain perception sympathetic activity when compared to a cold pressor test without VR facilitated exercise



Rodriguez, 2023: *J Clin Anesth*

48

VR Exercise and Fibromyalgia

- 10 people with FM in Tx 10 in control
- 8 wks/2x wk PT monitored sessions
- Both groups 30 mins aerobic/30 mins Pilates
- VR Tx 20 mins VR games

Table 3. Comparison of changes between groups (baseline-8th week).

	Exercise Group (n = 8) Median (IQR)	Exercise + IVR Group (n = 8) Median (IQR)	p*
VAS, cm	−2.05 (−3.75, −1.65)	−4.00 (−4.97, −2.90)	0.021*
MSOT, sway point			
- Eyes open Firm surface	−0.09 (−0.34, 0.00)	−0.12 (−0.19, −0.07)	0.461
- Eyes closed Firm surface	−0.09 (−0.18, −0.03)	−0.35 (−0.72, −0.03)	0.461
- Eyes open Foam surface	−0.13 (−0.30, −0.06)	−0.31 (−0.56, −0.10)	0.172
- Eyes closed Foam surface	−0.22 (−1.01, −0.01)	−0.39 (−0.61, −0.29)	0.599
TSK, score	−10.00 (−11.75, −5.25)	−12.00 (−21.25, −11.25)	0.034*
FIQ, score	−21.83 (−30.98, −13.34)	−27.87 (−43.70, −19.36)	0.294
FSS, score	−1.16 (−1.64, −1.00)	−2.81 (−3.63, −1.62)	0.013*
IPAQ, score	526.50 (353.62, 929.00)	1797.25 (1408.00, 4093.00)	0.001*
6MWT, m	50.00 (34.00, 65.00)	62.00 (39.20, 85.02)	0.344
SF-36, score			
Mental	70.25 (19.00, 110.00)	148.00 (98.75, 168.00)	0.016*
Physical	85.00 (65.25, 122.50)	139.00 (84.25, 189.25)	0.189

VAS, Visual Analog Scale; MSOT, Modified Sensory Organization Test; TSK, Tampa Scale for Kinesiophobia; FIQ, Fibromyalgia Impact Questionnaire; FSS, Fatigue Severity Scale; IPAQ, International Physical Activity Questionnaire; 6MWT, The Six-Minute Walk Test; SF-36, Short form-36; IQR, Interquartile Range.
*Mann-Whitney U test, *p < 0.05.

Both groups improved. VR group improved significantly more than control group for pain, kinesiophobia, fatigue, and level of physical activity

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Gulsen, 2022: *Assist Tech*

49

VR Exercise and SCI

- 11 people with SCI: Crossover design
- Each condition (VR & non-VR) was a six min trial on a standard arm cycle ergometer

Measure	*Group*	*Value*[a]	*95% CI*	*P*[b]	*Cohen's d*
Pain	VR	1.82 ± 1.60	0.74–2.9	0.009[c]	1.59
	Non-VR	4.10 ± 1.22	3.3–4.9		
Fatigue	VR	2.36 ± 2.25	0.85–3.8	0.012[c]	1.19
	Non-VR	5.10 ± 2.30	3.5–6.6		
Borg's RPE	VR	9.8 ± 3.79	7.3–12.4	0.013[c]	1.01
	Non-VR	12.7 ± 1.49	11.7–13.7		
Heart rate (bpm)	VR	79 ± 17.00	67.8–90.7	0.012[c]	0.72
	Non-VR	96 ± 27.41	77.3–114.1		

People with SCI experienced significantly less pain, fatigue, perceived exertion and Heart Rate during VR. VR Session decreased pain by 56% and fatigue by 54%

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Azurdia 2023 *Games Health J*

50

Gao, 2024 *Front Psych*

VR and Meditation

Superior to conventional meditation at achieving mindfulness and meditation experience

Auditory can provide instruction along with appropriate background noise

Positive effect on anxiety, mood, relaxation

Greater adherence to programs

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Ma, 2023: *Explore*

51

VR Meditation and Acute Pain in Patients with Opioid Tolerance

- 11 hospitalized patients with opioid tolerance or opioid use disorder with acute pain
- 1 10-min session of VR guided Meditation

Significant pain reduction
All patients experienced some pain reduction.
The mean % reduction was 55%

	Pre VR	Post VR
Pain Levels	6.7 (2.1)	3.4 (2.7)

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Hargett, 2022: *Pain Mgmt Nurs*

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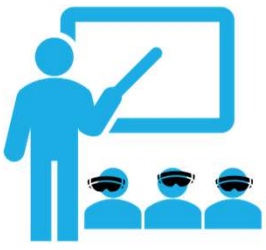

VR and Education

Multisensory presentation of material

Real-time Feedback

Gamification and Rewards

Increased attention and emotional engagement

Personalization of material

Accessibility and Convenience

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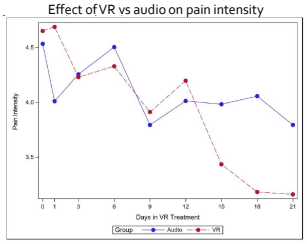
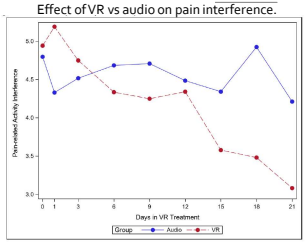
Self-Administered Skills-Based Virtual Reality Intervention for Chronic Pain: Randomized Controlled Pilot Study

Effect of VR vs audio on pain intensity



Effect of VR vs audio on pain interference.



