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Virtual reality and immersive technologies to promote workplace wellbeing: a systematic review

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\textbf{ABSTRACT}

\textbf{Background:} Work-related stress negatively impacts employee wellbeing. Stress-management interventions that reduce workplace stress can be challenging. Immersive technologies, such as virtual reality (VR), may provide an alternative.

\textbf{Aims:} This systematic review aimed to evaluate feasibility, acceptability, and effectiveness of immersive technologies to promote workplace wellbeing (PROSPERO 268460).

\textbf{Methods:} Databases MEDLINE, Web of Science, PsycINFO and Embase were searched until 22\textsuperscript{nd} July 2021. Studies were included if they tested a workforce or were designed for a workplace. Effective Public Health Practice Project quality assessment tool (EPHPP) was used for quality ratings.

\textbf{Results:} There were 17 studies (\(N=1270\)), published 2011–2021. Over half were conducted in Europe. Eight studies were controlled trials. Most studies involved brief, single sessions of immersive VR and provided evidence of feasibility, acceptability, and effectiveness when measuring wellbeing-related variables such as stress, relaxation, and restoration. VR environments included relaxation tasks such as meditation or breathing exercises, and nature-based stimuli, such as forests, beaches, and water. Studies tested office workers, healthcare professionals, social workers, teachers, and military personnel. EPHPP ratings were “strong” (\(N=1\)), “moderate” (\(N=13\)), and “weak” (\(N=3\)).

\textbf{Conclusions:} VR relaxation appears helpful for workplaces. However, limited longer-term data, controlled trials, and naturalistic studies mean conclusions must be drawn cautiously.

\textbf{Introduction}

Work-related stress is a leading cause of common mental health problems, such as anxiety, depression, and burnout, which impacts one in six working adults (Harvey et al., 2017; Seymour, 2010). It can also result in serious physical health consequences, such as cancer, diabetes, and cardiovascular disease (Wiegner et al., 2015). Organisations suffer the impact of work stress with 17.9 million workdays lost in 2019 in Great Britain (HSE., 2020b), costing the economy £5 billion (HSE, 2020a), with similar costs incurred worldwide (WHO., 2017). "Presenteeism", in which poor mental health impacts employees’ workplace productivity, is considered to be similarly damaging to organisations as absenteeism (Kirkham et al., 2015). COVID-19 has further amplified pressure faced by many workers, with increased staff absences and limited face-to-face contact, which has exacerbated rates of stress-related illness (Horesh & Brown, 2020; Mezzina et al., 2020).

Stress management interventions are increasingly being implemented in workplaces and can be used as an effective breaktime activity during the working day (Tetrick & Winslow, 2015). These interventions can either target employees currently experiencing stress or take a preventative approach by targeting all employees (Quick & Tetrick, 2011). Interventions, such as psychoeducational stress management workshops, yoga, mindfulness, and deep breathing techniques, have increased positive wellbeing and relaxation, and reduced physiological symptoms, such as high blood pressure and heart rate (Balaji et al., 2012; Edwards & Burnard, 2003; Li et al., 2020). Short daily mindfulness sessions can reduce stress and improve sleep quality and job satisfaction (Klatt et al., 2009; Michel et al., 2014; Wolever et al., 2012). However, many of these interventions can be incompatible with fast-paced working environments, or workers can find them difficult to engage with (Nahar & Gurav, 2018), so there is need for novel workplace stress management interventions.

Immersive technologies, such as virtual reality (VR), multi-sensory rooms, cave automated virtual environments, spatialised audio environments, and role-playing games,
employ virtual, immersive, and interactive elements to promote workplace wellbeing and optimise workplace conditions (Barton et al., 2020; Michalos et al., 2018; Rajguru et al., 2020; Riches & Smith, 2022). VR-based relaxation is a common immersive technology for stress reduction, typically using a head-mounted display (HMD), with immersive, interactive three-dimensional images of relaxing virtual environments (Slater et al., 1994; Villani et al., 2007). VR relaxation has been found to significantly reduce stress in clinical and non-clinical populations (Gorini & Riva, 2008; Riches et al., 2021; Veling et al., 2021); while, more generally, VR and other immersive technologies have been used to reduce pain (Nordgård & Låg, 2021), anxiety, and improve mood (Yu et al., 2018). Such immersive technologies have potential to be cost- and time-efficient tools that are engaging, promote wellbeing, and offer brief respite from the workplace without workers needing to physically leave their working location (Liberatore & Wagner, 2021; Riches et al., 2021). A recent scoping review concluded VR may have potential as a stress management tool in workplaces (Naylor et al., 2020); however, there is no systematic review assessing broader applications of VR and other immersive technologies to promote employee wellbeing and optimise workplace conditions to mitigate against work-related stress. This systematic review aims to narratively synthesise evidence of feasibility, acceptability, and effectiveness of VR and immersive technologies to promote workplace wellbeing.

**Methods**

This review is registered on the PROSPERO database (268460).

**Search strategy**

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Moher et al., 2009). A systematic search of published articles on MEDLINE, Web of Science, PsycINFO and Embase databases was carried out on 22nd July 2021. Search terms focused on the concepts of virtual reality and immersive technologies, workforces and workplaces, breaktimes and relaxation, and wellbeing. Truncations were used to search the roots of words and alternative endings. See Table 1 for the full list of search terms and search strategy. Database searches targeted keywords, title, and abstract information and were restricted to English language publications. Categories of “virtual reality”, “occupations”, “leisure time” and “wellbeing” were ‘exploded’ for MEDLINE, PsychINFO, and Embase, and results were combined with results generated from search terms. Searches and screening using Endnote were carried out by two reviewers (LT, P), under the supervision of another researcher (SR). This screening included abstract, article title, and full-text screening. Studies screened and included in this study were also found through other sources, which included reference lists of other publications and independent searching. This search strategy included an initial pilot phase that was carried out by the same research team before the formal search was conducted.

Studies were included if they were published in a peer-reviewed journal; written in English; used an experimental design; presented original data; N ≥ 5; tested virtual, immersive, or interactive environments that promote workplace wellbeing; and tested members of a workforce, or tested an intervention designed for a workforce, or tested an intervention in a workplace. Studies using mixed samples, e.g., participants who were employed, unemployed, or students, were included in the review if the primary study aim was investigating workplace wellbeing. Studies were excluded if they were conference proceedings, abstracts, books, book sections, grey literature, or dissertations; or if the immersive technology was used for staff training or for employees to carry out their work duties. Non-peer-reviewed journal publications were excluded to ensure that the review was methodologically robust.

Two researchers (SR, LT) led on the narrative synthesis, in collaboration with the wider research team. A structure of feasibility, acceptability, and effectiveness was used as a framework for the narrative synthesis because investigation of these issues was the main aim of the review. The review was defined as ‘feasibility’ as whether interventions were practical and delivered as intended; ‘acceptability’ as whether

<table>
<thead>
<tr>
<th>Table 1. Full list of search terms and Boolean operators.</th>
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<tbody>
<tr>
<td><strong>Virtual reality and immersive</strong>&lt;br&gt;technology terms</td>
</tr>
<tr>
<td>&quot;virtual real&quot; OR &quot;virtual-real&quot;</td>
</tr>
<tr>
<td>OR &quot;VR&quot; OR &quot;augmented&quot;</td>
</tr>
<tr>
<td>OR &quot;AR&quot; OR &quot;extended&quot;</td>
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</table>
participants found the intervention acceptable and that there were no adverse experiences; and ‘effectiveness’ as whether the intervention improved wellbeing outcomes.

