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Effectiveness of Digital Interventions in Reducing Occupational Stress: A Systematic Review

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Keywords
Occupational stress · Digital interventions · Workplace well-being · Systematic reviews

Abstract
Occupational stress is the response people may have when presented with work demands and pressures that are not matched to their knowledge and abilities, challenging their ability to cope. It is a pervasive concern in modern work environments, impacting workers' well-being and organizational productivity. Current available methods to manage workers' stress include providing psychologist consultations and using digital intervention. Digital interventions, including smartphone apps and website programs, have emerged as accessible tools for stress reduction. However, there is a need to assess their effectiveness systematically. A systematic review encompassed randomized controlled trials (RCTs) from the inception to May 2024. A comprehensive search in four electronic databases identified 15 eligible RCTs. Of a total of 15 included studies, all studies demonstrated a significant reduction in occupational stress with the use of digital interventions. Interventions varied in duration, frequency, and delivery platforms, with smartphone-based applications being predominant. Common intervention components included meditation, coping stress management, and nutritional and exercise content. Positive effects on worker mental health were observed to persist for up to 3–12 months post-intervention. The findings underscore the potential of digital interventions to promote employee well-being and contribute to healthier and more productive work environments. Digital interventions offer promising avenues for addressing occupational stress and promoting worker well-being.

Eficácia das intervenções digitais na redução do stress ocupacional: uma revisão sistemática

Palavras Chave
Estresse ocupacional · Intervenções digitais · Bem-estar no local de trabalho · Revisões sistemáticas

Resumo
O stress ocupacional é a resposta que as pessoas podem ter quando confrontadas com exigências e pressões de trabalho que não correspondem aos seus conhecimentos e capacidades, desafiando a sua capacidade de lidar com essas situações. É uma preocupação generalizada nos ambientes de trabalho modernos, impactando o bem-estar dos trabalhadores e a produtividade organizacional. Os métodos atualmente disponíveis para gerir o stress

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dos trabalhadores incluem consultas com psicólogos e o uso de intervenções digitais. As intervenções digitais, incluindo aplicativos de smartphone e programas de websites, surgiram como ferramentas acessíveis para a redução do stress. No entanto, há necessidade de avaliar a sua eficácia de forma sistemática. Esta revisão sistemática abrangeu Ensaios Clínicos Randomizados (ECRs) desde a sua criação até maio de 2024. Uma pesquisa abrangente em quatro bases de dados eletrónicas identificou 15 ECRs elegíveis. De um total de 15 estudos incluídos, todos demonstraram uma redução significativa do stress ocupacional com o uso de intervenções digitais. As intervenções variaram em duração, frequência e plataformas de entrega, com aplicativos baseados em smartphone sendo predominantes. Os componentes comuns das intervenções incluíram meditação, gestão do stress e conteúdos sobre nutrição e exercício. Efeitos positivos na saúde mental dos trabalhadores foram observados a persistir por até 3 a 12 meses após a intervenção. Os resultados ressaltam o potencial das intervenções digitais para promover o bem-estar dos trabalhadores e contribuir para ambientes de trabalho mais saudáveis e produtivos. As intervenções digitais oferecem vias promissoras para enfrentar o stress ocupacional e promover o bem-estar dos trabalhadores.

Introduction

Occupational stress, characterized by psychological, physical, and behavioral responses to work-related demands that exceed coping abilities, is a global health problem impacting diverse professions [1–3]. This pervasive issue has been the focus of numerous studies, revealing its detrimental consequences on worker health and organizational productivity [4] Prevalence studies shed light on the extent of occupational stress and its repercussions. In 2020, Salari et al. [5] found that 45% of front-line healthcare workers caring for COVID-19 patients experienced stress. Similarly, in 2018, Maharaj et al. [6] observed high prevalence rates of depression, anxiety, and stress, impacting Australian nurses. Furthermore, systematic reviews and meta-analyses, such as the 2021 study by Girma et al. [1], reported that healthcare professionals in Ethiopia faced a pooled prevalence of occupational stress at 52.5%. Similarly, Birhanu et al. [7], in 2018, noted that health professionals in Ethiopia endured workplace stress with a prevalence of 68.2%.

Occupational stress arises from several factors, with the nature of the occupation playing a pivotal role. In demanding fields like healthcare, high workloads, long hours, and a lack of social support contribute significantly to stress [1, 8]. The burden of excessive tasks and time pressure further exacerbates stress, as documented in a study of academic nurses [2]. Inadequate resources, such as staffing shortages and insufficient equipment, amplify stress levels, placing additional burdens on individual workers [2]. The absence of social support from colleagues and supervisors further complicates the coping process, intensifying stress levels [2]. Rapidly evolving industries bring additional challenges, forcing workers to adapt constantly and cope with uncertainty [2]. Work-life balance difficulties, particularly among those with long hours or irregular schedules, hinder personal responsibilities and self-care. In hostile environments characterized by workplace bullying and harassment, stress levels are intensified [9]. The recent COVID-19 pandemic has exacerbated occupational stress, particularly among healthcare professionals, due to factors like a lack of rewards, social interaction, and support [3].

Occupational stress has far-reaching implications for job performance and outcomes, as documented by studies showing its association with burnout, decreased job satisfaction, and increased turnover intentions [2, 10]. Addressing occupational stress offers numerous benefits, including improved well-being, enhanced productivity, reduced turnover, a positive organizational culture, increased job satisfaction, improved safety, and enhanced teamwork [4, 11–14]. Digital intervention can help in reducing stress, improving mental well-being, and enhancing job performance [15–17]. The flexibility, scalability, and personalization of digital interventions further enhance their appeal and effectiveness [18]. By adopting digital interventions, organizations can promote well-being, reduce stress, and enhance productivity, contributing to a healthier work environment and increased job satisfaction. Ensuring the quality and evidence-based nature of these interventions is vital to maximize their impact. Analysis of the advantages, disadvantages, barriers, and opportunities of using digital interventions for occupational stress management is shown in Table 1.

