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# **App Yourself: A Meta-Analysis of the Effectiveness of Well-Being Mobile**

## **Apps on Employee Well-Being and Mental Health**

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### **Abstract**

Employee well-being has become a significant management concern for employers who seek to improve employee performance and retention. Mobile apps can provide a convenient solution with readily available, adaptable, and employee-driven tools to address employee well-being and mental health issues. This paper presents a meta-analysis of 18 empirical studies that examined the effectiveness of mobile apps provided by employers for reducing stress, anxiety, and depression and improving overall well-being among employees. The study compared psychological and physical app orientations. The findings indicate that mobile apps are effective in reducing stress and depression and improving overall well-being. Mobile mental health solutions should be tailored to specific audiences based on variations in effectiveness by gender and age. This article provides recommendations for selecting and adapting mobile solutions to fit the organizational context.

***Keywords:** Anxiety, Depression, Mental health, Meta-analysis, Mobile app, Stress, Well-being*

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# **App Yourself: A Meta-Analysis of the Effectiveness of Well-Being Mobile**

## **Apps on Employee Well-Being and Mental Health**

In recent years, the topic of individual well-being at work has gained attention (Fox et al., 2022). With the COVID-19 pandemic (McFadden et al., 2021) and the shift to remote work (Charalampous et al., 2019), it has become a crucial consideration for organizations, society, and individuals. As work significantly impacts individual physical and mental health, research and organizational practices must prioritize employee well-being (Pagán-Castaño et al., 2020). The World Health Organization (WHO, 2004, p. 59) defines well-being as “a state ... in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully.” Governmental institutions have been asserting a persistent need to address mental health in organizations with employer-provided interventions (Dewa & McDaid, 2010). Organizations have reasons to pursue better employee well-being, as it is associated with better performance (Nielsen et al., 2017), alignment with organizational values and goals (Schwartz & Sortheix, 2018), higher employee engagement, productivity, creativity, and lower employee turnover (Matthews et al., 2022). Organizations are increasingly adopting interventions to enhance employee well-being, mental health, and job performance (Fox et al., 2022) and recently began to explore mobile solutions as an alternative to traditional interventions (Smith et al., 2020).

Mobile apps offer convenience of access and control, and employees generally value control over what they do and when they do it (de Wijn & van der Doef, 2022). A great variety of mobile apps now provide accessible and adaptable solutions for addressing employees' mental

health and well-being needs<sup>1</sup>. Existing studies documenting the effectiveness of well-being apps (e.g., Eisenstadt et al., 2021; Gál et al., 2021) focus on the general population and self-induced use of such apps and not on employer-provided solutions. Therefore, an investigation of the specific context of work stress and the employer–employee relationship is necessary (O’Connor et al., 2021).

Currently, few studies have focused on workplace settings (Paganin & Simbula, 2020). Self-selected apps are chosen by employees based on personal preferences and intrinsic motivation, and according to the self-determination theory (SDT), self-selected apps can produce higher engagement and effectiveness through autonomous motivation (Ryan & Deci, 2000). In contrast, employer-provided apps are part of organizational well-being strategies designed to address workplace-specific stressors and improve the well-being of employees. When organizations offer well-being apps, they supplementarily signal an investment in employee well-being, thereby increasing organizational attachment and motivating employee participation and engagement (Rhoades & Eisenberger, 2002). Therefore, employer-provided apps merit specific examination because they reside on different processes than the use of self-selected apps, relate to the employer–employee relationship (Rhoades & Eisenberger, 2002), and are expected to have different performance from self-selected apps. In general, interventions pay off only when they are sponsored by the employer or government and not by the employees themselves (Bishop, 1996). Thus, research shows that employer-sponsored interventions can produce greater job satisfaction, retention, and loyalty than self-funded options (Kosteas, 2023; Ng et al., 2024; Srinivas, 2008). They reduce the personal cost barrier to participation (Helling, 1998), making them more accessible to employees. Thus, focusing on employer-provided apps allows for an examination of

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<sup>1</sup> <https://www.businessofapps.com/data/wellness-app-market/#:~:text=Anxious%20and%20stressed%20people%20faced,100%20wellness%20apps%20in%202020.>

how organizational support can facilitate mental health improvements in a manner distinct from self-chosen solutions (Ng et al., 2024). The effort-recovery model (ERM) (Meijman & Mulder, 1998) further supports the need to examine these apps, as they provide structured recovery tools directly linked to the demands of the work environment.

Compared with traditional employer-led interventions, mobile apps provide greater flexibility, accessibility, and control for employees, reducing barriers to engagement (Lorca-Cabrera et al., 2020). The mobile health (mHealth) approach allows interventions to be available anytime (Pretorius et al., 2019) and at a lower cost (Lau et al., 2017), thereby overcoming treatment access barriers (Oliveira et al., 2016). With higher anonymity and privacy, they help reduce the stigma associated with seeking help (Conley et al., 2022). These advantages of mHealth eventually help to integrate workplace well-being interventions (Howe et al., 2022) and enhance therapeutic outcomes (Koh et al., 2022) and can even be more effective than traditional interventions (Wylde et al., 2017). To conclude, by studying employer-provided apps, we can better understand how organizational interventions reshape traditional workplace well-being strategies. Meta-analytic studies of employee mental health and well-being are needed to accumulate data and synthesize findings into generalizable knowledge (Richardson, 2017).

Some existing meta-analyses have also examined the effectiveness of digital health interventions in workplace settings (e.g., Carolan et al., 2017; Stratton et al., 2021). Their findings suggest that occupational digital mental health interventions can have a small but significant positive impact on both psychological well-being and work effectiveness among employees. Despite the noted variability in effectiveness, depending on the delivery method, mobile apps are understudied in these meta-analyses (only 2/21 in Carolan et al. [2017] and 1/23 in Stratton et al. [2021]). Stratton et al. (2021) found small but significant effects of digital mental health interventions on employee engagement and productivity but failed to consider the employees'

mental health and well-being. Bégin et al. (2022) carried out a scoping review of the use of mobile apps and online programs of mindfulness and self-compassion training in workers. They noted the great diversity of available programs and posited that mobile well-being apps have considerable advantages (i.e., low cost, accessibility, practicality, and feasibility) and, despite certain disadvantages (i.e., low engagement and motivation and concerns about confidentiality), positive outcomes for performance and mental health (including stress, depression, and well-being). The authors also prescribed further quantitative and meta-analysis studies to investigate when, in what context, and for whom mobile well-being programs are effective. Similarly, based on seven randomized-control trials comparing evaluated tailored digital interventions with waiting list control, Moe-Byrne et al. (2022) showed the advantage of tailored digital interventions regarding presenteeism, sleep, stress levels, and physical symptoms related to somatization, but these interventions were less effective for addressing depression, anxiety, and absenteeism. Therefore, more studies are needed to validate or refute the effects of workplace digital interventions on mental health. Even though tailored digital interventions did not reduce anxiety and depression in the general working population in Moe-Byrne et al.'s (2022) study, they significantly reduced depression and anxiety in employees with higher levels of psychological distress, showing great potential for solutions to employee mental health and well-being challenges. The authors also noted a high heterogeneity in outcome measures, which makes it difficult to carry out conclusive meta-analyses.