Quality assessment

The Effective Public Health Practice Project quality assessment tool for quantitative studies (EPHPP) (EPHPP, 2010) was used for quality ratings. EPHPP rates studies ‘weak’, ‘moderate’ or ‘strong’ on six methodological domains: selection bias, study design, confounders, blinding, data collection and withdrawals. Studies are given a Global Rating of ‘weak’ for two or more weak methodological domains, ‘moderate’ for only one weak methodological domain, and ‘strong’ for no weak methodological domains. The tool reclassifies randomised controlled trials (RCTs) as controlled clinical trials (CCTs) if no method of randomisation is reported.

The EPHPP was selected for this review because it can provide consistent quality ratings for a range of study designs. One researcher (LT) conducted quality ratings for all studies. A second researcher (PJ) rated a third of studies. Quality ratings were regularly discussed with another researcher (SR) who oversaw quality ratings. The research team met regularly to discuss any differences in quality ratings between researchers and studies were re-evaluated until consensus was reached.

Results

Study characteristics

In total, 10,563 articles were identified (Web of Science = 5,108; Embase = 3,106; MEDLINE = 1,942; PsychINFO = 394; other sources = 13). Thirty-nine full texts were retrieved and assessed for eligibility and 17 studies, published between 2011 and 2021, met inclusion criteria and were included in this review. See Figure 1 for PRISMA flowchart and Table 2 for study characteristics. Nine studies were conducted in Europe (Germany, N = 3; Finland, N = 1; Ireland, N = 1; Italy, N = 1; The Netherlands, N = 1; Spain, N = 1; United Kingdom, N = 1), four in North America (United States, N = 3; Canada, N = 1), three in Asia (China, N = 2; Records identified (n=10563)
<table>
<thead>
<tr>
<th>Databases: PsychInfo (n=394); Embase (n=3106); Medline (n=1942); Web of Science (n=5108); Registers (n=0); other sources (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Records removed before screening: Duplicate records removed (n=1971)</td>
</tr>
<tr>
<td>Records removed for other reasons: book sections (n=67); books (n=14); dissertations (n=75)</td>
</tr>
<tr>
<td>Records screened (n=8436)</td>
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<tr>
<td>Reports sought for retrieval (n=39)</td>
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<tr>
<td>Reports assessed for eligibility (n=39)</td>
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<tr>
<td>Studies included in review (n=17)</td>
</tr>
</tbody>
</table>

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of studies of virtual reality and immersive technologies to promote workplace wellbeing.
### Table 2. Characteristics of studies of virtual reality and immersive technologies to promote workplace wellbeing.

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>N</th>
<th>Comparison group (N)</th>
<th>Mean age (SD)</th>
<th>Participant Population</th>
<th>Study Location</th>
<th>Apparatus</th>
<th>Experimental condition</th>
<th>Comparison condition (s)</th>
<th>Sessions</th>
<th>Follow up</th>
<th>Measurements</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMD VR studies</td>
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<tr>
<td>Anderson et al. (2017)</td>
<td>United States</td>
<td>18 (9 F)</td>
<td>18 (9 F)</td>
<td>None</td>
<td>General population</td>
<td>Laboratory</td>
<td>HMD (Oculus Rift DK2), Dream Beach VR and Ireland VR (sourced from <a href="http://www.feelttherelaxation.com">www.feelttherelaxation.com</a>), HR device (Biopac MP150 with ED100C and ECG100C modules), AcqKnowledge 4.4.0, Biopac software; beach lounge chair, heat lamp</td>
<td>Experience 360-degree immersive HD VR scenes with beach lounge chair and heat lamp; Irish countryside with views of water/animals/evidence of human presence; Australian beach scenes with no signs of human presence/animals and ocean sounds; soothing music (15 min per scene)</td>
<td>Experience 360-degree HD VR empty classroom scene with no people/plants/animals</td>
<td>1</td>
<td>No</td>
<td>VVR, EDA, EKG, HRV, PANAS, MHPQ; qualitative comments on scene content; scene ranking (favourite to least favourite)</td>
<td>Significant physiological reduction in stress after experiencing VR natural scenes compared to control condition. Positive affect decreased after control VR but not after nature VR. Negative affect decreased after nature VR but not after control VR. More subjective ‘sense of presence’ in nature scenes. Scene preference had a significant positive effect on mood and subjects ‘sense of presence’.</td>
</tr>
<tr>
<td>Blum et al. (2019)</td>
<td>Germany</td>
<td>60 (31 F)</td>
<td>31</td>
<td>29</td>
<td>Employees from local companies (No more information given)</td>
<td>Laboratory</td>
<td>HMD (Oculus Rift CV1); VR-BF condition: virtual beach scene (programmed by authors); Standard-BF: graphical geometrical indicators; over-ear headphones; chest strap (Polar H7) connected to a Windows 10 computer via Bluetooth Low Energy; computer screen (Dell U2415); HRV measurement software (Kubios HRV)</td>
<td>VR-BF condition: Experience an immersive VR sunset beach whilst completing an audio guided diaphragmatic breathing exercise and biofeedback task. Beach scene included ocean views/campfire/rocks/palms with ocean and soundscape sounds. Continuous biofeedback was incorporated in the scene via changing cloud coverage in response to participants HRV parameter. Dichotomous biofeedback was visualized by lamps and campfire lighting up whenever HRV threshold was surpassed (30 min)</td>
<td>Standard-BF condition: Experience an audio guided breathing exercise and complete a biofeedback task with abstract feedback formed of graphical geometrical indicators on a computer screen. Ambient instrumental music and a pacemaker sound played throughout. Continuous biofeedback was represented by the amount of blue fill in a horizontal bar in the screens centre. Dichotomous biofeedback was represented by a colour indicator turning red to green when the HRV threshold had been surpassed (10 min)</td>
<td>1</td>
<td>No</td>
<td>Demographics; STAI; VAS (relaxation self-efficacy); ODI, SMS, Stroop colour task; HR, IBI, HRV; VAS (biofeedback treatment experience)</td>
<td>Standard-BF and VR-BF conditions produced similar physiological/self-measure increases in relaxation. VR-BF condition produced less mind-wandering, more relaxation self-efficacy, and more attention. VR-BF condition was subjectively liked significantly more compared to standard-BF condition.</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
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<td>Experimental group (N)</td>
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<tr>
<td>Chung et al. (2018)</td>
<td>South Korea</td>
<td>40 (18 F)</td>
<td>40 (18 F)</td>
<td>Employees, unemployed and students (No more information provided)</td>
<td>No information provided</td>
<td>Mobile VR system (LG G3 smartphone and LG 360-degree VR glasses); hard fascination stimuli: 3 360-degree 4K firewall VRs (YouTube); soft fascination stimuli: restorative nature 360-degree VR; 2-tone passive auditory oddball paradigm (750 Hz standard tone and 1000 Hz deviant tone presented at 75 dB, for 100 ms); auditory stimuli presented using Sony MDR 1 A headphones on an OptiPlex 7040 Mini Tower PC; E-Prime v.2.0 software for programming the experimental scene; revolving chair</td>
<td>Participants were asked to ignore standard and infrequent deviant tones from a 2-tone passive auditory oddball paradigm while viewing 3 silent VR firewall videos (hard fascination scenes) followed by 1 VR nature video (soft fascination scene) consisting of seaside/grassland/hills (5 min 53s per video)</td>
<td>None</td>
<td>1</td>
<td>No</td>
<td>Demographics; EHI; SSQ, PRS, EEG; MMN/P3a complex amplitude</td>
<td>Nature VR elicited both subjective and neurophysiological restorative responses. Firewall VRs consumed significantly more attentional resource and induced greater mental fatigue compared to the nature VR. Higher reported restorative impact of VRs resulted in less physiologically measured attentional fatigue. VR experience did not cause simulator sickness or other problems.</td>
<td></td>
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<tr>
<td>Cikajlo et al. (2017)</td>
<td>Ireland</td>
<td>8</td>
<td>None</td>
<td>employees/volunteers: 27–40; outpatients with TBI (No more information provided)</td>
<td>Group session: hospital rooms; Individual session: participants’ home</td>
<td>Mindfulness cloud-based app: Realizing Collaborative Virtual Reality for Well-being and Self-healing (ReCoVR); HMD (Samsung Gear VR), Gear VR smartphone app developed in Unity 3D (Unity Technologies) developed for Android operating system (tested with Lollipop 5.1 and 6.0 Marshmallow); 360-degree camera, server app hosting the web-based virtual meeting room developed (Unity 3D) and installed on cloud server (heroku.com); 3D VR</td>
<td>8 week guided meditation group session programme: Enter a virtual room with an instructor and participants. Instructor was visible to participants on a large screen in the VE. Participants were seen as avatars. Mindfulness sessions included group discussions, mindfulness exercises and poem readings. Instructor guided video and audio communication with groups/individuals through the web interface and could share resources. Two 360-degree</td>
<td>8 group sessions (1 per week for 8 consecutive weeks)</td>
<td>Unsupervised self-meditation sessions</td>
<td>None</td>
<td>8</td>
<td>group sessions (1 per week for 8 consecutive weeks)</td>
<td>All participants: demographics; SWLS, MAAS; head motion analysis using smartphones, built-in orientation sensor; VR usability; Likert scale questions</td>
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Table 2. Continued.