However, despite the wealth of research exploring the sources and consequences of occupational stress, a significant research gap remains concerning the effectiveness of interventions in mitigating the detrimental effects of stress in the workplace. While we have identified the contributing factors and their associated stressors, there is a need to systematically assess the efficacy of

Table 1. Analysis of digital interventions for occupational stress management

Advantages
• Accessibility: Can be used anytime, anywhere, making it convenient for users • Cost-effective: Often cheaper than traditional face-to-face therapy sessions • Anonymity: Users can seek help without the stigma associated with mental health issues • Scalability: Can reach many people with minimal additional cost • Variety of tools: Includes meditation, stress management techniques, CBT, and so on • Monitoring and feedback: Real-time monitoring and feedback can help track progress
Disadvantages
• Technology dependency: Requires access to digital devices and the Internet • Technical issues: Potential for technical problems that can disrupt use • Engagement: It may require high self-motivation and engagement from users • Privacy concerns: Risk of data breaches and privacy issues • Efficacy variability: Effectiveness can vary based on the individual and specific intervention
Barriers
• Cultural differences: Digital interventions developed in one region may not be effective in another due to cultural differences in work environments, resilience, and stress responses • Digital literacy: Variability among workers can affect the uptake and effective use of digital interventions • Access to technology: Not all workers have equal access to digital devices and reliable Internet connections • Privacy concerns: Concerns about the privacy and security of personal health data can hinder adoption • Engagement and adherence: Maintaining user engagement and adherence to digital interventions can be challenging • Technical issues: Technical glitches and software problems can disrupt the use and effectiveness of digital tools • Workplace integration: Difficulty integrating digital interventions into the existing workplace environment and routines
Opportunities
• Global reach: Digital interventions can be accessed globally, reaching diverse populations • Innovative solutions: Development of new, innovative stress management tools and applications • Data-driven insights: The collection of large amounts of data can provide insights into stress patterns and effective interventions • Customization and personalization: Potential for highly personalized AI and machine learning interventions • Continuous improvement: Feedback loops and data analysis can help continuously improve intervention effectiveness • Integration with other health tools: Can be integrated with other digital health tools and wearable devices for a comprehensive approach to well-being • Scalability: Ability to scale interventions to large organizations or populations with minimal additional cost • Remote support: Provides remote support options, especially valuable during situations like the COVID-19 pandemic

interventions that address these factors and offer strategies to alleviate occupational stress. This systematic review aims to bridge this gap by focusing on digital interventions, including smartphone apps and websites, as accessible and scalable tools for stress reduction. By evaluating the current evidence from randomized controlled trials (RCTs), the review will provide insights into the effectiveness of these interventions in reducing occupational stress and improving worker well-being.

Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines 2020 [19]. A detailed protocol was developed, outlining the research questions, search strategy, inclusion and exclusion criteria, data extraction methods, and quality assessment procedures. A systematic search was conducted across four electronic databases from the inception to May 2024: PubMed, ScienceDirect, Scopus, and Web of Science. Only studies in the English language were included. The following keywords were utilized: "Digital Intervention" OR "Mobile application" OR "Online Intervention" AND "Occupational stress" OR "Work stress" OR "Workplace stress" OR "Stress" OR "Workplace Well-being" OR "Mental health" OR "Mental Health at Workplace" OR "Job Stress" OR "Burnout" AND "Worker" OR "Employee." The PRISMA flowchart is shown in Figure 1. The inclusion criteria for study selection were as follows:

- RCTs published from the inception to May 2024.

