Journal of Technology in Behavioral Science
https://doi.org/10.1007/s41347-025-00583-2

ORIGINAL RESEARCH ARTICLE

Exploring the Effects of a Smartphone App on Psychological Well-Being in University Students: A Randomized Controlled Trial

Silvia Simbula[1,2] · **Margherita Herold**[1,2]

Received: 6 April 2025 / Revised: 2 August 2025 / Accepted: 2 December 2025

Abstract
Stress management and well-being are increasingly recognized as important due to their documented impact on students' physical and mental health. Traditional mental health support services often face challenges of accessibility, stigma and limited capacity, highlighting the need for innovative interventions. This study aimed to explore the preliminary effects of a smartphone-based intervention designed to reduce stress and promote well-being in university students through exercises based on positive psychology, mindfulness and self-compassion. In addition to evaluating its efficacy, the study also explores user engagement and perceived usability. We developed a controlled randomised trial; 98 students were randomly allocated to intervention ($n=46$) and control ($n=52$) groups. Both groups completed two self-report questionnaires, one before (T0) and one after (T1) the intervention. The intervention group used the app over a three-week period. The intervention did not lead to a significant reduction in perceived stress; however, small-to-moderate effects were found for other outcomes. In particular, the intervention appeared to prevent a deterioration and modestly improve psychological capital dimensions related to hope and resilience (e.g., $\eta_p^2 = 0.095$ for hope; $\eta_p^2 = 0.044$ for resilience). Psychosomatic malaise also decreased in the intervention group ($\eta_p^2 = 0.040$), with an interaction effect close to significance ($p=.051$), but not supported by post hoc comparisons. Life satisfaction improved significantly over time in the intervention group ($\eta_p^2 = 0.052$). User feedback indicated good usability and moderate engagement, although suggestions were made to improve the interactivity, customisation and content diversity of the app. These findings offer preliminary insights into the potential of mobile health (mHealth) interventions to support students' mental health by addressing barriers such as stigma and accessibility. However, given the exploratory nature of this study and its methodological limitations, further research is necessary to determine the actual effectiveness and applicability of such tools in broader and more rigorous contexts.

Keywords M-health · Well-being · Stress management · University students

Introduction

In recent years, the mental health of university students has received increasing attention (Lister et al., 2023), partly because mental health issues among this group represent a significant and widespread public health concern (Barkham et al., 2019). As Lister et al. (2023) have highlighted, there has been an increase in symptoms of anxiety and depression, which has led to greater institutional recognition of the problem by universities and health systems. Students' psychological well-being affects not only their personal and academic success, but also represents an important factor in the development of society as a whole. Mentally healthy students are indeed more likely to contribute positively to economic, social, and cultural life (Liu et al., 2022). Although university students may not face the same adversities as some of their non-student peers, the transition from adolescence to adulthood, combined with academic pressures and lifestyle changes, exposes them to a specific risk of psychological distress (Ferrari et al., 2022). In light of these considerations, the relevance of research related to the importance of developing interventions specifically aimed at university students becomes evident. In this context,

✉ Silvia Simbula
silvia.simbula@unimib.it

[1] Department of Psychology, University of Milano-Bicocca, Piazza dell'Ateneo Nuovo, 1, Milan 20126, Italy

[2] Bicocca Center for Applied Psychology, University of Milano-Bicocca, Piazza dell'Ateneo Nuovo, 1, Milan 20126, Italy

Published online: 18 December 2025

mobile apps play a vital role, as their features enable practitioners to efficiently reach a broad audience, particularly young individuals, while ensuring user anonymity. Moreover, numerous studies have demonstrated the effectiveness of app-based mobile interventions in reducing stress levels and enhancing well-being (Da et al., 2020). However, despite growing interest in digital interventions, few RCTs have specifically evaluated short-form, stress-focused apps tailored for university students (Ferrari et al., 2022; Laure et al., 2024). Therefore, the main aim of this study is to evaluate the preliminary efficacy of *WellBe!*, a brief, self-guided smartphone application grounded in evidence-based practices—namely positive psychology, mindfulness, and self-compassion—in reducing perceived stress and improving psychological well-being among university students. Furthermore, the study aims to evaluate the app's acceptability and user experience, both of which are crucial factors for ensuring successful implementation in real-world settings.