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>Gaggioli et al. (2014)</td>
<td>Italy</td>
<td>121 (73 F)</td>
<td>40 (23 F)</td>
<td>CG: 42 (30 F); W-L: 39 (20 F)</td>
<td>EG: 46.3 (7.7); CG: 42.9 (5.5); W-L: 39.6 (9.7)</td>
<td>High-school teachers in Milan, paediatric nurses in Messina</td>
<td>Therapist's office (located in Instituto Scientifico Ospedale San Luca, Milan, Italy, OR Healthcare Centre OR schools)</td>
<td>HMD (Vuzix Wrap 1200VR, 3D and tracking support), VR software (NeuroVR 3.0), PC (Core i5, 8 GB RAM, NVIDIA GeForce GT 540 M), Smartphone (iPhone 4S, 16GB), Physiological data recording device (Empatica E3 wrist sensor), Wireless cardiovascular belt (developed by University of Roa)</td>
<td>EG: In therapist's office (interreality session): 1) Interacted in stressful, job specific, immersive role-playing scenarios (such as teachers coping with parent criticism) whilst learning coping techniques from a therapist (such as cognitive restructuring). 2) Experienced immersive, interactive relaxing nature VE (such as walking along a beach/campfire in the mountains/desert oasis) with and without biofeedback which controlled certain aspects of the VE (such as the size of fire or the flow of a waterfall). Audio narratives describing the therapy</td>
<td>CG: In therapist's office session: Received a traditional CBT protocol following the same structure as EG (8 one-hour sessions in five weeks). Participants were asked to close their eyes and imagine a stressful situation with an audio guide describing the stressful context. Received audio guided relaxation (1 hour per session)</td>
<td>8 sessions over 5 weeks</td>
<td>Yes</td>
<td>MNL demographics, STAI-Y1, STAI-Y2, COPE, PSS, PSM, VAS-A, HRV, HRVd</td>
<td>EG and CG reduced perceived stress significantly more than W-L. EG produced a significantly greater reduction in chronic &quot;task&quot; anxiety compared to CG. Both CG and EG significantly increased stress coping skills. EG was the only condition to significantly increase Emotional Support Skill.</td>
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<td>Study</td>
<td>Country</td>
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<td>Kasacan et al. (2021)</td>
<td>Germany</td>
<td>Study 1: 51 (17 F)</td>
<td>Study 2: 101 (53 F)</td>
<td>Study 1: 22.82 (3.15)</td>
<td>Study 2: 39.36 (9.61)</td>
<td>Participants were asked to track stress levels throughout the day, wear a physiological data recording device to record contextual stress, and complete homework involving non-immersive guided relaxation and VEs with biofeedback viewed on a smartphone.</td>
<td>Study 1 and 2: High immersion calming condition with 360-degree video played on a laptop screen. Participants moved through the VE with a mouse control (10 min).</td>
<td>Study 1 and 2: Demographics, PRS, positive and negative affect Likert scale; simulator sickness Likert scale</td>
<td>Study 1 and 2: High immersion conditions were more immersive and created a sense of 'being away' compared to low immersion nature condition. High immersion conditions increased positive affect and decreased negative affect via 'being away'. High immersion calming scenes were significantly more subjectively fascinating than low immersion calming scenes. High immersion stimulating nature scene led to increased positive affect compared to a high immersion calming scene. Most participants did not report simulator sickness. Study 2 only.</td>
<td>High immersion conditions were more immersive and created a sense of 'being away' compared to low immersion nature condition. High immersion conditions increased positive affect and decreased negative affect via 'being away'. High immersion calming scenes were significantly more subjectively fascinating than low immersion calming scenes. High immersion stimulating nature scene led to increased positive affect compared to a high immersion calming scene. Most participants did not report simulator sickness. Study 2 only.</td>
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<td>Maarsingh et al. (2019)</td>
<td>Netherlands</td>
<td>Group 1: 111 (69 F)</td>
<td>Group 1: 111 (69 F)</td>
<td>None</td>
<td>Group 1: local companies' employees (No more information provided)</td>
<td>HMD (HTC Vive); image controller; VR biofeedback game &quot;Stressjam&quot; (produced by Jamzone); HRV chest sensor</td>
<td>Group 1: Play the applied VR game &quot;Stressjam&quot; with HRV biofeedback. Participants explore an interactive tropical island scene in which their physiological responses are used to complete tasks (such as inducing stress to open a gate). Stress levels are updated every 60 seconds as a baseline measurement. Changing colors on in-game controller indicates to participant if they above or below their baseline score (1 hour per session)</td>
<td>None</td>
<td>1</td>
<td>No</td>
<td>Demographics; HRV (measured using rMSSD); SMM-G; SUS; PI</td>
<td>Immersion stimulating nature scene led to significantly greater reduction in negative affect via perceived fascination.</td>
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<tr>
<td>Mattila et al. (2020)</td>
<td>Finland</td>
<td>100 (44 F)</td>
<td>None</td>
<td>Students and employees (No more information provided)</td>
<td>Office</td>
<td>HMD (HTC Vive); headphones; VR application developed by 3D-modelling professionals using a game engine (Unreal Engine); rotating office chair</td>
<td>Participants were seated in a rotating office chair and explored an immersive VR closed view forest scene consisting of local plant species/butterflies and movement of objects in the wind. A soundscape consisting of ambient sounds such as winds and birds accompanied the VE (5 min).</td>
<td>None</td>
<td>1</td>
<td>No</td>
<td>Demographics; SVS; PANAS; ROS</td>
<td>VR forest scene significantly increased positive mood, relaxation, attention restoration and vitality and decreased negative mood. Positive impacts of VR forest scene were not significantly different between gender, age, or occupation. VR forest scene was perceived by participants as more restorative, coherent, and fascinating compared to real (continued)</td>
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<tr>
<td>Study</td>
<td>Country</td>
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<tr>
<td>Nayler et al. (2019)</td>
<td>Australia</td>
<td>49 (21F)</td>
<td>“Soundself” condition: 16 (10F), “rainy day” condition: 17 (16F)</td>
<td></td>
<td>27.33 (6.96)</td>
<td>General population students (No more information provided)</td>
<td>Office</td>
<td>HMD (Oculus Rift development kit; Windows 7 laptop; HR device (Fitbit Charge); “Soundself condition”: 20 min version of “Soundself alpha build 2015-06-10” meditation program created by Amott &amp; Balster, 2013, available from <a href="http://soundselfgame.com">http://soundselfgame.com</a>); breathing condition: audio from “relaxation breathing guided” (sourced from Cura smile YouTube channel, 2013), combined with visuals generated using VUIR (version 0.7.5) from Valynx Studio (2015); control condition: “rainy day office window” video (sourced from Jason Comerford Photography YouTube channel, 2015)</td>
<td>Soundself condition: experience an interactive and immersive HMD audio-guided meditation program consisting of a void of colourful lights and sounds controlled by user input (20 min)</td>
<td>Breathing condition: experience an immersive but not interactive HMD guided meditation program consisting of a void of colourful lights and sound with generated visuals changing pattern and colour in response to paired audio (not controlled by user) (20 min)</td>
<td>1</td>
<td>No</td>
<td>Demographics; Stroop colour test; HR PANAS; Likert scale and qualitative questions about user experience</td>
<td>All HMD conditions significantly reduced HR post-intervention session. All HMD conditions significantly reduced positive and negative affect post-intervention. Participants mostly supported the use of VR in workplaces/collages and reported feeling relaxed using HMD. Breathing condition showed a significant interaction between time and condition on negative affect. Privacy was a common concern.</td>
</tr>
<tr>
<td>Palanca et al. (2019)</td>
<td>Canada</td>
<td>Study 1: 84 (41F)</td>
<td>Nature-3D condition: 23 Urban-3D condition: 21</td>
<td></td>
<td>33.6 (7.4)</td>
<td>Klick Inc employees (technology, media, and research company in the healthcare sector)</td>
<td>Private room inside employee’s office building</td>
<td>Nature condition stim: UHD 360-degree “beach environment” video (sourced from YouTube) (4 min); urban condition stim: UHD 360-degree “urban city environment” video (sourced from YouTube) (4 min), 3D conditions: HMD (Oculus Rift headset); 2D conditions: mobile tablet</td>
<td>Nature-3D condition: experience a UHD 360-degree beach environment displayed on HMD, while performing an AUT task (4 min); Urban-3D condition: experience a UHD 360-degree urban city environment displayed on HMD, while performing an AUT task (4 min)</td>
<td>1</td>
<td>No</td>
<td>Demographics; AUT</td>
<td>Participants in 3D and 2D nature environment conditions produced significantly more alternative responses (fluency), categories of responses (flexibility) and original responses (originality) compared to the 2D and 3D urban environment conditions.</td>
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<tr>
<td>Rockstroh et al. (2019)</td>
<td>Germany 68 (41 F) 24</td>
<td>2D-BF: 22 CG: 22</td>
<td>22.9 (4)</td>
<td>University students and part-time/full time employees (No more information provided)</td>
<td>Laboratory</td>
<td>Windows 10 computer with Nvidia GeForce GTX 1080 graphics card, 32 GB RAM/Intel Core i7–6700K; computer monitor (Dell U2415); HMD (Oculus Rift CV1 with a resolution of 2160 x 1200); headphones (Panasonic RP-HE05E-A over ear); HRV chest strap; analysed heart rate variability data with Kubios HRV software; Beach scene VE programmed with game engine Unity3D; auditory pacemaker</td>
<td>VR-BF condition: experience a virtual nature environment, displayed on HMD, of a beach at sunset with views of the ocean/sand/palms with soft lighting and a relaxing, natural soundscape. Participants were asked to maintain a state of heart coherence using biofeedback (such as deep diaphragmatic breathing) via a chest strap. Biofeedback would change scene stimuli (e.g., positive feedback cleared clouds from the sky, lit lights and changed scene sounds such as crackling fire/soft wave sounds) (10 min)</td>
<td>CG condition: watched a 2D neutral nature video, displayed on HMD, depicting a Mediterranean island without a biofeedback session (10 min)</td>
<td>1</td>
<td>No</td>
<td>Demographics; HR; IBI; MDBF; VAS for motivation and subjective attention</td>
<td>Both biofeedback conditions (VR-BF and 2D-BF) were equally as effective in increasing short-term HRV whereas the control group was not. All conditions showed a decrease in HR and IBI pre to post session. VR-BF condition elicited more motivation and increased subjective attentional focus compared to CG and 2D-BF conditions.</td>