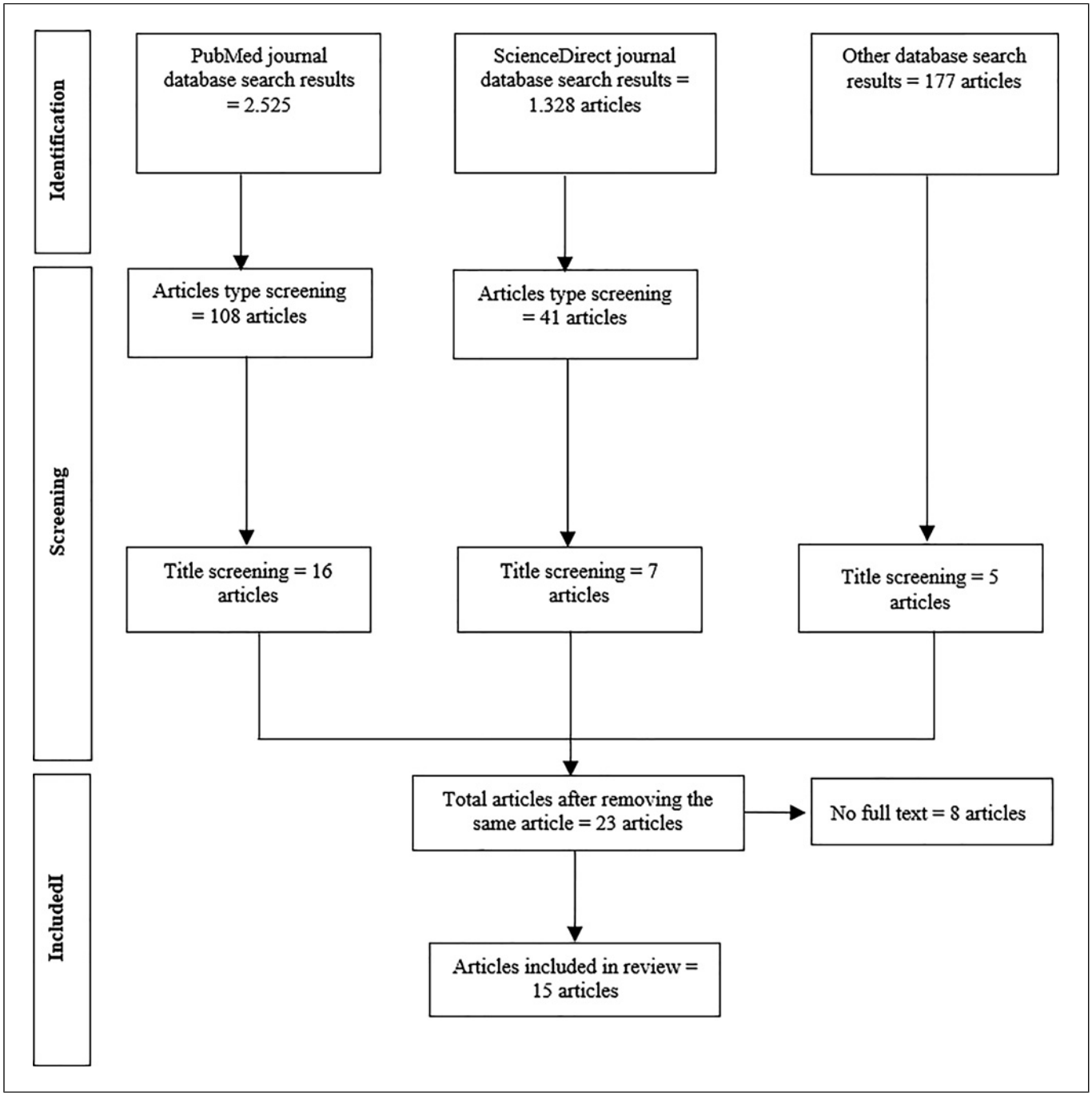

Fig. 1. PRISMA flowchart.

- Studies investigating the use of digital interventions, including smartphone apps and websites, for the reduction of occupational stress.
- Studies measuring the impact of digital interventions on occupational stress reduction.
- Written in English.

The exclusion criteria included the following:

- Studies that are not RCTs.
- Studies with populations outside the scope of workers or not addressing occupational stress.
- Studies examine interventions other than digital interventions.

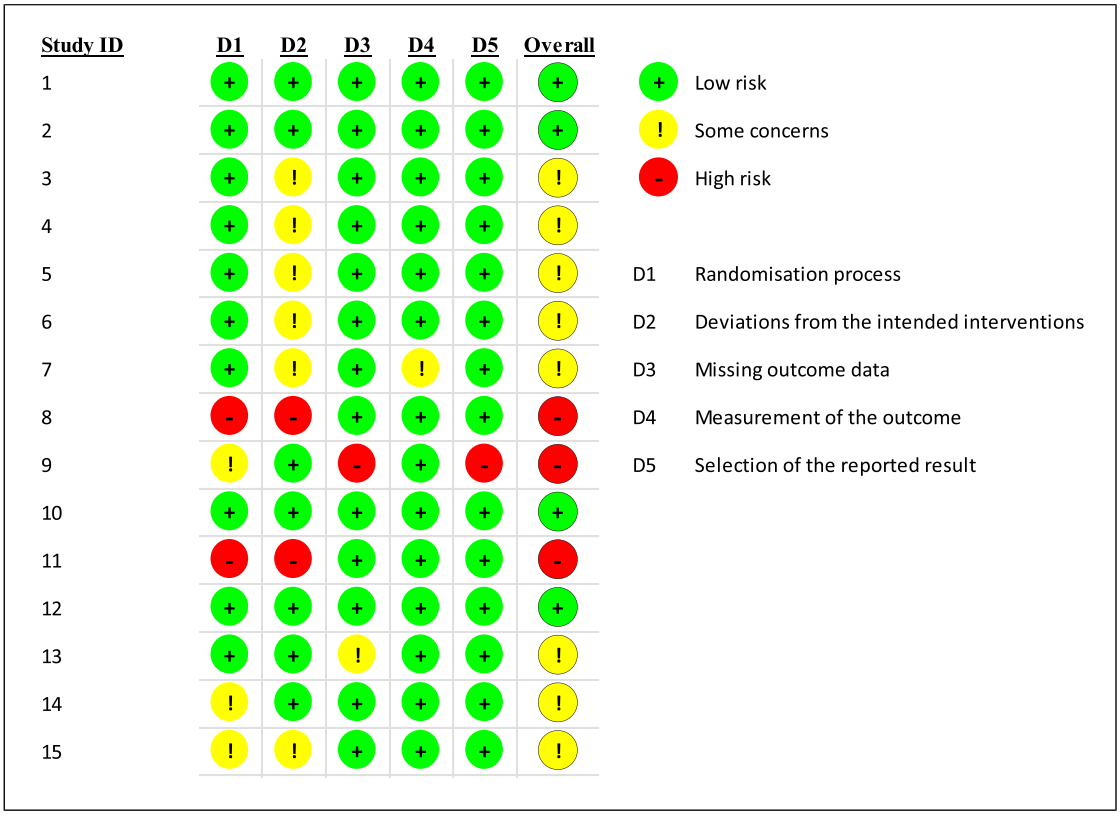

Fig. 2. Risk of bias assessment.

Study selection involves two reviewers who independently search and choose it from each electronic database. Cochrane risk of bias tool for RCTs was used to assess the risk of bias of the included studies. The study that has been collected is imported to the Mendeley Reference Manager version 2.91. Any discrepancies were discussed with a third reviewer to reach a consensus. Data about the first author, title, methodological data, and result data were extracted independently by two reviewers. The first author of the study was contacted to see if additional data was needed. Articles that did not directly measure or report relevant outcomes were excluded.

Results

After the initial search, a considerable number of articles were identified, exemplified by the retrieval of 2,475 articles from the PubMed database. To streamline the review toward observational studies, a filter specific to studies conducted after 2013 was applied, resulting in 1,233 articles meeting the criteria. Subsequently, a filter for RCT types was applied, denoted by the inclusion of the term "RCT" [Publication Type]. This screening process yielded 106 articles categorized as RCTs, aligning with the systematic review's objectives. The comprehensive initial search ensured the inclusion of a diverse range of relevant literature, while the subsequent application of the RCT filter guaranteed the suitability of the selected articles. The 106 RCTs underwent careful assessment against inclusion and exclusion criteria to determine the final set of studies included, as illustrated in Figure 1 of the PRISMA flowchart.