The Importance of Stress Management and Mental Health in University Contexts

The period of postsecondary education is crucial for students as they transition from late adolescence to early adulthood (Morton et al., 2014): this transition represents a critical period during which young people are at increased risk of developing psychological problems. Approximately 62.5% of individuals with major psychiatric disorders experience onset before the age of 25, with the majority of cases beginning in adolescence, around the age of 14.5 on average (Solmi et al., 2022). Although most mental health conditions first appear in adolescence, the challenges of postsecondary education can exacerbate these difficulties and hinder coping mechanisms. Findings from the World Mental Health Surveys—International College Student Project conducted by the World Health Organization indicate that between 20% and 31% of university students meet the criteria for a diagnosable mental disorder (Auerbach et al., 2018). Due to the high prevalence of mental health issues among students, targeted stress management interventions have become increasingly relevant. Specifically, stress management interventions aim to increase awareness of the causes and consequences of stress, develop adaptive coping styles, reduce potentially dangerous factors, and strengthen personal protective factors and levels of resilience (Balducci, 2015). Within stress management interventions, there is a growing interest in practical methods to reduce stress and improve well-being through paths consistent with positive psychology, self-compassion, and mindfulness techniques which aim to increase positive feelings, behaviours, thoughts, and awareness (Baer et al., 2016; Carr et al., 2021). University counseling services are a valuable resource for supporting the mental health and well-being of university students, yet they are not always able to meet the demand (Ponzo et al., 2020). Although universities may offer counseling services, students must still engage in help-seeking behaviours to access these services, and they may hold stigmatizing attitudes towards professional help. Among the barriers to utilizing such services, the literature highlights a lack of time, privacy concerns, stigma, financial constraints, a lack of perceived need for formal help, and a preference for self-management (Ponzo et al., 2020). The COVID-19 pandemic also brought significant changes in the provision of mental health care, as many non-essential health services were forced to shut down. However, in many cases, efforts were made to mitigate this disruption through services that employed digital technologies (WHO, 2022).

Digital Interventions and their Potential for Reducing Stress and Improving well-being

Considering the numerous barriers reported with traditional approaches and the growing influence of technology in various aspects of daily life in the twenty-first century (Howells et al., 2016), in these years we have also assisted in a paradigm shift from traditional, predominantly face-to-face interventions to interventions mediated by technology. Digital interventions to address well-being have developed rapidly and have been considered an innovation that promises better access, acceptance, and greater convenience than traditional face-to-face interventions (Lattie et al., 2019). The transition described above has given rise to a new domain known as *mHealth*. The World Health Organization defines mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" (World Health Organization, 2011, p. 6). Such practices are promising tools for promoting well-being since they are accessible to everyone, anytime and anywhere. These tools can help overcome barriers such as stigma, time constraints and unfamiliarity with the health care system, while encouraging positive health behaviour change (Oskari et al., 2021; WHO Executive Board, 2018). Emerging studies have investigated the effectiveness of smartphone-based interventions in improving mental health outcomes (Valentine et al., 2025). Generally speaking, previous research gives hope for the future of these apps, highlighting improvements in awareness and self-compassion, reduction in perceived stress and anxiety, improvement in mood, as well as in general health, increase in well-being, and development in skills coping (Schulte-Frankenfeld et al., 2022; Ponzo et al., 2020; Kajitani et al., 2020). Finally, smartphone-based interventions may be particularly suitable for university students as research indicates that the

preference for self-help via the internet is higher among young people (Batterham et al., 2017).

User Engagement and Usability

Other important issues to consider when developing smartphone-based interventions are user engagement and usability. User engagement is the quality of the user's experience characterized by the depth of their investment when interacting with a digital system (O' Brien et al., 2018), while usability refers to the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (International Organization for Standardization, 1998). The assessment of usability aims to understand how easy an application is to use and is an essential part of system development; in recent years, the focus of usability evaluation has expanded from usability engineering to a broader assessment of the user experience, including emotions, values, and motivations (Inal et al., 2020). Both these aspects have been identified as key factors influencing the success of using a smartphone application (Lemon et al., 2020). Indeed, a satisfying experience is crucial for maintaining user motivation over time, especially in m-Health applications (Eaton et al., 2024). Furthermore, some studies report that users who are more engaged in app-based interventions are more likely to experience health improvements compared to their less engaged counterparts (Bidargaddi et al., 2018). Despite this, both these aspects are under-researched (Lemon et al., 2020).