Therefore, our study aims to complement existing studies by focusing on the workplace context, employees' samples, and mobile mental health solutions, specifically the mobile apps provided by employers. It examines studies published from 2014 to 2022, focusing on principal mental health outcomes, including stress, anxiety, and depression, as well as overall well-being. We also compare the effectiveness of different types of mobile apps based on their focus on

psychological or physical activities and on the socio-demographic characteristics of the employees. Finally, we discuss how the integration and adjustment of well-being mobile apps can enhance their effectiveness.

## **Theoretical Framework and Research Questions**

### ***Effort-Recovery Model***

The effectiveness of well-being apps on the mental health and well-being of employees fits within the ERM (Meijman & Mulder, 1998). By emphasizing the restoration of psychological and physical resources depleted during work, the ERM provides a robust theoretical foundation for understanding how workplace well-being apps contribute to employee recovery and well-being (Meijman & Mulder, 1998). According to the ERM, work-related demands drain these resources, making recovery essential to prevent negative outcomes, such as stress, fatigue, and impaired well-being (Bennet et al., 2018). In this context, workplace well-being apps are highly relevant, as they facilitate recovery through tools that promote relaxation, mindfulness, and detachment from work-related demands. This aligns with the dual pathways of recovery in ERM: while detachment from work mitigates negative effects such as fatigue, mastery experiences foster positive outcomes such as vigor (Fritz, Lam, & Spreitzer, 2011).

While other models, such as the job demands-resources (JD-R) model (Demerouti et al., 2001) and SDT (Ryan & Deci, 2000), offer valuable insights into work engagement and motivation, they do not emphasize recovery as explicitly as the ERM. The JD-R model connects job demands and resources to burnout and engagement but lacks a direct focus on recovery processes, which are central to the function of well-being apps. Similarly, SDT explains how meeting psychological needs fosters engagement, but it primarily addresses motivation rather than recovery from work-related efforts. In contrast, the ERM provides a precise framework for

understanding the recovery mechanisms facilitated by well-being apps, which are designed to restore resources and mitigate the negative effects of work. For example, conservation of resources theory (Hobfoll, 2011) complements the ERM by highlighting how these apps not only halt resource depletion but also help build new psychological resources, such as self-efficacy and mastery, leading to enhanced vigor and reduced fatigue (Siltaloppi et al., 2009). By focusing on the recovery process, the ERM offers a comprehensive explanation of how well-being apps contribute to improved mental health and reduced work-related stress (Sonnentag, 2015).

### ***Mental Health and Well-Being***

Well-being is a theoretical concept that refers to an individual's state of psychological equilibrium (Rodman & Fry, 2009). It is agreed that well-being is a state of positive feelings and functioning well in life (Keyes, 2005), which allows individuals to fulfill their work duties to the best of their capacities while withstanding everyday difficulties (WHO, 2004). Well-being is a multidimensional construct that extends beyond the mere absence of mental illness or negative states (Keyes, 2007). Drawing from Warr's (1990) model, mental health and well-being are closely related but distinct constructs. Warr's framework emphasizes affective well-being, which is assessed through two key dimensions: pleasure and arousal. These dimensions are further broken down into dimensions such as "anxiety-contentment" and "depression-enthusiasm," capturing emotional responses in occupational settings and non-work contexts. While these emotional states are central to understanding well-being, mental health extends beyond affective experiences to include elements such as competence (an individual's ability to manage challenges) and aspiration (goal setting and motivation). Thus, well-being can be viewed as a component of mental health, focusing on emotional and affective states, whereas mental health encompasses a broader set of psychological, cognitive, and behavioral factors. Warr's model highlights that while these constructs are interrelated, mental health is more comprehensive, integrating both the emotional



facets of well-being and the functional aspects like competences. Therefore, apart from well-being, the following dimensions of employee mental health should be considered (Warr, 1990): stress, anxiety, and depression tendencies. Anxiety, the most prevalent psychological disorder (Wilmer et al., 2021), is characterized by an emotional response of fear or apprehension, often triggered by perceived risks or dangers. Anxiety is located in the high-arousal, low-pleasure quadrant. In his model, this falls under the axis of “anxiety-contentment,” where anxiety represents negative affect with high arousal. Depression is a common emotional and mental condition characterized by a lack of interest or pleasure, feelings of guilt, low self-esteem, disrupted sleep, reduced appetite, low energy, and impaired concentration (Stroud et al., 2008). Depression is placed in the low-arousal, low-pleasure quadrant. This is part of the “depression–enthusiasm” axis, where depression signifies a state of low pleasure and low arousal.

Globally, stress is recognized as a predominant psychological issue affecting employees, significantly impacting their mental and physical health (Quick & Henderson, 2016). Stress is not explicitly labeled on Warr’s axes but can be inferred as a state involving high arousal and either low pleasure (in situations of distress or anxiety) or high pleasure (in situations involving challenge or excitement). Stress is thus context-dependent but often aligns with the anxiety–contentment axis when related to negative outcomes like burnout.

These dimensions are often measured together (e.g., DASS, cf. Vignola & Tucci, 2014) and are believed to have common physiological and emotional features at different levels of intensity (Mello et al., 2007). Research has firmly established that adverse working conditions and the nature of the workplace itself have significant impacts on employee well-being, increasing the likelihood of experiencing mental health disorders (Rugulies et al., 2023). Therefore, work-related mental health issues and jeopardized well-being should also be addressed by the employer.

## *Addressing Mental Health and Well-Being with Well-Being Mobile Applications*

Large corporations and small businesses have started to include well-being in strategic plans and practical programs (Sorensen et al., 2018). Previous research has demonstrated that targeted workplace interventions aimed at improving employee well-being can indeed be effective (de Wijn & van der Doef, 2022; Fox et al., 2022). While interventions such as seminars, therapy, and workplace meditations are beneficial, the accelerated pace of work, rise of remote working (Charalampous et al., 2019), and the demand for autonomy and accountability (De Moya & Pallud, 2020) highlight the need for a well-being resource that is accessible anytime and anywhere and can be individually managed by each employee (Hofer et al., 2018). Indeed, some studies show that giving access to such apps can increase employee well-being (Bostock et al., 2019) and decrease depression (Mascaro et al., 2020) and work-related fatigue (van Drongelen et al., 2014). However, these studies are controversial, as some do not find any significant effects (Mascaro et al., 2020; Thøgersen-Ntoumani et al., 2020). In the face of the varied landscapes of well-being mobile apps, the primary aim of our study is to determine the extent to which these apps can enhance mental health and overall well-being in the workplace:

*RQ1: Can well-being mobile apps improve mental health and well-being?*

The effectiveness of well-being apps in the workplace depends on app functionalities and socio-demographic factors. We focus on three key moderators—app type, gender and age—to unravel the complexities of how different groups interact with and benefit from these digital tools. These moderators are detailed below.