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<tr>
<td>Vaquero-Blasco et al. (2021)</td>
<td>Spain 23 (14 F)</td>
<td>23 (14 F)</td>
<td>None</td>
<td>University classroom</td>
<td>HMD (Oculus Quest) and HMD controller; 360-degree VR experiences (RELAX) developed using Unity software (2010 version). SPSL was programmed to appear in-game view and answered with HMD controllers; MST task was implemented as a graphical interface using MATLAB R2016a (MathWorks); ECG acquisition</td>
<td>VR experiences reduced physiological biomarkers of stress. All VEs were equally effective at reducing stress. Reported stress level significantly decreased during VR intervention. Physiological and self reported measures of stress correlated suggesting measured HR biomarker was a reliable indicator of stress. Most participants</td>
<td>None</td>
<td></td>
<td>1</td>
<td>No</td>
<td>Demographics; SPSL (ECG biomarker); MST; PSS; User experience surveys</td>
<td>(continued)</td>
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<td>Study</td>
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<tr>
<td>Wang et al., 2019</td>
<td>China</td>
<td>96 (63 F)</td>
<td>96 (63 F) grouped into one of seven forest environments: (1) structure; (2) wood; (3) wood with bench; (4) wood with platform and bench; (5) platform with trees; (6) waterfall with trees; (7) pool with plants</td>
<td>None</td>
<td>24.03 (5.29)</td>
<td>University students and healthcare social workers</td>
<td>Laboratory</td>
<td>UCVR EYE-01 camera (Pinkang Smart Company); BP and HR monitor (HEM-7111 electronic sphygmomanometer produced by upper arm, OMRON); saliva collection tube (salivate, SARSTEDT); VR illusion mirror type glasses</td>
<td>Participants experienced one of seven VR environments whilst imagining being in the environment: (1) structure, (2) wood, (3) wood with bench, (4) wood with platform and bench, (5) platform with trees, (6) waterfall with trees, (7) pool with plants (5min each)</td>
<td>None</td>
<td>1</td>
<td>No</td>
<td>Demographics; BP, HR, salivary amylase; BPOMS</td>
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<tr>
<td>Other Immersive Technology Studies</td>
<td>United Kingdom</td>
<td>31 (15 F)</td>
<td>31 (15 F)</td>
<td>University postgraduate students and University staff</td>
<td>Anechoic chamber</td>
<td>Headphones (Beyerdynamic DT 150); 27'' LED monitor (Samsung LS27A350); high-resolution photograph of furnished open-plan office (sourced from K2 Space's flickr.com account); Autodesk 3ds MAX with Mental Ray used to model and render the water feature animations over the office photograph; Audio-visual condition: Part 1: audio-visual preferences. Paired comparison task 15 pairs of water sounds were played over the sounds of 'irrelevant speech' (7 seconds per sound) whilst participants viewed a high-resolution image of an open plan office with animated water features in varying places on an LED</td>
<td>Audio-only condition: Same procedure as the audio-visual condition but without visual materials (40min)</td>
<td>1</td>
<td>No</td>
<td>Demographics; q1, q2, STI; Paired comparison questions; Likert scale (perception of water sounds)</td>
<td>4-step cascade, dome fountain, foam fountain, and 37-jet fountain sounds were preferred and improved people's perception of their working environment across both conditions. The favoured water feature sound in the audio-only condition was the 37-jet fountain whereas the 4-step cascade sound was favoured in audio-visual</td>
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<td>water particle simulation carried out using RealFlow 2015 (Next Limit), water sounds: six 7 seconds long binaural signal recordings (4-step cascade, dome fountain, foam fountain, 37-jet fountain, large jet, narrow jet), irrelevant speech sounds: 7 seconds long high-quality speech recordings of one side of telephone conversations (sourced from Veitch et al., 2002); sounds were calibrated using handheld sound analyser, (Bruel and Kjaer type 2250); audio production software (Studio One 3, Presonus), office desk, office chair</td>
<td>monitor, for each pair participants chose which sound they would prefer to work in over a long period, time helped them concentrate. (35 min)</td>
<td>Part 2: audio-visual perception condition. Participants listened to 6 pairs of ‘irrelevant speech’ followed by ‘irrelevant speech’ masked with a water feature sound (7 seconds per sound) whilst viewing the high-resolution office image with animated water features. Participants were asked how their perception of the office changed with/without the water feature sound (5 min)</td>
<td>Positive perception of all water feature sounds increased up to 2.5 times in the audio-visual condition compared to the audio-only condition suggesting a visual element increases positive perceptions of water sounds. Adding physical or audio water feature sounds in the centre and sides of an office space can mask irrelevant office sounds, reduce distraction, and (continued)</td>
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<tr>
<td>Ma and Shu (2018)</td>
<td>China</td>
<td>Experiment 3 30 (no more information provided)</td>
<td>None</td>
<td>No information provided</td>
<td>University graduate students; (Tianjin University)</td>
<td>No information provided</td>
<td>Binaural signals played back by computer using headphones (AKG K702); images displayed on 46-inch screen; physiological responses/ psychological experience/task performance measured on a hemodynamometer; wrist blood pressure monitor</td>
<td>Completed a calculation task to create stress and attentional fatigue before listening to either negative (air conditioning) or positive (water feature) sounds whilst looking at either a bad or good image of an open-plan office. Participants then performed a 1-minute target searching task. This procedure was repeated until all combinations of audio-visual stimuli were completed by each participant (48 min)</td>
<td>The same participants observed silence instead of audio-visual stimuli before completing the 1-minute target searching task (8 min).</td>
<td>1</td>
<td>No</td>
<td>SP; DI; HR; POMS; TST</td>
<td>The combination of the water feature sound with a good image of an open-plan office induced the greatest restorative impact on self-reported tension, fatigue, and annoyance. The water feature sound was significantly more restorative than the air conditioner sound with both bad and good images. Task performance improved when audio and visual stimuli was consistent (i.e., good image with positive sound and bad image with negative sound). Physiological measurements showed no significant results between groups.</td>
</tr>
<tr>
<td>Putrino et al. (2020)</td>
<td>United States</td>
<td>219</td>
<td>219</td>
<td>None</td>
<td>Mount Sinai hospital healthcare workers</td>
<td>HD projector; HD audio recordings; ‘Recharge Room’ (179.38 square foot neurophysiology laboratory); Hue Bridge automatic lighting; voice-activated technology (Google Home)</td>
<td>VR-relaxation group: Participants explored a multisensory (visual, auditory, and olfactory), nature inspired physical ‘Recharge Room’. The room included imitation plants, voice-activated projections of calming landscapes, scented oil diffusers, HD nature-inspired audio recordings. Lighting was synchronised with different nature scenes (such as a blue hue for ocean scenes) (15 min)</td>
<td>None</td>
<td>1</td>
<td>No</td>
<td>Likert scales for stress; NPS</td>
<td>Self-reported stress significantly decreased after visiting the ‘Recharge Room’; 99% of participants promoted the use of the ‘Recharge Room’</td>
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<td>Stetz et al. (2011)</td>
<td>United States</td>
<td>60 (20 F)</td>
<td>30</td>
<td>30</td>
<td>32.8 (8.74)</td>
<td>Military medical professionals (Ryder Trauma Centre, Florida, USA)</td>
<td>Cinema</td>
<td>Cinema screen; &quot;Dream Island&quot; VR relaxation tool developed using Utility 2.5 Pro VR toolkit with embedded guiding narratives, mouse and keyboard; portable play station</td>
<td>Participants experienced the &quot;Dream Island&quot; VR tool in which they were guided through calming scenes and relaxing images (e.g., slow waves on the shore) while practicing progressive muscle relaxation and controlled breathing (7 min per session). &quot;Dream Island&quot; VR was controlled by an instructor. Participants practiced relaxing techniques outside of the sessions by watching videos of the VR environment on a portable play station. Participants also completed a stressful 'hands-on' task (such as a simulation of a mass causality in which they had to perform medical procedures) before the first VR relaxation session and after the last VR relaxation session. (7 min per VR relaxation)</td>
<td>CG: Did not receive an intervention</td>
<td>3</td>
<td>No</td>
<td>Demographics; PCL-M; STAI; UQO-PQ; focus groups/questionnaire of user perceptions of the VR tool</td>
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Key: Demographics: F: Female; TBI: Traumatic Brain Injury; Conditions: CG: Control Group; EG: Experimental Group; W-L: Waiting List Group; VR-BF: Virtual Reality Biofeedback. Equipment: HMD: head-mounted display; VE: virtual environment; VR: virtual reality; UHD: ultra-high-definition. Measures: AUT: Alternate Uses Test; BPO: Brief Profile of Mood States; CQ: Cognitive Interference Questionnaire; COPE: Coping Orientation to the Problems Experienced; DP: diastolic pressure; EDA: electrodermal activity; EEG: electroencephalogram; EHI: Edinburgh Handedness Inventory; EKG: electrocardiogram; HR: heart rate; HRV: heart rate variability; IBI: interbeat interval; MAAS: Mindful Attention Awareness Scale; MBB: German Multidimensional Mood Questionnaire (Mehrdimensionaler Befindlichkeitfragebogen); MINI: Mini-International Neuropsychiatric Interview; MIST: Montreal Imaging Stress Task; MMN/P3a complex amplitude: Mismatch Negativity/P3a Complex Amplitude; MMSE: Mini-Mental State Examination; MRJPQ: Modified Reality Judgement and Presence Questionnaire; NPS: Net Promoter Score; PANO: positive and negative affect schedule; PCL-M PTSD: Check List-Military Version; PI: Personal Involvement Inventory; POMS: Profile of Moods States; PRS: Perceived Restorativeness Scale; PSS: Perceived Stress Scale; RG: relative gamma; RMSSD: root mean square of successive differences; RDS: Restoration Outcome Scale; t: Privacy Distance; SMM: Stress Mindset Measure; SMS: State Mindfulness Scale; SP: systolic pressure; SPR: Self Perceived Stress Level; SQ: Simulator Sickness Questionnaire; STAI: State Trait Anxiety Inventory; STAI-Y1: State-Trait Anxiety Inventory – "state anxiety"; STAI-Y2: State-Trait Anxiety Inventory – "trait anxiety"; S1: Speech transmission index; SUS: System Usability Scale; SVS: Subjective Vitality Scale; SWLS: Satisfaction With Life Scale; TST: Task Searching Test; UQO-PQ: Université du Québec en Outaouais Presence Questionnaire; VAS: Visual analogue scale; VAS-A: Visual Analogue Scale for Anxiety; VVR: Value of Virtual Reality.
South Korea, $N = 1$), and one in Australia (Australia, $N = 1$).