In electronic databases, 24 articles with relevant titles to the eligibility criteria were discovered. After eliminating duplicates and conducting a full article review, 15 articles were included in this review. Exclusion criteria were applied to articles with relevant titles that did not provide a measurement of the relationship between variables. The study selection process is depicted in Figure 1 of the search flowchart. The included studies were conducted in diverse regions, including Germany (4 studies), Australia (2 studies), the USA (2 studies), Sweden (2 studies), and one study each in England, Korea, Greece, Poland, and Taiwan. A total of 4,964 workers were recorded from the included studies. The mean age of subjects ranged from 31.1 years to 57.7 years, with seven studies having a mean age of less than

Table 2. Summary of the included studies

Study index	Author	Sample detail	Intervention	Measured outcome	Results
1	Baldwin et al. [25] (2020), Australia	*N* = 780 adults (18–75 years) with T2DM and mild-to-moderate depressive symptoms Mean age = 57.7 years	• myCompass® (fully automated eMH program) 8 weeks, followed by a 4-week tailing-off • The attention control program uses the Healthy Lifestyles® app for 8 weeks, (without CBT content)	• Stress (WSAS) • Depression (PHQ-9) • Anxiety (GAD-7)	• Both my Compass group and Healthy Lifestyle group showed a significant improvement in WSAS, PHQ-9, and GAD-7 • The Healthy Lifestyles group reported higher ratings of social and occupational functioning than the myCompass group • WSAS showed a significant improvement between pre- and post-intervention, which was maintained at both 6- and 12-month follow-ups
2	Comtois et al. [26] (2022), United States	*N* = 838 unemployed workers because of COVID-19 or were COVID-19-designated essential workers Mean age = 31.1 years	The intervention group used 3 active apps: • meditation (Calm®) • COVID-19 coping (COVID Coach®) • chat and positive psychology (7 Cups of Tea®) The attention control app used only mood tracking (Beautiful Mood) Duration: 4 weeks	• Depression (PHQ-9) • Anxiety (GAD-7) • Emotion dysregulation (DERS-SF) • Suicidal behaviors (SBQ-R)	• No differences between the apps in any outcome but significant changes in depression and anxiety over time • No significant changes in suicidal behavior or emotional regulation for the 4 weeks • Significant dose-response pattern for changes in depression and anxiety • Using the app at least once a week resulted in greater improvements in treatment conditions over time for depression and anxiety • There was no association between app frequency and changes in suicidal behavior or emotional regulation
3	Bostock et al. [27] (2019), England	*N* = 238 employees at two UK companies (a pharmaceutical firm and a high-tech Company) and thus participants were excluded if they reported no work stress (scored zero on a 6-item work overcommitment scale) Mean age = 35–36 years	• App group: Headspace® app for 8 weeks • Control group: wait to treat	• Psychological well-being (WEMWBS) • Anxiety and depressive symptoms (HADS) • Job strain was assessed with 16 items extracted from the Whitehall II study questionnaire • Mindfulness using seven items selected from the Freiburg Mindfulness Inventory	• The intervention group reported significant improvement in well-being, distress, job strain, and perceptions of workplace social support compared to the control group • The intervention group had a marginally significant decrease in self-measured workday systolic blood pressure from pre to post-intervention • Sustained positive effects in the intervention group were found for well-being and job strain at the 16-week follow-up assessment
4	Xu et al. [28] (2021), Australia	*N* = 148 permanent or casual clinical and nonclinical staff having daily access to a smartphone with Internet access	• App group: Headspace® app for 4 weeks (twice a week, each session >10 min) • Control group: wait to treat	• Stress (PSS) • Maslach Burnout Inventory • Frequency of a range of mindfulness states daily (MAAS) • Mental well-being (WEMWBS)	• There was a statistically significant improvement in PSS. • All three components of burnout (emotional exhaustion, depersonalization, personal accomplishment), mindfulness, and well-being levels were improved from pre-intervention to 3 months later with small effect sizes
5	Hwang et al. [29] (2019), Korea	*N* = 60 nurses employed at college hospitals in Seoul, Korea, and the surrounding metropolitan area	• Intervention group: using a Mind Healer® app that consisted of music focused on healing, meditation, breathing methods, and yoga intervention, including health information for mental health care every week (diet, benefits of exercise, etc.) • The control group didn't get anything • Duration = 4 weeks, ≥2×/weeks, for at least 10 min per usage	• Stress (PSS) • Depression (PHQ-9) • Anxiety (GAD-7) • Korean-Emotional Labor Scale • WHO-5	• Stress, emotional labor, self-efficacy, and well-being were significantly different in the experimental group, but the control group's average scores did not change significantly • Perceived Stress Scale scores decreased by 1.5 points • Korean Occupational Stress Scale scores decreased by 0.87 points • Depression and anxiety were not significantly different

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Table 2 (continued)