**The Role of App Type.** Aligned with the literature that highlights variations in the use and effectiveness of well-being apps based on their type and design (Douglas et al., 2023), we explore how apps focusing on psychological aspects compare to those centered on physical activity.

Indeed, it remains uncertain whether physical (Haufe et al., 2019; Thøgersen-Ntoumani et al., 2020) or psychological (Mascaro et al., 2020; Schulte-Frankenfeld & Trautwein, 2022) activities equally affect employee well-being, and whether all employees benefit similarly from such apps. While most well-being apps emphasize psychological techniques such as mindfulness-based programs, physical activity is another way to manage mild-to-moderate mental health conditions (Bize et al., 2007; Paluska & Schwenk, 2000). Some studies indicate that workplace physical exercise interventions can yield benefits (Jex, 1991; Thøgersen-Ntoumani & Fox, 2005) comparable to meditation or relaxation techniques (van der Zwan et al., 2015). This suggests that incorporating regular exercise into one's routine could be an effective option for enhancing overall mental health and well-being (Marquez et al., 2020). However, some research indicates that the impact of physical exercise on well-being is limited (De Geus & Van Doornen, 1993; Kerr & Vos, 1993). Therefore, we explore whether the effectiveness of well-being apps varies when they are focused on psychological versus physical aspects of well-being.

*RQ2: Does the effectiveness of well-being mobile apps differ for psychological and physical oriented apps?*

**The Role of Gender and Age.** The effectiveness of well-being mobile apps is expected to differ depending on the targeted public. The influence of gender on stress and coping mechanisms is well documented (González-Morales et al., 2006). In addition, men and women differ in their attitudes toward available mobile health solutions (Mackenzie et al., 2006). While men are more susceptible to experiencing stress at work, they are also less inclined to seek professional psychological assistance or to utilize mobile mental health solutions (Yousaf et al., 2015). Thus, our study

investigates the manifestation of gender differences in the effectiveness of well-being apps (Antezana et al., 2022).

Karabinski et al. (2021) discovered that contrary to initial assumptions, interventions aimed at enhancing well-being are more efficacious for older employees than younger adults (below 40 years old), who generally report higher levels of stress (Hogan et al., 2002). This can be attributed to the significant influence of age on well-being stability. Older employees typically exhibit greater well-being stability (Mäkikangas et al., 2016). In line with these insights, our study investigates how age impacts the perception and efficacy of well-being apps. Therefore, our final research question is as follows:

*RQ3: Does the effectiveness of a well-being mobile app differ for employees depending on gender and age?*

## **Materials and Methods**

### ***Literature Search and Study Selection***

We conducted a systematic literature search in the four most relevant databases for our research scope and objectives (i.e., PsycNet, Elsevier, EBSCO, and Web of Science) in September 2023 (Bramer et al., 2017). This meta-analysis was conducted according to the PRISMA guidelines (Moher et al., 2010) and the Cochrane recommendations for the reduction of subjectivity biases and data extraction errors (Higgins et al., 2011). We created a search algorithm that included the terms mental health, stress, anxiety, depression, well-being, mobile apps, and controlled trials

(including synonyms)<sup>2</sup>. We complemented our search by manually searching the retrieved articles and double-checking the search algorithm on Google Scholar. After contacting the authors of the pilot studies and protocols to inquire about the unpublished results, we focused on published studies.

The meta-analysis included studies that met two criteria: (1) they were written in English, and (2) they were published in a peer-reviewed journal. This resulted in a sample of 4237. The research was not limited to any specific timeline due to the recent emergence of mobile apps. The initial sample was filtered to remove duplicates and papers not focused on mobile apps (i.e., face-to-face or simple web-based interventions), which resulted in 2406 remaining studies. To prevent publication biases, we also restricted our study to papers published in journals ranked Q1 to Q2 on SCIMAGO after further filtering (Aert et al., 2019) (n = 566). We identified studies directly related to the conceptual framework by focusing on abstracts and full papers. We considered the following criteria: (1) users (actual users versus caregivers or parents), (2) device used (smartphone vs. web app or physical intervention), (3) method (randomized trial vs. feasibility studies or protocol), (4) presence of control group, and (5) evaluating one of the studied outcomes. This filtering allowed us to reduce the sample to N=65<sup>3</sup>. Finally, we found only N = 18 studies that were related to the work-related use of well-being mobile apps and reported complete data suitable for inclusion in a meta-analysis. The data collection and filtering process is presented in Figure 1 and further details regarding the search protocol and process are provided in Appendix C.

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<sup>2</sup> The search terms included the following: “mobile app” OR “mobile application” AND (depression OR anxiety OR “well-being” OR “quality of life” OR “life satisfaction” OR stress OR “mental health”) AND (“control trial” and “randomized trial”). The spelling “well-being” provides the same results as “wellbeing”.

<sup>3</sup> Two authors filtered the studies in parallel. The inter-rater reliability is 99%, with less than 1% (4 studies out of n=566) receiving different decisions for inclusion vs. exclusion. The final decision was made based on the full-text of the publication with arbitration from the third author.

[Insert Figure 1 here]

### ***Analysis and Reporting***

The focus was on the immediate impact of well-being mobile app use, specifically at the end of the intervention, rather than follow-up measures that varied significantly in time and sample size. The meta-analytic analyses were conducted using Stata version 14. Regarding the diversity in mobile applications (i.e., intervention) and respondents (i.e., the population), we expected a high level of heterogeneity and therefore opted for the random effects model (Hedges & Vevea, 1998). As we have a limited number of available studies, we decided to include all studies with corresponding dependent variables, without excluding the outliers. Four separate meta-analyses were performed for (1) stress, (2) anxiety, (3) depression, and (4) well-being.

The effect size (ES) was measured based on the standardized mean difference, since it is the most common method of calculating ES in meta-analysis. An ES is an index of the magnitude of the effect of one variable (or set of variables) on another variable. The two most common measures of effect are Cohen's  $d$  and Pearson's  $r$  (Allison & Gorman, 1993): the  $D$ -statistic calculated with the standardized difference between the means of the treatment and control groups, while Pearson's  $r$  is a correlation-based measure. Taking into account the nature of the studies and available statistical information, we used Cohen's  $d$  to evaluate the ES. Obviously, the variety of research designs and statistical reporting in studies is a great impediment to ES calculation in meta-analyses (Allison & Gorman, 1993), especially in the multi-discipline domain of mental health apps (Moe-Byrne et al., 2022). However, in our sample, we selected experiments that employed randomized control trials, all of which reported means and standard deviations prior to and after the interventions, which are necessary for this method. The only study we had to exclude was a

publication by Deady et al. (2022) in Australia due to the format of the presented results and the absence of results for the control group.