Studies used VR HMDs ($N = 13$), immersive 2D audio-visual interventions ($N = 3$), or multi-sensory rooms ($N = 1$).

In total, 1,270 people participated in the studies, with 859 experiencing an immersive technology intervention. One study did not record the number of participants experiencing an experimental intervention (Karacan et al., 2021). Studies ranged from having eight to 219 participants, with five studies including 100 or more participants (Gaggioli et al., 2014; Karacan et al., 2021; Maarsingh et al., 2019; Mattila et al., 2020; Putrino et al., 2020). Thirteen studies included part-time or full-time employees, of which three were conducted in employees’ workplaces (Karacan et al., 2021; Mattila et al., 2020; Palanica et al., 2019). Three studies included samples of healthcare professionals (Cikajlo et al., 2017; Gaggioli et al., 2014; Putrino et al., 2020), with one of them also including patients (Cikajlo et al., 2017) and one also including teachers (Gaggioli et al., 2014). Other studies included a mixed sample of social workers and students (Wang et al., 2019), university staff and students (Abdalrahman & Galbrun, 2020), employees of a large, German logistics company (Karacan et al., 2021), employees of a marketing and research company in the health sector (Palanica et al., 2019), and military personnel (Stetz et al., 2011). Five studies provided limited information about participant occupations; these participants were either employees from local companies (Blum et al., 2019; Maarsingh et al., 2019), mixed samples of employees and students (Mattila et al., 2020; Rockstroh et al., 2019), or students, employees, and unemployed participants (Chung et al., 2018). Another four studies included student or general population samples but explicitly stated a workplace application to the intervention (Anderson et al., 2017; Ma & Shu, 2018; Naylor et al., 2019; Vaquero-Blasco et al., 2021).