Objectives and Hypotheses

Given the rising prevalence of mental health challenges such as stress, anxiety, and depression, especially among students and professionals, there is a growing need for scalable interventions. As stated before, mobile health (mHealth) apps represent a viable solution (Lahtinen et al., 2023; Demirel et al., 2024). Indeed, growing evidence highlights both the benefits and limitations of digital interventions in promoting mental health. Specifically, evidence from Demirel et al. (2024) showed that app use can significantly improve coping self-efficacy and reduce burnout symptoms. Similarly, Lappalainen et al. (2024) found that even brief online interventions can improve life satisfaction, particularly in individuals with initially low well-being. In line with these findings, Lahtinen and colleagues (2023) found that a mindfulness app led to small yet significant reductions in stress and depression in a university population. Taken together, these studies suggest that app interventions can play a role in alleviating stress and emotional difficulties, potentially reducing psychosomatic malaise (Demirel et al., 2024).

Although several digital applications for mental health support are now available (e.g. Calm, Wildflowers, Headspace, Smiling Mind), the empirical evidence supporting their efficacy among university students remains limited (Choudhury et al., 2023). Moreover, their effectiveness is still uncertain and poorly documented in peer-reviewed literature (Herold et al., 2024). Indeed, most studies tend to focus on web-based interventions or clinical protocols, while randomized controlled trials evaluating brief, self-guided, and resource-enhancing app-based interventions remain scarce (Ferrari et al., 2022). This gap underscores the need for further research specifically targeted to the university population.

To address this gap, we developed and tested *WellBe!*, a brief, self-guided smartphone application grounded in evidence-based practices, namely positive psychology, mindfulness, and self-compassion, designed to manage stress and promote psychological well-being among university students. *WellBe!* aims to fill a gap in digital mental health support by offering a low-effort, scalable intervention specifically tailored to the needs and context of university students.

Starting from these considerations, the following hypotheses were developed:

Hypothesis 1 *(H1)*. Participants using *WellBe!* will show a greater reduction in perceived stress over time than those in the control group.

Hypothesis 2 *(H2)*. Participants using *WellBe!* will show a greater increase in psychological capital and its subscales—optimism (H2a), hope (H2b), resilience (H2c), and self-efficacy (H2d)—over time than those in the control group.

Hypothesis 3 *(H3)*. Participants using *WellBe!* will show a greater increase in life satisfaction over time than those in the control group.

Hypothesis 4 *(H4)*. Participants using *WellBe!* will show a greater reduction in psychosomatic malaise over time than those in the control group.

Despite the relevance of evaluating its effectiveness, planning and evaluating a digital intervention cannot ignore Usability and engagement are central to the efficacy of any digital intervention; studies by Kowalski and colleagues (2024) and Maqbool and Herold (2024) highlight the importance of user experience and engagement in sustaining app-based behavioural changes. Therefore, the second aim of the study was to explore participants' perceptions of the *Wellbe!* app. Specifically, we formulated two exploratory objectives regarding the user experience:

Objective 1 (O1): To explore whether WellBe! is positively evaluated in terms of usability.

Objective 2 (O2): To explore whether WellBe! is positively evaluated in terms of user engagement.

Materials and methods

Research Design

A randomised controlled trial consisting of two conditions, an intervention group and a waitlist control group, has been conducted to test the hypotheses. In the intervention group, participants received a three-week mobile app intervention, and they were asked to complete pre- and post-intervention questionnaires (T0 and T1). In contrast, participants in the waitlist control condition were just asked to complete the two questionnaires at T0 and T1.

Procedure

Participant recruitment began in February 2023 and finished in November 2023. All participants in both the intervention and control groups completed the study during class periods and outside exam periods. This ensured that exposure to academic stressors was relatively consistent across participants and conditions.

Participants were eligible if they were enrolled in any degree program officially recognized by the Italian university system, regardless of faculty or discipline. An additional inclusion criterion was the possession of an Android smartphone, as *WellBe!* was developed exclusively for the Android operating system and was not yet available for iOS devices at the time of the study. University students were invited to participate in the research via posts published on social media platforms (e.g. Instagram, Facebook, and WhatsApp). Interested students were asked to leave their email address via a Google Form so they could be contacted with more information about the project. A representation of the participation flowchart is presented in Fig. 1. Those who provided a valid email address ($N = 194$) were subsequently contacted by the research team. Participants received a detailed information sheet outlining the study objectives, procedures, data protection policies and their rights. They were only allowed to access the T0 questionnaire after reading this information and providing informed consent to participate and to