Following the traditional way of assessing the homogeneity/heterogeneity of sets of studies in meta-analyses (Huedo-Medina et al., 2006), we provide statistics indicating the presence of heterogeneity with Cochran's Q test and the degree of heterogeneity with Higgins's  $I^2$  (Huedo-Medina et al., 2006). Cochran's Q test takes values from 0% to 100%, with 0% indicating that statistical homogeneity exists, while for Higgins's  $I^2$ , the heterogeneity is described as low, moderate, and high for values of 25%, 50%, and 75% (Sedgwick, 2013). However, in small meta-analyses, the heterogeneity might be overestimated (Von Hippel, 2015).

Statistical heterogeneity is addressed with subgroup analysis (Sun et al., 2012, 2014), which divides the total sample into two subgroups (activity: psychological vs. physical; age of participants: younger vs. older than 40 years old; gender of participants: mostly male vs. mostly female) and tests whether these subgroups differ from each other (Cuijpers et al., 2016). To compare the subgroup differences of the two groups, we use Q-statistic (Spineli & Pandis, 2020). The subgroup analysis does not indicate the source of heterogeneity in itself and does not provide evidence on the significance of differences between the groups; instead, it provides observational results (Higgins et al., 2021). These results can be interpreted as the presence of characteristics that differentiate between groups with within-group similarities (low heterogeneity within the group) and between-group differences (presence of heterogeneity between the groups) (Higgins et al., 2021).

## Results

### *Characteristics of the Included Studies*

The final sample comprised 18 studies published between 2014 and 2022 (cf. Appendix A). Half of the studies (9/18) were conducted in Europe, followed by Australia (4/18), the United States (4/18), and a single study from Asia. Thirteen out of 18 apps focused on the psychological aspect, offering meditation, advice for better sleep and stress reduction, breathing exercises, and mindfulness exercises. The studies differ greatly in their measures of mobile app effectiveness. However, the most common measures are the depression, anxiety, and stress scale (DASS-21), quality of life (QoL and SF-36), and well-being (WHO-5 and the Warwick-Edinburgh Mental Well-Being Scale). The interventions typically lasted for 1–2 months. The overall sample size was  $N = 2348$  for the effect on stress,  $N = 1211$  for the effect on anxiety,  $N = 2221$  for the effect on depression, and  $N = 3435$  for the effect on well-being.

### *Overall Effects*

The results show that well-being mobile apps provided to employees allows reducing stress ( $g = -0.276$ , CI 95% [-0.403; -0.149];  $z = -4.261$ ,  $p < .001$ ) and depression ( $g = -0.207$ , CI 95% [-0.386; -0.028];  $z = -2.270$ ,  $p < .050$ ), while also allowing the improvement of overall well-being ( $g = 0.193$ , CI 95% [0.065; 0.320];  $z = 2.963$ ,  $p < .010$ ) (Table 1). Yet, we found no significant effect on anxiety. At the same time, all significant effects have high heterogeneity, except for moderate–high heterogeneity for the well-being outcome ( $I^2 = 66.3\%$ ). These levels of heterogeneity call for the investigation of possible within-group differences.

[Insert Table 1 here]



**Differences by Type of App.** For the stress outcome, the only type of mobile app studied was psychology oriented. For the anxiety outcome, both psychology-oriented and physical activity-oriented apps are not effective and do not show evidence of a difference between them (Q-value = 0.03,  $p > .050$ ), while psychology-oriented apps have lower heterogeneity (Q-value = 4.53,  $p < .050$ ,  $I^2 = 33.8\%$ ). For the depression outcome, psychology-oriented apps have a significant negative effect on the level of significance of 90% ( $g = -0.019$ , CI 95% [-0.395; 0.016];  $z = -1.811$ ,  $p < .100$ ), while physical activity-oriented apps do not show such effect ( $g = -0.244$ , CI 95% [-0.767; 0.279];  $z = -0.913$ ,  $p > .050$ ). However, the two groups of apps do not show evidence of difference (Q-value = 0.04,  $p > .050$ ). Finally, for the well-being outcome, both mind- and physical activity-oriented apps are effective. One study on an app that combines both mind- and body-oriented stress-relieving techniques did not find significant improvements in well-being, which contributes to the significant between-group heterogeneity (Q-value = 14.18,  $p < .001$ ). Overall, we can conclude that psychology-oriented apps seem to provide better results.

**Differences by Age.** Age does not seem to be the source of heterogeneity for the stress outcome, as the use of well-being mobile apps helps individuals both younger and older than 40 years old to reduce stress ( $g = -0.231$ , CI 95% [-0.365; -0.097];  $z = -3.380$ ,  $p < .001$  for older than 40 years old;  $g = -0.344$ , CI 95% [-0.614; -0.073];  $z = -2.411$ ,  $p < .050$  for younger than 40 years old). Furthermore, no between-subgroup heterogeneity exists (Q-value = 0.53,  $p > .050$ ). In a similar vein, no heterogeneity exists between the age groups for the anxiety outcome (Q-value = 0.12,  $p > .050$ ). However, for the older generation, the effect on anxiety is negative and significant at the level of 90% ( $g = -0.167$ ;  $z = -1.658$ ,  $p < .100$ ), also exhibiting low heterogeneity within the subgroup (Q-value = 3.27,  $p < .050$ ;  $I^2 = 38.8\%$ ). The age difference is not evident for the depression outcome, where for both age groups the

effect of mobile apps is significant at 90% confidence and where the subgroup heterogeneity is significant yet almost non-existent (Q-value = 0.00,  $p < .050$ ). For well-being, the positive effect of mobile app use is more pronounced for the younger generation ( $g = 0.342$ , CI 95% [0.212; 0.473];  $z = 5.131$ ,  $p < 0.001$ ), and the heterogeneity of this effect in the subgroup is minimal (Q-value = 0.75,  $p < .050$ ;  $I^2 = 0\%$ ). The between-subgroup heterogeneity for the well-being outcome is not significant for the age groups and is thus not a source of the main effect heterogeneity (Q-value = 2.56,  $p < .050$ ).