Fourteen studies included a single session, one included three sessions (Stetz et al., 2011), and two included eight sessions (Cikajlo et al., 2017; Gaggioli et al., 2014). Session length ranged from four minutes to one hour. Twelve studies used sessions of under 20 minutes. One study reported follow-up data, after an eight-session intervention (Gaggioli et al., 2014). Numerous psychological measures were used across studies. In several studies, stress, anxiety, and mood were measured with self-report measures, such as Perceived Stress Scale (PSS), Profile of Mood States (POMS), and State-Trait Anxiety Inventory (STAI). One study measured creativity with an Alternative Uses Test (AUT) (Palanica et al., 2019). Some studies employed physiological measures, such as heart rate variability (HRV) and electroencephalogram (EEG) to assess stress pre- and post-intervention sessions.

There were 13 head-mounted display VR studies. Twelve used immersive nature-based VR with ambient music or nature sounds, and one used a VR graphical ‘void of colourful lights and sounds’ as experimental stimuli (Naylor et al., 2019). Seven of the 12 nature-based studies involved participants viewing 360-degree high-definition video footage of real-life geographical locations, such as Irish countryside, Australian coastlines, Aurora Borealis, African safari with wild animals for office workers in the logistic sector, and waterfalls and pools in enclosed forests in Beijing. The other five studies used computer-programmed natural environments to immerse participants in interactive virtual scenes, such as beaches at sunset, tropical islands, or mountain tops with panoramic views. Four of the 12 nature-based studies incorporated elements such as fireworks (Chung et al., 2018), urban cityscapes (Palanica et al., 2019), fireplaces (Cikajlo et al., 2017), and helicopter rides (Karacan et al., 2021). Nine studies included specific relaxation tasks that were carried out while participants were exposed to the natural imagery. Four studies used a biofeedback task which involved participants trying to control physiological biomarkers of stress, such as HRV, that were being fed back to them in real-time (Blum et al., 2019; Gaggioli et al., 2014; Maarsingh et al., 2019; Rockstroh et al., 2019); and five studies incorporated guided meditation or breathing exercises with a real-life facilitator, audio-guided instruction, or a mixture of audio-guide and real-life facilitation.

Five studies measured perceived stress or stress-related mindset as the primary outcome (Gaggioli et al., 2014; Maarsingh et al., 2019; Rockstroh et al., 2019; Vaquero-Blasco et al., 2021; Wang et al., 2019), three measured relaxation (Anderson et al., 2017; Blum et al., 2019; Naylor et al., 2019), three measured restoration (Chung et al., 2018; Karacan et al., 2021; Mattila et al., 2020), one measured life satisfaction (Cikajlo et al., 2017), and one measured creativity (Palanica et al., 2019). HMDs used were Oculus Rift ($N = 5$), HTC Vive ($N = 2$), Samsung GearVR ($N = 2$), LG 360 VR glasses ($N = 1$), VUZIX Wrap 1200VR ($N = 1$), and Oculus Quest ($N = 1$). One study did not report the HMD brand but described the HMD as “second-generation VR glasses of the illusion mirror type” (Wang et al., 2019).