Study index	Author	Sample detail	Intervention	Measured outcome	Results
					• Emotional labor decreased by 0.16 points, and well-being and self-efficacy mean scores increased by 0.492 and 0.162, respectively
6	Radin et al. [30] (2023), Sweden	*N* = 161 workers ≥18 years old, employed at a large academic medical center, had a BMI equal to or greater than 25 kg/m^2 and reported mild to moderate levels of stress in the previous month (as determined by a Perceived Stress Scale score of 15 or higher), and had daily access to a smartphone or computer Mean age = 37.9 years	• Meditation group (MED): got access to a digitally based meditation program (Headspace® app- Basics + "Letting go of stress" packs) and asked them to engage with the app for at least 10 min/day for 8 weeks • Healthy eating group (HE): healthy eating consultation and digitally based mindful eating program 1×/week for 8 weeks and sent text message reminders 3 times per week • MED+HE • Control: waitlist group (WL)	• Stress (PSS) • Food Acceptance and Awareness Questionnaire • Body Mass Index	The MED group or MED+HE group showed the greatest decreases in PSS score (with no differences between MED vs. MED+HE), compared to those in HE or WL(no differences between HE vs. WL)
7	Perrson Asplund et al. [21] (2017), Sweden	*N* = 117 first line and middle managers who had volunteered for the project and fulfilled the criteria for an adjustment disorder (F43) Reaction to severe stress, based on (ICD-10). In addition to an adjustment disorder, participants had to fulfill the following criteria: • a minimum age of 18 years • mastering Swedish • have access to a computer or a tablet computer with Internet access • not be on full-time sick leave Mean age = 46.9 years	Intervention: iSMI for 8 weeks Control: attention control (AC) Participants assigned to the AC group were given a brief weekly text module (half a regular page), via the web platform, about a stress-related topic (e.g., stressors, recuperation, or feedback). They were then invited to discuss each topic, anonymously, with other participants in a moderated web forum. Compared with the iSMI, the AC was a passive learning experience and did not involve any behavioral modification, worksheets, or exercises	• Stress (PSS) • Shirom-melamed Burnout Questionnaire • Montgomery Åsberg Depression Rating Scale • Insomnia Severity Index • Alcohol Use Disorders Identification Test • Work Experience Measurement Scale • Absenteeism, presenteeism, and healthcare consumption	• Participants in the iSMI intervention reported significantly fewer symptoms of perceived stress and burnout compared with controls at post-assessment • Significant medium-to-large effect sizes were also found for depression, insomnia, and job satisfaction • Long-term effects (6 months) were seen in the mental health outcomes
8	Misretta et al. [31] (2018), USA	*N* = 60 employees at Mayo Clinic, Arizona with these criteria: • aged ≥18 years • owning a smartphone • scoring at least 5 on the DASS-21 stress subscale Mean age = 46 years	• The MBRT group met for six weekly 120-min sessions facilitated by a clinical psychologist/developer of MBRT (BD) • Smartphone resiliency training group: The application, provided by Soma Analytics (London, UK), was designed to provide users with data on their sleep and emotions to increase awareness of current levels of well-being (comparable to that provided to the MBRT and control groups), as well as to provide targets of potential change to individuals • The control group received no additional intervention Duration: 6 weeks	• Stress (DASS-21) • WHO-5	• Both the MBRT and the smartphone groups showed improvements in well-being • Only the MBRT group showed improvements in stress and emotional burnout over time • The control group did not demonstrate sustained improvement in any outcome • The Smartphone group showed significant improvements in the primary outcome of stress from baseline to 3-month follow-up, and the primary outcome of well-being from baseline to 6 weeks and baseline to 3-month follow-up

Table 2 (continued)

Study index	Author	Sample detail	Intervention	Measured outcome	Results
9	Smoktunowicz et al. [22] (2021), Poland	*N* = 1,240 workers representing the health-related profession that involved direct patient care Mean age = 36 years (20–66 years)	Med-Stress® is a self-guided Internet intervention. It contains 2 main modules that were made available to participants in different variants depending on randomization to study conditions: • self-efficacy and perceived social support sequential enhancement modules (SE+SS; experimental condition) • perceived social support and self-efficacy sequential enhancement modules (SS+SE; experimental condition) • self-efficacy enhancement module (SE; active control condition) • perceived social support enhancement module (SS; active control condition) Duration: 6 weeks for EC, 3 weeks for AC	• Stress (PSS) • Job burnout (Oldenburg Burnout Inventory Secondary outcomes) • Depression (PHQ-9) • Work engagement (Utrecht Work Engagement Scale-3) • Job-related traumatic stress (Posttraumatic Stress Disorder Checklist 5)	• After 6 months, participants in that experimental condition reported the lowest job stress when compared with all 3 remaining study groups • For job-related traumatic stress, a significant difference was found between study groups only at month 6: stress was lower in the experimental condition in which self-efficacy was enhanced first than in the active comparator enhancing solely social support • The same result was found for work engagement, which means that it was lower in the same condition that was found beneficial for stress relief
10	Ebert et al. [23] (2016), Germany	*N* = 264 workers with these inclusion criteria: • currently employed individuals • age ≥18 years • scores ≥22 on the Perceived Stress Scale (PSS-10) • had Internet access • sufficient skills in reading and writing German (self-report) Mean age = 42 years	Intervention: self-guided iSMI (GET.ON Stress®) GET.ON Stress® was based on the Lazarus and Folkman transactional model of stress and its distinction between problem-focused and emotion-focused coping. Duration: 7 weeks Control: Waitlist control group	• Stress (PSS) • Depression (CES-D), anxiety (anxiety subscale of the HADS-A); insomnia severity (Insomnia Severity Index), and worrying (PSWQ-PW) • Work-related health: Emotional exhaustion (subscale emotional exhaustion of the Maslach Burnout Inventory, MBI-EE), work engagement (UWES) psychological detachment from work (subscale of the REQ-PD) were assessed as work-related outcomes. TiC-P-G were used to assess the number of "work loss" days in the previous 3 months	• The iSMI participants showed a significantly higher reduction in perceived stress from baseline to posttreatment at 7 weeks and to the 6-month follow-up compared to the WLC. • Significant differences with small to moderate effect sizes were also found for depression, anxiety, emotional exhaustion, sleeping problems, worrying, mental health-related quality of life, psychological detachment, emotion regulation skills, and presenteeism, in favor of the experimental group • At the 6-month follow-up, all outcomes remained significantly better for the experimental group except work engagement, physical health-related quality of life, and absenteeism, which did not significantly differ between the iSMI and WLC groups
11	Hsieh et al. [32] (2020), Taiwan	*N* = 159 nurses with inclusion criteria: • had worked for at least 3 months • had experienced any workplace violence exerted by patients or their families in the past 12 months • own a smartphone Mean age = 32.2–38.85 years	• BT: included self-guided muscle relaxation, diaphragmatic breathing, paced breathing, pursed-lips breathing, and real-time respiratory sinus arrhythmia biofeedback over a 60-min session, weekly for 6 weeks • SDBT: each participant got an MP4 video file containing guided shorter meditation practices and the processes of real-time biofeedback once a week for 6 weeks to enhance their resilience • Waitlist control group	• Stress (revised Chinese version of the OSI-2) • Depressive symptoms (CES-D)	• After 6 weeks, SDBT can significantly reduce occupational stress • BT has no significant effect on occupational stress • Both SDBT and BT can significantly reduce depressive symptoms
12	Fasthoff et al. [33] (2023), Germany	*N* = 65 public service employees Mean age = 39–42.7 years	• Face-to-face training for 1 day • Web-based online course for 5 weeks (consisting of five modules, @90–115 min) • Waitlist control group (WLC) • Follow-up at 6 weeks after intervention	• Stress (PSS) • Emotional exhaustion (MBI-D) • Work engagement (UWES-9)	• Participants in the online courses group show reduction in stress, while the face-to-face training group did not show this • Both face-to-face training and online course groups did not show improvement in emotional exhaustion and work engagement shortly and 6 weeks after the intervention than before the intervention and compared to the WLC