**Differences by Gender.** To account for the gender effect, we divided the studies between mostly female (>50% of the initial sample) and mostly male studied populations<sup>4</sup>. For the stress outcome, only one study out of 10 was mostly male. For both subgroups, the effect on stress is negative and significant, and while there is a between-subgroup heterogeneity (Q-value = 7.02,  $p < .010$ ), the size of the sample is insufficient for a comparison of the two genders (i.e., mostly male studies account for only 7% of the studied aggregated sample). For anxiety, the negative effect is only significant for the mostly male samples ( $g = -0.318$ , CI 95% [-0.495; -0.141];  $z = -3.518$ ,  $p < .001$ ). Given the significant heterogeneity between the subgroups (Q-value = 7.17,  $p < .010$ ) and the presence of the effect for the male sample against the absence of the overall effect, the gender difference is an interesting moderator of the effect of mobile app use on anxiety levels. Similarly, only the male predominant samples show a significant effect of mobile app use on depression ( $g = -0.473$ , CI 95% [-0.651; -0.295];  $Z = -5.917$ ,  $p < .001$ ). There is also evidence of gender subgroup differences for the depression outcome (Q-value = 4.98,  $p < .050$ ). Finally, the within-group heterogeneity in

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<sup>4</sup> Within the studied sample, two studies approached the 50% cutoff for mainly male samples: Bartlett et al. (2022) had 45% male respondents, while an der Meer et al. (2020) had 47.1% male respondents. To avoid the possible misinterpretation of gender effect, robustness checks excluding both studies from the stress subsample and Barlett et al. (2022) from depression and well-being subsamples were carried out. These results do not differ significantly from the further reported results.

male-dominant samples for anxiety and depression is very low (Q-value = 0.00,  $p > .050$ ;  $I^2 = 0\%$ ). Interestingly, the gender differences remain for the overall well-being outcome; however, here, only the predominantly female samples show a significant positive effect ( $g = 0.243$ , CI 95% [0.093; 0.393];  $z = 3.181$ ,  $p < .001$ ), while the gender subgroup heterogeneity is no longer significant (Q-value = 0.26,  $p > .050$ ).

## **Discussion**

### *Theoretical Implications*

In the context of employee well-being, mental health apps provide a convenient and accessible resource for seeking support anytime and anywhere (Smith et al., 2020). We found that well-being apps help reduce stress and depression and have a positive effect on overall well-being. Unexpectedly, the results show no immediate impact on anxiety. These results are in line with the reported effectiveness of well-being mobile apps. Thus, Healthy Mind Innovations<sup>5</sup> (studied in Hirshberg et al., 2022) states that their app can reduce stress by 28%, depression by 24%, and anxiety only by 18%. The overall effects are highly heterogeneous, suggesting between-subgroup differences. These differences are partly explained by the app's type and the users' gender.

The results of our study align with previous meta-analyses on the effectiveness of mobile apps in managing stress and depression (e.g., Khademian et al., 2021; Lecomte et al., 2020) and improving well-being (Eisenstadt et al., 2021; Gál et al., 2021). However, previous studies primarily focused on users who voluntarily downloaded and used well-being mobile apps and lacked insights into the use of mobile apps as workplace well-being interventions. These findings also align with previously reported positive outcomes of digital (not only mobile) mental health

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<sup>5</sup> <https://hminnovations.org/workplace-wellness-program>

interventions provided by employers for the mental health and well-being of employees (e.g., Carolan et al., 2017; Stratton et al., 2021). Yet, it shows much more promising effects for stress, depression, and well-being than the effect of digital interventions on employee mental health reported by Moe-Byrne et al. (2022). Furthermore, our results challenge previously published studies on the effectiveness of mobile apps and digital interventions in addressing anxiety (e.g., Lecomte et al., 2020). Although the apps have a positive and significant impact on well-being, depression, and stress, their effectiveness in reducing anxiety appears to be limited. Stratton et al. (2021) similarly found no evidence that any digital health intervention in the workplace has the effect of reducing anxiety levels. Several factors may contribute to this result. Thus, anxiety is a complex and multifaceted condition that encompasses various specific disorders<sup>6</sup>, such as generalized anxiety, phobias, social anxiety, worry disorder, panic disorder, and post-traumatic stress disorder (Bandelow et al., 2017). It appears that interventions provided by apps may not adequately address the specific subtypes of anxiety that users experience. Unlike well-being, depression, and stress, which share common underlying psychological processes targeted by the app, anxiety disorders are different (Thibaut, 2017) and highly individualized (Curtiss et al., 2021). Perceived stress refers to the ability to respond to stressors, whereas anxiety refers to the health risks associated with prolonged or unrelieved severe stress (Kessler et al., 2015). Furthermore, anxiety is future oriented, as it relates to the fear of future events, while depression and stress are present- and past-oriented (Eysenck & Fajkowska, 2018). Therefore, as cognitive patterns to counter anxiety are different from stress and depression, the generalized well-being app might be ineffective in treating anxiety disorders. Additionally, the duration of app use during the study

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<sup>6</sup> Specific phobias are the most common, with a prevalence of 10.3%, then panic disorder (with or without agoraphobia) is the next most common with a prevalence of 6.0%, followed by social phobia (2.7%) and generalized anxiety disorder (2.2%) (Bandelow et al., 2017).

period might not have been sufficient to observe significant changes in anxiety levels, as anxiety may require longer-term interventions or additional therapy (Curtiss et al., 2021). Therefore, cognitive patterns that counter anxiety differ from stress and depression. Additionally, the duration of app use during the study period might not have been sufficient to observe significant changes in anxiety levels, as anxiety may require longer-term interventions or a different additional approach (Curtiss et al., 2021). Finally, anxiety disorders are highly individualized (Curtiss et al., 2021; Robinson et al., 2013), and effective treatment often demands personalized approaches based on specific symptoms and triggers that the app's interventions may not have adequately addressed. Thus, anxiety disorders often necessitate special treatment, combining both psychotherapy and pharmacotherapy (Bandelow et al., 2017) or specifically designed mobile apps (Chandrashekar, 2018).

While psychological health and well-being are related to the overall health and physical form of individuals (Ruggeri et al., 2020), fewer studies focused on physical activity and exercise (i.e., four studies), and only one study investigated an app combining psychological and physical techniques (Van Drongelen et al., 2014). The limited number of studies on exercise and physical activity yields inconclusive results, showing no definitive differences between psychological and physical well-being apps. Haufe et al. (2019) recommended sports and healthy lifestyles to factory workers with metabolic syndrome and found significant improvements in the levels of well-being, anxiety, and depression after they practiced the app-induced physical activities. However, when Lee et al. (2017) focused on neck pain and occupational disorders, they found that the suggested exercise and self-enhancement techniques were not helpful. Similarly, Thøgersen-Ntoumani et al. (2020) and Stephenson et al. (2021) did not document improvement of mental health and well-being from apps aiming to reduce the sedentary lifestyle and promote moving and walking. This may be related to the fact that work stressors reduce individuals' propensity to engage in stress-

reducing, high-effort sports activities (Sonnentag & Jelden, 2009). The evidence on apps addressing physical activity as the main lever of mental health suffers not only from a dearth of studies in general but also from the diversity of problems addressed.