There were four studies that used other immersive technologies. Two displayed images of an office on a two-dimensional screen while a sample of students (Ma & Shu, 2018) or university staff and students (Abdalrahman & Galbrun, 2020) listened to audio playback of nature sounds on headphones (Abdalrahman & Galbrun, 2020; Ma & Shu, 2018). One of these studies included audio of air conditioner sound effects and office conversations with nature sounds (Ma & Shu, 2018). A study with medical surgeons as participants used a computer-generated tropical “Dream Island” scene on a cinema screen, with audio facilitation of relaxation techniques, to test the calming effect of the scene before participants were instructed to undertake a stressful VR-based task, such as an emergency surgery simulation (Stetz et al., 2011). In another study, frontline healthcare worker participants explored an immersive multi-sensory “Recharge” room with high-definition projections of natural landscapes, voice-activated colour lighting, and ambient music (Putrino et al., 2020). Three studies assessed stress, and one measured sound perception and preferences in offices (Abdalrahman & Galbrun, 2020) as a primary outcome.

**Feasibility, acceptability, and effectiveness**

**Head-mounted display virtual reality studies**

Out of 13 studies, 10 indicated the feasibility of HMD VR as a tool to support wellbeing in the workplace. Seven
Studies concluded that VR is a practical, intuitive, and convenient tool for those lacking access to outdoor space, such as those working in isolated and confined environments (Anderson et al., 2017) or offices (Blum et al., 2019; Chung et al., 2018; Mattila et al., 2019; Naylor et al., 2019; Vaquero-Blasco et al., 2021). Seven studies argued that VR is a time- and cost-efficient tool to support wellbeing in the workplace, which is becoming more affordable due to technological developments (Anderson et al., 2017; Chung et al., 2018; Mattila et al., 2020; Naylor et al., 2019; Rockstroh et al., 2019; Stetz et al., 2021; Vaquero-Blasco et al., 2021), although pointed out that costs of certain equipment are prohibitive (Gaggioli et al., 2014). Four studies reported occasional technical or practical difficulties with hardware, such as equipment overheating (Cikajlo et al., 2017), participants struggling to operate technology (Gaggioli et al., 2014), physical difficulties wearing HMDs relating to its weight and the brightness of visual stimuli (Naylor et al., 2019), and cybersickness (Karacan et al., 2021).

Six out of 13 studies indicated the acceptability of HMD VR as a tool to support wellbeing in the workplace. Participants reported that interventions were immersive (Vaquero-Blasco et al., 2021), interesting (Maarsingh et al., 2019), a positive experience (Anderson et al., 2017), improved confidence (Blum et al., 2019), and increased motivation (Rockstroh et al., 2019). Participants expressed a desire to use VR in the future (Anderson et al., 2017; Rockstroh et al., 2019), with 80% indicating they would recommend it for workplace wellbeing (Maarsingh et al., 2019; Naylor et al., 2019). Data privacy was a concern for a minority of participants in one study (Naylor et al., 2019).

Three studies reported reduced stress or changed mindset about stress in HMD conditions, although there were no comparison conditions (Maarsingh et al., 2019; Vaquero-Blasco et al., 2021; Wang et al., 2019). Two controlled studies reported reduced stress with HMDs, although there was no significant difference with comparison conditions of a 2D image of an open plan office compared to an audio only condition, and masked hearing (Cikajlo et al., 2017). However, a subsequent stressful VR task paired with water feature sounds increased positive perception of a 2D image of an attractive open plan office (Putrino et al., 2020). A 2D image of an attractive open plan office paired with water feature sounds had a significantly more (Abdalrahman & Galbrun, 2020). Two out of four studies evaluated acceptability, and both reported positive feedback. Ninety-nine percent of healthcare worker participants, from a sample of 219, recommended the “Recharge room” for wider use in healthcare settings, especially during the COVID-19 pandemic (Putrino et al., 2020). Participants who experienced the “Dream Island” scene reported that they would like to use the intervention again in the future (Stetz et al., 2021).

The large “Recharge Room” study (N = 219) found significantly reduced self-measured stress after 15 minutes (Putrino et al., 2020). A 2D image of an attractive open plan office paired with water feature sounds had a significant restorative impact (Ma & Shu, 2018). Military medical personnel had significantly less anxiety after a VR guided relaxation scene compared to a waiting list control (Stetz et al., 2011). However, a subsequent stressful VR task showed no significant differences between conditions. One study found the addition of a simulated water feature combined with water feature sounds increased positive perception of a 2D image of an open plan office compared to an audio only condition, and masked ‘office conversations’ significantly more (Abdalrahman & Galbrun, 2020).

Quality assessment

Global ratings were “strong” (N = 1), “moderate” (N = 13), and “weak” (N = 3). See Table 3 for quality ratings. Of the HMD VR studies, global ratings were “strong” (N = 1), “moderate” (N = 10), and “weak” (N = 2). Seven studies were RCTs, of which five were classified by the EPHPP tool.
as CCTs. The remaining studies were single group cohorts \((N = 6)\) and rated “moderate”. All seven RCTs did not report if the assessor was blind to participant conditions or if participants were blind to study research questions. One study was rated “strong”, eight “moderate”, and four “weak” for how likely participants were to represent the target population. Data collection tools of seven studies were “strong” with evidence of validity and reliability. All studies reported an 80–100% study completion rate, giving them a withdrawals and dropouts rating of “strong”, although it is important to note that most studies were using a single session. Of the other immersive technology studies, global ratings were “moderate” \((N = 3)\) and “weak” \((N = 1)\). One study had an RCT study design, classified as a CCT, and rated “strong”. The remaining studies were single group cohorts \((N = 3)\) rated “moderate”. All studies were unclear on important confounder information and rated “weak”. All studies were rated “moderate” for failing to report participant and assessor blinding. All studies demonstrated validity but not reliability in data collection tools giving them a “moderate” rating. Two studies were rated “strong” for reporting an 80–100% participant completion rate, and two rated “weak” because they had low or unreported withdrawals and dropouts.

Discussion

This systematic review provides a narrative synthesis of evidence for feasibility, acceptability, and effectiveness of VR and immersive technologies to promote workplace wellbeing. Seventeen studies were included in the review, of which 13 used HMD VR and four used other immersive technologies, such as audio-visual environments and multisensory rooms. VR and immersive technologies were found to be feasible, acceptable, and effective. Experimental conditions mainly consisted of immersive audio-visual nature-based scenes with half employing relaxation exercises. They were found to improve wellbeing and reduce work-related stress and stress-related variables, such as restoration. Findings are consistent with research that indicates VR is a safe and popular wellbeing tool (Barton et al., 2020; Jerdan et al., 2018), can be used for stress management interventions (Naylor et al., 2020; Riches et al., 2021), and is increasingly affordable and available to consumers and organisations (Ahmaniemi et al., 2017).