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Table 2 (continued)

Study index	Author	Sample detail	Intervention	Measured outcome	Results
13	Weber et al. [20] (2019), Germany	*N* = 532 workers from the private or public sector Mean age = 40.6 years (17–72 years)	• App group using Kelaa Mental Resilience App (smartphone-based) for 4 weeks with a goal of six to seven daily sessions (@2–4 min to read) • Waitlist control group • Follow-up post-intervention at week 6	• Stress (COPSOQ II) • WEMS • Resilience (13-item Resilience Scale) • Sleeping troubles (COPSOQ II)	• Workers in the app group experienced a greater decrease in both general and cognitive stress and more well-being compared to the waitlist control group after intervention • No significant improvement in sleeping troubles between the two groups
14	Heber et al. [24] (2016), Germany	*N* = 264 workers with PSS ≥22 Mean age = 43.3 years	• iSMI group participants were advised to complete 1–2 weekly sessions for 7 weeks. After intervention follow up conducted on month 6 and month 12 • Waitlist control group	• Stress (PSS) • Depression (CES-D) • Anxiety (HADS)	• There is a significantly large effect difference between iSMI and waitlist control groups for perceived stress at posttest • The iSMI group significantly has better improvement in depressive and anxiety symptoms compared to the waitlist control group • The effects in the iSMI group were maintained at 12-month follow-up
15	Alexiou et al. [34] (2021), Greece	*N* = 38 women healthcare professionals with inclusion criteria: • presence of mild to very severe symptoms of depression, anxiety, or stress as measured by DASS • have moderate or high symptoms of emotional exhaustion, depersonalization, or lack of personal accomplishment by MBI Mean age = 31.7–33.9 years	• Intervention group = online positive psychology • Placebo control exercise group • Duration = 3 weeks	• Stress, Depression, and Anxiety (DASS-21) • Emotional exhaustion (MBI)	There was a significant reduction in stress, depression, anxiety, and emotional exhaustion in the intervention group after the intervention, while this reduction was not observed in the placebo group

BT, biofeedback training; CBT, cognitive behavioral therapy; CES-D, Chinese version of the Centre for Epidemiological Studies Depression; COPSOQ II, Copenhagen Psychosocial Questionnaire-Revised Version; DASS-21, Depression, Anxiety, and Stress Scales; DERS-SF, Difficulties in Emotion Regulation – Short Form; ED, Emergency Department; eMH, electronic Mental Health; GAD-7, Generalized Anxiety Disorder Scale; HADS, Hospital Anxiety and Depression Scale; HRV, Heart Rate Variability; iSMI, Internet-based stress management intervention; MAAS, Mindfulness Attention Awareness Scale; MBRT, Mindfulness-based Resilience Training; OLBI, Oldenburg Burnout Inventory; OSI-2, Occupational Stress Indicator; PHQ-9, Patient Health Questionnaire; PSS, Perceived Stress Scale; PSWQ-PW, Penn State Worry Questionnaire Ultra Brief Version-past week; REQ-PD, Recovery Experience Questionnaire; SBQ-R, Suicide Behaviors Questionnaire-Revised; SDBT, Smartphone-Delivered Biofeedback Training; T2DM, type 2 diabetes mellitus; TiC-P-G, Trimbos and Institute of Medical Technology Assessment Cost Questionnaire for Psychiatry; UK, United Kingdom; UWES, Utrecht Work Engagement Scale; WEMWBS, Warwick Edinburgh Mental Well-being Scale; WHO-5, WHO (Five) Well-Being Index; WSAS, Work and Social Adjustment Scale.

40 years, eight studies with a mean age of more than 40 years, and the remaining study lacking information on the mean age of participants. The highest worker age was 72 years recorded from the included studies conducted by Weber et al. [20] in Germany. In general, this review mostly focused on workers aged 30–50 years, limiting the coverage for workers with age more than 50 years.

The assessment of risk across the included studies revealed varying degrees of methodological quality. Utilizing the Cochrane risk of bias tool for RCTs, it was found that 4 out of the 15 studies demonstrated a low risk of bias, while 8 studies raised some concerns, and 3 studies presented a high risk of bias. Specifically, concerning aspects such as the randomization process and deviations from intended interventions, 2 studies were flagged with a high risk of bias. Additionally, one study exhibited a high risk of bias related to outcome data and selection of the reported result. However, notably, none of the studies were deemed to have a high risk of bias in the measurement of the outcome domain. The risk of bias assessment is summarized in Figure 2.