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Darnall, 2020: *JMIR Form Res*

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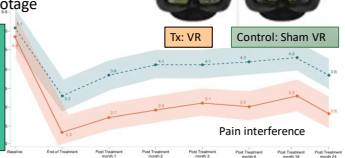
Chronic Pain and VR delivered Skills-based Program

- 179 people with chronic back pain
- Tx (n = 89): HMD w/ 3D skills-based program
- Control (n=90): HMD w/ 2D nature footage



Immediately after treatment people in 3D VR demonstrated significantly greater improvements in pain intensity (d = 1.31) & pain interference (d = 1.27) These improvements lasted for 24 mos after completing the study (n = 127).

This VR skills-based training program now has FDA approval as a "medicine" and can be prescribed and reimbursed

Dosage: Both groups received daily 2-16 min sess:56 days

Garcia, 2021: *J Med Internet Res;* Maddox, 2023: *Pain Med*

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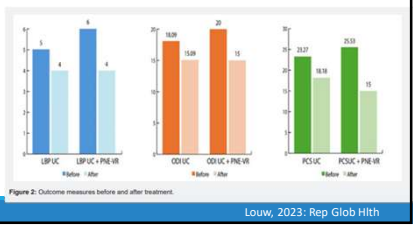
VR delivered Pain Neuroscience education and people with Chronic Low Back Pain (CLBP)

- 19 patient with CLBP in VR PNE; 11 in PT
- Both groups received PT, VR PNE received 12 minutes of PNE delivered via HMD
- Dosage: 2x wk for 3 weeks.

VR PNE had significantly greater reduction in pain than PT



Louw, 2023: Rep Glob Hlth

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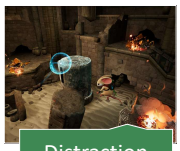
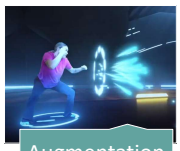
Three Mechanisms for VR analgesia


Distraction


Embodied VR


Augmentation

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VR Logistics

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Costs

HMD/Controllers: $100 - >$2000

Software: $0-$50

Peripherals

- Computer
- Tablet
- Accessories

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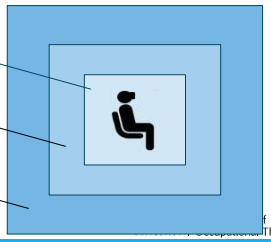
Space

Passive – Limited Space

Stationary – 3' x 3'

Room Scale 6.5' x 6.5



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Wi-Fi

Wi-Fi needs depend on the VR system

- Standalone HMD vs Tethered
- Casting

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Time

Time to Learn

- Time and patience to learn how to use VR system
- Generally simple to use – unbox and use

Time within Therapy

- Dosage varies by application
- Set-up/Clean-up generally simple

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Safety

Vision Occluded | Cyber-Sickness | Infection

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Vision Occluded

- Slips, Trips and Falls
- Hitting Furniture
- Safety Features
  - Guardian
  - Therapist

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VR Sickness

Some users experience symptoms of motion sickness

- Discomfort
- Headaches
- Upset stomach
- Dizziness
- Sweating
- Etc

Less common than it used to be because of improved immersion

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Infection Control

- No wounds
- Silicone face covers
- All parts of the headset can be cleaned except the lenses
  - Do not wipe the lenses with liquid! Use a microfiber cloth
- UVC Disinfection

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VR can be feasible in most Clinics

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Summary

VR is an effective method for pain management

Immersive VR is a feasible, motivating, engaging and fun method to provide pain relief for both patients with acute and chronic pain

VR provides additional benefits for clients with chronic pain including improved function, and pain management

There are multiple, compatible mechanisms that provide pain relief

Health practitioners should consider VR as one tool in their management of pain

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Questions

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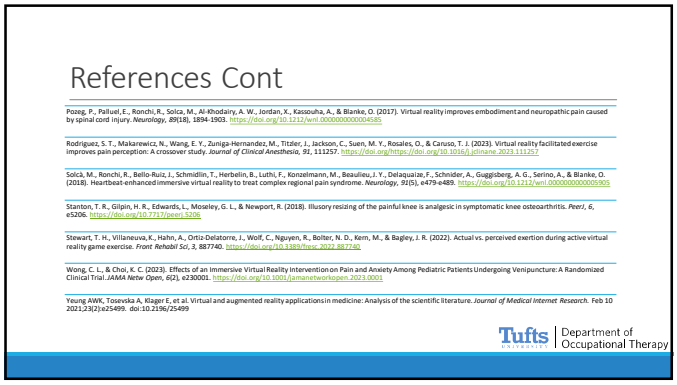
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