Our study highlights an important factor—gender—that moderates the effectiveness of mental health apps. Meta-analysis results show that well-being apps are more effective in reducing stress, anxiety, and depression among men. This effect can be explained by the difference in stress response patterns between men and women (González-Morales et al., 2006). Thus, women use more social support coping (i.e., sharing and discussing), while direct action (i.e., identifying and resolving problems) is more effective for men. This explains why our results show that adopting a proactive approach (i.e., using a well-being app) is more effective for male samples. Furthermore, while men are more vulnerable to psychological distress following psychosocial work exposures (Vermeulen & Mustard, 2000), they are less capable of recognizing psychological issues and demonstrate lower awareness of mental health services than women (Haavik et al., 2019). Hence, forcefully providing a well-being app might be more beneficial for male workers than for female workers who have already acted on the identified health problems and tensions. It is also true that men often exhibit less favorable attitudes than women when it comes to utilizing mental health services (Mackenzie et al., 2006; Yousaf et al., 2015). Therefore, mobile mental health, which offers more discreteness (Bégin et al., 2022; Deady et al., 2022) and is available without specific requests or effort from employees, might be especially valuable to the male labor force. Such a preference for self-help aligns with the active stigma-free role the mobile app can play in managing the well-being of men at work. In fact, as women ‘know’ how to identify mental health needs and ask for help, they are also more responsive to well-being apps and relate the use of wellbeing apps to the improved perceived well-being (Antezana et al., 2020), while men are less helped (Peters et

al., 2018) and would therefore benefit more from employer-provided easily accessible and easy-to-use mobile solutions.

Our research also indicates a positive impact of the use of mental health apps on the well-being of younger employees. This effect may be attributed to the fact that younger employees exhibited more noticeable fluctuations in well-being over time when contrasted with their older peers (Mäkikangas et al., 2016) and the tech-savvy nature of younger individuals who are accustomed to utilizing mobile applications (Iancu & Iancu, 2020). Furthermore, younger individuals demonstrate a more open attitude toward preventative approaches to mental health (Pretorius et al., 2019). At the same time, older adults usually express a greater willingness to seek assistance from primary care physicians (Mackenzie et al., 2006). While previous studies found that compared to millennials and Gen Zs, older generations have a higher appreciation of wellness and mindfulness programs (Ott-Holland et al., 2019), they might still prefer traditional interventions to mobile solutions. An alternative explanation may stem from the variation in mental health disorders throughout the lifespan so that the level of worries and anxieties tends to decrease with age before increasing again at the elderly life stage (Lenze & Wetherell, 2011).

Mobile apps serve as effective tools for aiding recovery by providing psychological support and promoting physical activity, which are crucial in mitigating the effects of work-related strain. The ERM posits that sustained work effort leads to resource depletion, which necessitates recovery to restore physical and psychological resources (Meijman & Mulder, 1998), and our findings confirm that mobile apps can be levers facilitating the restoration of resources, preventing long-term negative consequences associated with mental issues. Further findings also support the ERM, suggesting that better recovery through accessible interventions can enhance employee well-being (Koldijk et al., 2016). Thus, the significant effects of psychology-oriented apps on well-being

reinforce the ERM's proposition that recovery activities not only alleviate negative outcomes but also promote positive resource building, such as overall well-being. The beneficial effect of the psychological activities offered by the apps (e.g., mindfulness, meditation, and breathing exercises) corresponds to the four dimensions of recovery: psychological detachment, relaxation, mastery, and control (Sonnentag et al., 2007). Our study extends the ERM by exploring moderators of recovery effectiveness. We found that gender and age contribute to variations in app effectiveness, indicating that individual differences can influence the recovery process. These results emphasize the need for personalized recovery strategies, as outlined by the ERM (Meijman & Mulder, 1998).

### ***Practical Implications***

Providing mental health apps to employees is an effective and accessible way to enhance well-being and reduce stress in the workplace (Smith et al., 2020). Employers should tailor app offerings to meet diverse employee needs, recognizing that no single solution suits all psychological health issues (de Wijn & van der Doef, 2022). For instance, apps specifically dedicated to anxiety are necessary, as complex disorders like anxiety and depression require more comprehensive treatment and specialist interventions. Additionally, integrating physical activities with mental health exercises, such as combining sports and meditation within a single app, can offer more holistic benefits. Examples such as the Calm app, which includes sections for both meditation and mild physical exercises, demonstrate the potential of this integrated approach.

To reduce the gender-related stigma of the well-being app, developers might need to propose solutions designed for and specifically targeted at men. For example, there is a growing



number of mental health apps designed specifically by men and for men<sup>7</sup>. These apps combine design features (e.g., dark and sober colors), representativeness (male coaches), inspirations (e.g., navy, firefighters), and masculine-oriented vocabulary (e.g., “murder anxiety”) to appeal to male users. Furthermore, employers should force the initial use of available well-being solutions to avoid auto-selection bias from male employees. Thus, if it is a corporate practice and not an individual choice, men can avoid being perceived as or feeling vulnerable for resorting to mental help. To maximize the effectiveness of mental health apps, it is crucial to recruit older employees and develop age-specific strategies. Thus, while observing a particular positive impact on the well-being of younger employees, we also observed that older generations are prone to react positively (e.g., reduced stress and anxiety) to well-being apps. However, to be more effective, the well-being app might need to be better adapted to their needs in terms of easy-to-use design and adapted activities (e.g., including restorative and neuro-cognitive exercises).

The effects of apps also depend on employee engagement (Bartlett et al., 2022). For this reason, it may be advisable to guide the introduction of the application with an approach that better engages employees, such as seminars or group therapy. These initiatives should not only highlight the accessibility, privacy, and convenience aspects but also address any lingering stigma associated with seeking mental health support. By showcasing the advantages of these apps, including their user-friendly interfaces and autonomy, they assist individuals in managing their well-being, and educational efforts can encourage broader adoption. The results suggest that apps that show significant positive results in terms of improvement of mental health and well-being are introduced with a specifically tailored strategy, which includes adjustment of the target group’s needs and the mobile solution, constant tracking and motivational support, and the possibility of performing

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<sup>7</sup> e.g., HeChangedIt <https://hechangedit.com/> or Mental <https://www.getmental.com/>

well-being activities in the vicinity of the employer. Furthermore, mobile apps should provide easy-to-follow advice that can change everyday routines. It can also be suggested to associate the introduction of well-being apps with periodical reminders (e.g., every 1.5 months) and incorporate persuasive technology and personalization of the app (Carolan et al., 2017).