Table 2 summarizes the findings from the included studies. Various instruments were employed to measure occupational stress in the reviewed studies, with the Perceived Stress Scale (PSS) being the most frequently used, utilized in eight studies. Following closely was the Patient Health Questionnaire 9 (PHQ-9) in three studies, and the Generalized Anxiety Disorder Scale 7 (GAD-7) and WHO (Five) Well-Being Index (WHO-5) in two studies each. Of the 15 included studies, all studies demonstrate a significant benefit in reducing occupational stress using digital interventions. Furthermore, insights gleaned from the included studies indicate that the positive effects on workers' mental health persist for a considerable duration after the cessation of the intervention. Specifically, findings suggest that these effects endure for periods ranging from 3 to 12 months post-intervention. Notably, the majority of studies (4 studies) demonstrated that the positive effects persisted for up to 6 months following the conclusion of the intervention period [21–24].

The duration of interventions ranged from 3 to 8 weeks, with the majority (9 studies) implementing interventions lasting 6–8 weeks [21–25, 27, 30–32]. Additionally, the frequency of interventions varied across studies, with some interventions requiring 20 min per week (3 studies) [20, 28, 29], while others necessitated 45–60 min per week (3 studies) [23, 30, 32], and two studies implemented interventions requiring 2–3 h per week [21, 33]. This variability in duration reflects the flexibility in designing interventions to suit different study contexts and participant needs. Moreover, all included studies implemented digital interventions that could be carried out at home or workplace, demonstrating their flexibility. However, most studies require the sample to have the ability to use technology as inclusion criteria. Regarding the types of workers involved, the studies encompassed a diverse range of occupational settings. Notably, seven studies focused on healthcare workers, highlighting the relevance of stress management interventions in this sector [22, 27–29, 31, 32, 34]. Other studies involved workers in community settings, hi-tech companies, and academic centers, underscoring the broad applicability of digital interventions across various work environments.

In terms of platform usage, smartphone-based digital interventions were predominant, being utilized in eight studies [20, 26–32]. This prevalence may be attributed to the accessibility and convenience offered by smartphones, aligning with the modern workforce's reliance on mobile technology. Among smartphone applications, the Headspace® app emerged as a popular choice, featured in three studies, possibly due to its being able to be downloaded for free, user-friendly interface, and great functionality for stress management. The digital interventions employed a range of stress management methods, reflecting the multifaceted nature of addressing occupational stress. These methods included meditation, educational materials, positive and motivational content, coping stress management techniques, relaxation techniques, and nutritional and exercise content. Additionally, several applications integrated cognitive-behavioral therapy features to tailor interventions to individual circumstances, enhancing their effectiveness and relevance. Despite the diversity of stress management methods utilized, certain approaches were more commonly employed across the included studies. Specifically, meditation [26–30, 32], coping stress management [21–23, 25, 26, 31, 33], and nutritional and exercise content [21–23, 25, 29] emerged as the most frequently utilized methods. This highlights the importance of incorporating holistic approaches to stress management, addressing both psychological and physical aspects of well-being in the workplace.

Discussion

The findings from the included studies underscore the significant effectiveness of digital interventions in reducing occupational stress among workers. Across the included studies, digital interventions demonstrated consistent benefits, with all studies indicating a notable reduction in occupational stress levels. The utilization of standardized measurement tools is paramount in accurately assessing work-related stress, depression, and anxiety within occupational settings. Among these, the PSS emerges as a particularly valuable instrument for quantifying perceived

stress levels among workers. Its widespread adoption in research settings facilitates comparability across studies and enables a comprehensive understanding of the prevalence and impact of occupational stress [35–37]. Additionally, the PHQ-9 is an effective tool for screening depression symptoms, offering a structured approach to identifying individuals who may require further assessment or intervention [38, 39]. Similarly, the GAD-7 plays a crucial role in evaluating anxiety symptoms, providing valuable insights into the prevalence and severity of anxiety disorders among workers [40, 41]. Overall, integrating PSS, PHQ-9, and GAD-7 into occupational health assessments represents a proactive approach to addressing mental health concerns in the workplace and fostering a supportive and resilient workforce.

Digital intervention plays a pivotal role in mitigating occupational stress through diverse mechanisms. A comprehensive analysis and synthesis of Internet-based psychological interventions administered in workplace settings revealed that digital mental health interventions can enhance employees' psychological well-being and boost work efficacy [42]. These interventions typically offer guidance within a condensed timeframe, employ alternative delivery methods like emails and text messages, and integrate features of persuasive technology, such as self-monitoring and customization, which may foster increased engagement and adherence [42]. Furthermore, digital interventions have demonstrated effectiveness in reducing occupational stress levels among nurses [43]. The varied duration and frequency of interventions, ranging from 4 to 8 weeks and encompassing different time commitments per week, suggest flexibility in intervention design while maintaining efficacy. The prevalence of smartphone-based interventions highlights the accessibility and convenience afforded by mobile platforms in delivering stress management support to workers. Importantly, the observed persistence of positive effects on workers' mental health for up to 3–12 months post-intervention, with the majority of studies indicating effects enduring for up to 6 months, emphasizes the enduring impact of digital interventions beyond the intervention period. By incorporating evidence-based digital interventions into their workplace stress management strategies, employers can proactively address occupational stress. Such interventions have the potential to reduce absenteeism, increase job satisfaction, enhance employee engagement, and improve overall productivity. Furthermore, these interventions provide flexibility, scalability, and personalization, allowing organizations to tailor stress management approaches to individual needs, and fostering a more supportive work environment. Investing in infrastructure, digital literacy programs, and organizational support can facilitate the successful implementation of digital interventions as part of comprehensive workplace health promotion strategies in the region. By embracing digital interventions, organizations can promote worker well-being and, in turn, create a healthier, more harmonious, and more efficient work environment while simultaneously supporting employees in coping with the challenges of modern work life.