Most studies indicated that nature-based virtual stimuli reduced stress and improved wellbeing in the short-term. This is consistent with reviews that have concluded that virtual nature-based experiences have a positive impact on wellbeing-related variables such as stress and affect (Riches et al., 2021). Even after short exposures, virtual nature – much like real-world nature – increases parasympathetic activity, lowers blood pressure, and reduces cerebral blood flow in the cerebral cortex, which improves wellbeing, mood, and stress (Annerstedt et al., 2013; Bowler et al., 2010; de Kort et al., 2006). Stress Reduction Theory postulates that nature, compared to urban environments, is uniquely restorative due to our evolutionary adaption to natural places. Attention Restoration is another prominent theory that explains the positive effect of nature on stress. In a work context, emotional recovery during breaktimes has been shown to increase job satisfaction and have a positive impact on work performance (Nijland et al., 2021; Panaccio & Vandenberghe, 2012; Sonnentag & Zijlstra, 2006), suggesting experiencing nature-based immersive technologies may be an effective way to improve employee wellbeing and productivity, particularly for those who do not have access to real-world nature during the working day.

The studies included in this review used both self-reported and physiological measurements to assess primary
outcomes, such as stress, which enabled evaluation of the use of immersive technologies for workplace wellbeing. Most studies had comparison conditions which allowed the effectiveness of VR and immersive technology interventions to be more confidently assessed. Nearly a third of studies included 100 or more participants, which improved the strength of the findings. Limitations of the reviewed studies include a primary focus on short-term effectiveness and limited, brief interventions, which means that it is not possible to draw conclusions about any longer-term impact of these technologies. Only one study had follow-up data and most studies consisted of single-session interventions. In terms of study design, there were limited RCTs and most of these failed to report blinding. Sample limitations included limited information on participant occupations, limited occupations and workplaces tested, and demographically homogenous samples. Several studies discussed the application of immersive technologies in workplaces but only a small minority tested interventions in naturalistic workplace settings. Having longer-term data in real workplace environments is critical to validate the benefits of immersive technologies and assess if they can be maintained over time. Although several studies in this review reported that immersive technologies are now more cost-effective than they used to be (Putrino et al., 2020), this was generally not investigated by the studies themselves. Although some HMDs are significantly cheaper than they used to be, many non-HMD immersive technologies remain expensive (Guilbaud et al., 2021), which is likely to have contributed to the lack of these studies.

This systematic review is the first to assess the feasibility, acceptability, and effectiveness of VR and immersive technologies to promote workplace wellbeing. The comprehensive search strategy, with multiple databases searched, strengthens the confidence that the review found the most relevant research. Formal searching, screening, and data extraction were completed by two researchers which minimises researcher bias. Screening limitations might include the omission of grey literature, which may mean that interesting research not published in academic journals was excluded; and the research team’s limited capacity to review only English language publications, which means non-English language studies may have been overlooked. The review was deliberately broad in scope to cover a range of interventions and mixed samples. Therefore, further limitations of the review might include a lack of standardisation of sampling, interventions, measurements, and definitions. Sampling limitations reduces generalisability to broader workplace populations or to specific occupations. Stress was defined inconsistently across studies, and no standardised ‘stress’ measure was adopted, with each study implementing different self-report and physiological measures. Interventions varied in duration and number of sessions, which limits comparisons. Although this breadth of interventions and samples may hinder the extent to which studies can be compared, it also enabled a more comprehensive review of interventions for a variety of workers and workplaces in what is an emerging and exciting area of research.

The findings of this review, that VR promotes wellbeing, improves relaxation, and decreases stress in the workplace, indicates it has potential to be implemented as both a stress prevention and management tool in a variety of workplaces. Many VR HMDs and immersive technologies require minimal space, deployment costs, and maintenance, making them particularly viable and convenient (Vaquero-Blasco et al., 2021). This review found VR HMD interventions were widely considered easy-to-use and intuitive, making them particularly useful for those working from home, travelling away from home for work, or working in small or confined environments (Kanas et al., 2009). Wider research has found VR to be a generally popular intervention technology, suggesting it would be well-received in a variety of workplaces (Pretsch et al., 2020). The convenience and immersiveness of VR may lend itself to emotionally challenging working environments in which there is a lack of time to engage in stress management or access natural environments during the working day (Nahar & Gurav, 2018).

With certain workforces, such as keyworkers, who may be at high risk of stress-related illnesses, VR and other immersive technologies could play an important role in facilitating stress relief in the workplace, both in general or as a designated ‘breaktime’ (Lin et al., 2015; Rössler, 2012). The findings of this review indicates that VR and immersive technologies that promote wellbeing in the workplace are likely to be important tools to provide early intervention and prevention of mental health problems for employees. This conclusion is supported by VR relaxation and wellbeing studies on people with mental health conditions that indicate benefits for stress and affect (Herrero et al., 2014; Liszio et al., 2018; Veling et al., 2021).

Immersive technologies may be particularly useful for employees impacted by COVID-19 who have seen workplaces and roles affected by changing circumstances. Indeed, government guidelines such as social distancing and working from home, have increased the number of people isolated and without regular contact with colleagues, leading to higher rates of mental illness (Holmes et al., 2020). For employees working during the pandemic, such as healthcare professionals and other keyworkers, COVID-19 has created extremely demanding workloads in unfamiliar working environments, severe staff shortages, and concerns for personal safety (Blake et al., 2020; Putrino et al., 2020). Immersive technologies offer employees, particularly those with less access to real-world nature, a viable respite from increasingly stressful workplaces. Organisations may wish to consider introducing these technologies to support staff wellbeing.

Given the limited number of studies and methodological limitations in this promising area, future research is vital. Research should aim to standardise study protocols, measures, and definitions, and consider differences amongst worker populations. Further research on a broader range of immersive technologies, such as cave systems and multi-sensory rooms, which show promise (Manjrekar et al., 2014), should be encouraged, as well as expanding outcome measures to other work-related variables, such as creativity and
concentration. Longitudinal data, specialist employee-only samples, and larger RCT studies are crucial to understanding effectiveness, especially in the longer-term, of these immersive technologies. Naturalistic field studies testing specific worker populations in real working environments will help validate the applicability of immersive technologies in real-world workplaces. Studies should also investigate “dose” of the intervention (given that many had only one session), measure effects beyond the immediate change in stress and affect, and investigate mechanisms. Formal cost-effectiveness studies are needed, calculating effect on absenteeism, productivity, and healthcare costs.

In conclusion, this is the first systematic review and narrative synthesis of VR and other immersive technologies that aim to promote workplace wellbeing. Most studies used HMDs to display nature-based VR, with the majority reporting improvements in a range of wellbeing-related outcomes. Although methodological limitations mean caution should be taken when generalising findings to broader worker-populations or technologies, this review provides optimism for the use of immersive technologies, particularly VR, to promote workplace wellbeing. These technologies can be feasible, acceptable, and effective interventions that help mitigate the mental health impacts of isolating and unfamiliar working environments, and for those with highly stressful work demands.

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