To conclude, forging partnerships and collaboration with employees is a strategic move to integrate mental health apps into workplace well-being initiatives. The promotion of these apps as valuable tools to mitigate stress levels, combat depression, and enhance overall employee well-being can contribute to fostering a healthier and more productive workforce, aligning with the growing emphasis on holistic approaches to employee well-being within organizational settings. However, applications should not replace a good organizational strategy and an adapted lifestyle.

### ***Limitations and Future Research Directions***

This study is subject to several limitations that can be overcome in future studies. First is the limited number of published studies. Although there are published and registered study protocols on the effectiveness of well-being apps in the work context, many of these studies have not been carried out. There is also a risk of publication bias, due to which only studies with significant results or results in line with initial hypotheses are published (Seehra et al., 2023). Publication quality bias, on the other hand, is addressed by the journal rank filter. Second, the results of the meta-analysis can be biased by the type of available studies. Next, few studies combine psychological and physiological activities, yet the app focus is complementary. Therefore, future studies should also address the effects of combining multiple apps on mental health and well-being. Fourth, not all valuable data were reported in the published studies. In the exploration of mental health mobile applications, it is crucial for research efforts to include scales that evaluate

both the quality and usability of these applications<sup>8</sup>, while simultaneously assessing factors such as work-related and family-related stress (Duxbury et al., 2018). Thus, the app's accessibility and convenience play a pivotal role in enhancing its effectiveness (Alqahtani & Orji, 2020). However, few studies reported the actual usability and appreciation of the app. Future studies can refer to a robust method to scrutinize the effectiveness of well-being interventions in the workplace, such as the integrated training transfer and effectiveness model (Nielsen & Shepherd, 2022). While we addressed the main socio-demographic variables (i.e., gender and age), other moderators could be interesting to consider (e.g., regions, occupation, periods of increased stress, or length of treatment [Richardson & Rothstein, 2008]). Thus, acknowledging the findings of Shaffer et al. (2000), it would be interesting to explore how regional factors—encompassing cultural, economic, and environmental aspects—shape employees' stress experiences (Misra & Castillo, 2004) and their interaction with well-being apps. Indeed, previous studies have shown great diversity in attitudes toward mental health and seeking support (Zheng et al., 2021), levels of stigma (Mojaverian et al., 2013; Yin et al., 2019), and the effectiveness of well-being interventions among different countries (Misra & Castillo, 2004; Mojaverian et al., 2013).

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<sup>8</sup> <https://mhad.science/en/> the Mobile Health App Database presents the ratings based on the MARS scale.

## Appendix A. Characteristics of the Selected Papers

Study	Region/ Country	App	Type of app	Control (n)	Trial (n)	Age (M)	% Male	Dimension of well-being and mental health
Bartlett et al. (2022)	Australia (Tasmania)	Smiling Mind Workplace Program App	psychological	70	71	27	45%	Quality of life (AQoL) [WB], stress, and distress [D]
Birney et al. (2016)	USA	MoodHacker	psychological	150	150	40.6	37%	Depression (PHQ-9) and well-being (WOS-life satisfaction)
Bostock et al. (2019)	Europe (UK)	Headspace app	psychological	81	105	n/a	n/a	Anxiety and depression symptoms (HADS), well-being (WEMWBS)
Coelhoso et al. (2019)	Brazil	Flourishing App	psychological	250	240	n/a	33.8%	Depression, anxiety, and stress (DASS-21)
Fiol-DeRoque et al. (2021)	Europe (Spain)	PsyCovid App	psychological	234	248	42	16.8%	Depression, anxiety, stress (DASS-21)
Haufe et al. (2019)	Europe (Germany)	No name	physical	154	160	48.1	86%	Anxiety severity, depression, and quality of life (SF-36) [WB]
Hirshberg et al. (2022)	USA	Healthy Minds Program	psychological	289	280	42.58	12.02%	Psychological distress (stress-PSS, anxiety and depression-PROMIS) [S], well-being (WHO-5)
Lee et al. (2017)	Asia (South Korea)	No name	physical	9	11	n/a	n/a	Quality of life (SF-36) [WB]
Mascaro et al. (2020)	USA	Headspace app	psychological	47	48	n/a	n/a	Anxiety, stress, and depression (DASS-21)
Mistretta et al. (2018)	USA	No name	psychological	15	22	n/a	n/a	Depression, anxiety, and stress (DASS-21); (WHO-5)
Rich et al. (2021)	Europe (UK)	No name	psychological	63	62	n/a	n/a	Stress (DASS-21)
Schulte-Frankenfeld & Trautwein (2022)	Europe (Germany)	Balloon App	psychological	49	50	25	69.4%	Stress, life satisfaction, and self-regulation
Stephenson et al. (2021)	Europe (Northern Ireland)	Worktivity	physical	13	18	37.9	61%	Stress, distress [D], and quality of life (QoL) [WB]
Thøgersen-Ntoumani et al. (2020)	Australia	START	physical	47	50	n/a	n/a	Anxiety, depression, and well-being (WHO-5)
van der Meer et al. (2020)	Europe (Netherlands)	SUPPORT Coach	psychological	114	85	43.37	47.1%	Post-traumatic syndrome severity (PCL-5) [S]
van Drongelen et al. (2014)	Europe (Netherlands)	MORE energy	both	251	251	40.9	93%	Checklist individual strength [WB]
Weber et al. (2019)	Europe (Germany, England, and Northern Ireland)	Kelaa Mental Resilience	psychological	227	111	n/a	n/a	General stress (COPSOQ) and well-being (WEMWBS)
Xu et al. (2022)	Australia	Headspace App	psychological	74	74	40	22%	Stress (PSS) and wellness (WEMWBS) [WB]

Notes: [A] = anxiety, [D] = depression, [S] = stress, [WB] = well-being; DASS-21 = Depression Anxiety Stress Scales (Lovibond & Lovibond, 1995), SF-36 = The Short Form Health Survey (Ware & Sherbourne, 1992), QoL = quality of life (J. Richardson et al., 2014), WEMWBS = Warwick-Edinburgh Mental Well-Being Scale (Tennant et al., 2007); WHO-5 = Well-Being Index (Topp et al., 2015); PSS = Perceived Stress Scale (Cohen et al., 1983); PROMIS = Patient-Reported Outcomes Measurement Information System; Copenhagen Psychosocial Questionnaire – Revised Version (COPSOQ II; [Pejtersen et al., 2010]); HADS = Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983); WOS-life satisfaction = Workplace Outcome Suite (Attridge, M. (2024).