Several key components contribute to the success of digital interventions in reducing occupational stress. First, most countries included in this review share similar characteristics regarding data consumption and literacy concerns. All included studies are from countries with an Internet adoption rate of more than 90% of their total population, with Greece and Poland being the exceptions at around 87% [44]. These rates are considerably higher than those in low-income regions such as Eastern Africa (26%), Middle Africa (32%), Western Africa (42%), Southern Asia (51%), and Southeast Asia (71%) [44]. Additionally, the literacy rates in the countries included in our review are notably high, exceeding 90%, whereas many African and South Asian countries have literacy rates around 70% [44]. This emphasizes the critical role of Internet adoption and literacy rates in ensuring the successful implementation of digital interventions. Craig and Moe-Byrne underscore the importance of tailoring organizational interventions to cultural contexts, noting that interventions that are sensitive to the cultural and organizational environment are more likely to be successful. This is particularly relevant to our findings, as the positive effects of digital interventions observed in country with high Internet adoption rate settings may not directly translate to low Internet adoption rate country without appropriate cultural adaptation [45]. The content diversity and customization options offered by digital platforms allow for tailored interventions that address the specific stressors and needs of individual workers. Commonly employed stress management methods, such as meditation, coping stress management, and nutritional and exercise content, underscore the importance of holistic approaches in addressing occupational stress. Additionally, the incorporation of cognitive-behavioral therapy features enhances the adaptability of interventions, enabling workers to identify and implement strategies that resonate with their unique circumstances. Moreover, the duration and frequency of interventions, which varied across studies, suggest that interventions can be effective within flexible time frames, accommodating diverse work schedules

and commitments. The widespread utilization of smartphone-based interventions, particularly those utilizing popular applications, highlights the accessibility and user-friendliness of mobile platforms in delivering stress management support to workers. Overall, the integration of diverse stress management techniques, customization options, and mobile accessibility emerges as key components that contribute to the success and effectiveness of digital interventions in mitigating occupational stress.

While the findings from the included studies demonstrate the effectiveness of digital interventions in reducing occupational stress, it is essential to acknowledge potential barriers to their implementation, particularly in diverse cultural contexts such as Southeast Asia, South Asia, South America, and Africa. This lack of representation from the region raises concerns about the generalizability, where cultural norms, work environments, and worker resilience may differ significantly from those in the included studies region. The positive effects observed in the included studies may not necessarily be applicable directly to other regional settings, necessitating further research to validate these findings in culturally diverse contexts. Moreover, differences in technological infrastructure, access to digital devices, and Internet connectivity may pose additional challenges to the widespread adoption of digital interventions in other regions not represented by included studies. This review also predominantly focused on workers aged 30–50 years, limiting the coverage and insights for workers over 50 years of age. Therefore, future research should focus on adapting and validating digital interventions for other regional workplaces and other age groups, considering cultural nuances and contextual factors to ensure their effectiveness and relevance in diverse cultural settings. Most studies also require the sample to have the ability to use technology as inclusion criteria, which is not representative of workers who do not have access to ICT technology.

Looking ahead, it is imperative to address the gaps identified in this review. One of the primary limitations of this review is the high heterogeneity observed among the included studies. Variations in study designs, intervention types, outcome measures, and participant characteristics contribute to heterogeneity, potentially impacting the synthesis and interpretation of findings. Additionally, the limited representation of studies from Southeast Asian contexts, including Indonesia, may restrict the generalizability of results to this region.

In summary, this systematic review offers compelling evidence of the efficacy of digital interventions, such as smartphone apps and web-based programs, in reducing occupational stress among workers. The consistent positive outcomes and the adaptable nature of these interventions make them valuable tools for promoting worker well-being and creating healthier and more efficient work environments. This systematic review underscores the positive impact of digital interventions on reducing occupational stress. As workplaces continue to evolve, the integration of these evidence-based interventions holds great promise for the well-being of employees and the overall productivity of organizations. By prioritizing worker health and providing accessible and scalable resources for stress management, organizations can significantly contribute to a healthier, more harmonious, and efficient work environment in a dynamically changing professional landscape.

Conclusion

This systematic review provides evidence of the significant effectiveness of digital interventions in reducing occupational stress among workers. The findings highlight the diverse range of interventions, including smartphone-based applications and web-based programs, which have demonstrated positive impacts on worker well-being across various occupational settings. Moreover, the observed persistence of positive effects on workers' mental health underscores the enduring impact of digital interventions beyond the intervention period. Further research is warranted to validate the effectiveness of digital interventions in culturally diverse settings and to explore their applicability and feasibility in Southeast Asian workplaces. Collaborative efforts between researchers, policymakers, and industry stakeholders are essential to tailor interventions to local contexts and maximize their impact on worker health and well-being.

Statement of Ethics

This systematic review did not involve collecting or analyzing primary data involving human subjects. The study solely focused on synthesizing existing literature from randomized controlled trials (RCTs) to evaluate the effectiveness of digital interventions in reducing occupational stress. As such, ethical approval was not required for this research. As this study did not involve the participation of human subjects or the collection of individual data, consent was not applicable. All data used in this systematic review were obtained from publicly available

sources and published studies. Any identifiable information regarding individuals was anonymized in the included studies to ensure confidentiality and privacy.

Conflict of Interest Statement

The authors declare no conflicts of interest related to this systematic review.

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Author Contributions

The author's contributions to this manuscript were as follows: Bima Indra, Valie Palmasutra, and Febry Afrianto Setyawan contributed to the study's conceptualization. Design and methodology were primarily handled by Bima Indra and Valie Palmasutra. Bima Indra and Valie Palmasutra carried out data collection. Bima Indra and Valie Palmasutra conducted data analysis and interpretation. The initial writing and drafting of the manuscript were primarily the responsibility of Bima Indra, while critical revisions were made by Valie Palmasutra and Febry Afrianto Setyawan. Febry Afrianto Setyawan provided supervision throughout the project. All authors reviewed and approved the final version of the manuscript before submission.

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