## Appendix B. Complete Meta-Analysis Results

Outcome measures	Subgroups	N <sub>studies</sub>	N <sub>participants</sub>	Hedge's g (SMD)	95% CI	Weight	Z (effect size)	Heterogeneity Q-value/ I <sup>2</sup>	
<b>Stress</b>	Overall	10	2348	-0.276	[-0.403; -0.149]		-4.261***	18.09*/ 77.4%	
	Older	6		-0.231	[-0.365; -0.097]	62%	-3.380***	7.37/32.2%	
	Younger	4		-0.344	[-0.614; -0.073]	38%	-2.411*	8.77*/65.8%	
	Between-subgroup heterogeneity Q-value = 0.53 (ns.)								
	Mostly female	9		-0.240	[-0.345; -0.136]	93%	-4.504***	11.03/27.5%	
	Mostly male	1		-0.813	[-1.223; -0.402]	7%	-3.883***	-	
Between-subgroup heterogeneity Q-value = 7.02**									
<b>Anxiety</b>	Overall	6	1211	-.107	[-0.280; 0.065]		-1.219	9.41*/ 46.9%	
<i>Activity</i>	Psychological	4		-0.080	[-0.277; 0.117]	64%	-0.799	4.53/ 33.8%	
	Physical	2		-0.124	[-0.569; 0.320]	36%	-0.549	3.86/ 74.1%	
Between-subgroup heterogeneity Q-value = 0.03 (ns)									
<i>Age</i>	Older	3		-0.167	[-0.365; 0.030]	65%	-1.658 <sup>†</sup>	3.27/ 38.8%	
	Younger	2		-0.069	[-0.578; 0.441]	35%	-0.265	4.21/ 76.3%	
Between-subgroup heterogeneity Q-value = 0.12 (ns); total 5 studies and 1114 respondents included									
<i>Gender</i>	Mostly female	4		-0.003	[-0.150; 0.144]	58%	-0.040	2.24/ 0%	
	Mostly male	2		-0.318	[-0.495; -0.141]	42%	-3.518***	0.00/ 0%	
Between-subgroup heterogeneity Q-value = 7.17 (p < .007)									
<b>Depression</b>	Overall	9	2221	-0.207	[-0.386; -0.028]		-2.270*	30.92***/74.1%	
<i>Activity</i>	Psychological	7		-0.190	[-0.395; 0.016]	78%	-1.811 <sup>†</sup>	24.19***/75.2%	
	Physical	2		-0.244	[-0.767; 0.279]	22%	-0.913	5.29*/ 81.1%	
Between-subgroup heterogeneity Q-value = 0.04 (p > .050)									

<i>Age</i>	Older	5		-0.233	[-0.491; 0.026]	66%	-1.761 <sup>†</sup>	24.77***/83.9%
	Younger	3		-0.233	[-0.506; 0.040]	34%	-1.672 <sup>†</sup>	3.88/ 48.5%
Between-subgroup heterogeneity Q-value = 0.00 (p > .050); total 8 studies and 2124 included								
<i>Gender</i>	Mostly female	6		-0.144	[-0.371; 0.084]	73%	-1.236	21.62***/76.9%
	Mostly male	2		-0.473	[-0.651; -0.295]	27%	-5.917***	0.00/ 0%
Between-subgroup heterogeneity Q-value = 4.98 (p < .050); total 8 studies and 2124 included								
<b>Well-being</b>	Overall	13	3435	0.193	[0.065; 0.320]		2.963**	35.62***/66.3%
<i>Activity</i>	Psychological	9		0.253	[0.131; 0.376]	72%	4.057***	16.24*/50.7%
	Physical	3		0.201	[0.011; 0.391]	17%	2.078*	1.96/0%
	Both	1		-0.149	[-0.325; 0.026]	11%	-1.672 <sup>†</sup>	-
Between-subgroup heterogeneity Q-value = 14.18 (p < .001)								
<i>Age</i>	Older	7		0.158	[-0.026; 0.342]	66%	1.681 <sup>†</sup>	17.15***/78%
	Younger	4		0.342	[0.212; 0.473]	34%	5.131***	0.75/0%
Between-subgroup heterogeneity Q-value = 2.56 (p > .050); total pool 11 studies and 3318 participants included								
<i>Gender</i>	Mostly female	7		0.243	[0.093; 0.393]	63%	3.181***	16.03*/ 62.6%
	Mostly male	4		0.163	[-0.106; 0.432]	37%	1.186	13.32**/ 77.5%
Between-subgroup heterogeneity Q-value = 0.26 (p > .050); total 11 studies and 3318 participants included								

Notes: \*\*\* p < .001; \*\* p < .010; \* p < .050; <sup>†</sup>p < .100

## Appendix C. Search Strategy

### Appendix C.1. Search Protocol

Research stage	Research action	Author 1	Author 2	Author 3
<b>Search and working procedure</b>	Creating and validating the research protocol	V	V	V
<b>Search</b>	Creating search algorithm	V		
	Validating search algorithm		V	
<b>Collect</b>	Data collection from multiple platforms using approved algorithm	V		
<b>Selection and exclusion criteria</b>	Suggesting the criteria	V		
	Completing the criteria		V	
	Validating the criteria			V
<b>Filtering</b>	Applying automatic filters	V		
	Manual filtering	V	V	
	Arbitrage on disagreements in manual filtering			V

### Appendix C.2. Search Algorithm

Search categories	Device	Mental outcome	Method
Search keywords	(“mobile app” OR “mobile application”) AND	(depression OR anxiety OR “well-being” OR “quality of life” OR “life satisfaction” OR “mental health”) AND	(“control trial” OR “randomized trial”)

Notes: Platform filters include the language of the publication (English only), type of publication (peer-reviewed journal), and no time limit.

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**Table 1***Results of the Meta-Analysis*

Outcome measures	Subgroups	N <sub>studies</sub>	N <sub>participants</sub>	Hedge's g (SMD)	95% CI	Z (effect size)	Heterogeneity Q-value/ I <sup>2</sup>
<b>Stress</b>	<b>Overall</b>	<b>10</b>	<b>2348</b>	<b>-0.276</b>	<b>[-0.403; -0.149]</b>	<b>-4.261***</b>	<b>18.09*/ 77.4%</b>
Anxiety	Overall	6	1211	-.107	[-0.280; 0.065]	-1.219	9.41*/ 46.9%
<b>Depression</b>	<b>Overall</b>	<b>9</b>	<b>2221</b>	<b>-0.207</b>	<b>[-0.386; -0.028]</b>	<b>-2.270*</b>	<b>30.92***/74.1%</b>
<b>Well-being</b>	<b>Overall</b>	<b>13</b>	<b>3435</b>	<b>0.193</b>	<b>[0.065; 0.320]</b>	<b>2.963**</b>	<b>35.62***/66.3%</b>

Note: \*\*\* p < .001; \*\* p < .010; \* p < .050; <sup>†</sup>p < .100. The results in bold are significant.

**Figure 1**

*The PRISMA Flowchart*