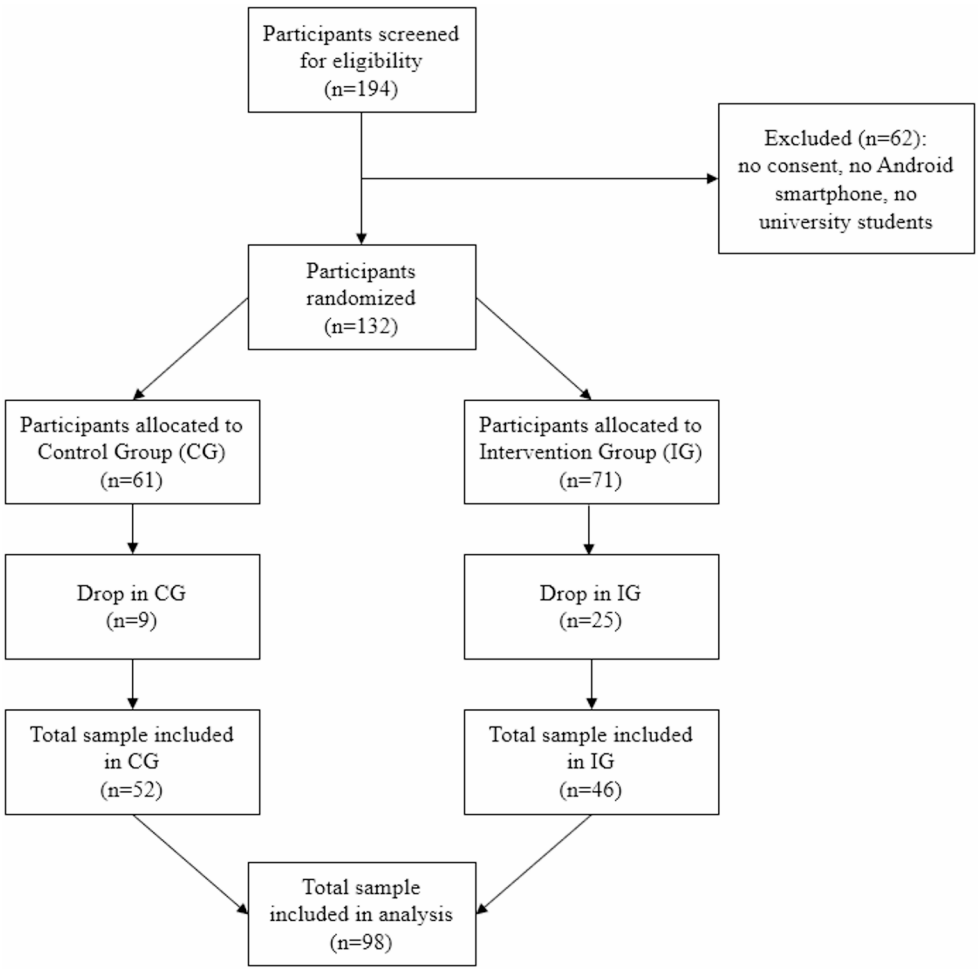

Fig. 1 Study participation flowchart

the processing of their data. Therefore, informed consent was obtained from all individual participants included in the study. To complete the T0 questionnaire, participants were asked to create their alphanumeric identification code to guarantee anonymity. A total of 132 valid questionnaires were returned (response rate = 68%) and used for randomization. This was conducted using the random number generator function in SPSS, to ensure that each participant had an equal and unbiased chance of being assigned to either the intervention or control group. Participants discovered their group assignment by entering their alphanumeric ID into the Qualtrics platform. Those assigned to the intervention group could then download the *WellBe!* app via the link that appeared after entering their ID. Participants assigned to the intervention group were asked to participate in a 3-week smartphone-based intervention in which they had to use the *WellBe!* app. The intervention consisted of a series of exercises, to be carried out from Monday to Friday, aimed at promoting participant's personal resources that are useful for managing stress and improving level of well-being. Access to the app occurred using the identification code created when filling out the first questionnaire (T0). After logging in, and choosing a nickname and avatar, participants should assess their well-being through a quick questionnaire, which was offered every day and allowed participants to monitor their daily state of well-being. Every day, from Monday to Friday, a different exercise was proposed for fifteen days. It was possible to perform only one exercise per day and only the exercise scheduled for that day. The exercises presented were short and easy to do. At the end of the intervention (T1), all participants, both in the intervention and control groups, were asked to complete a second questionnaire (T1). The total number of valid questionnaires included in the analysis was 98 (46 participants in the intervention group and 52 participants in the control group). There were no rewards or incentives for participation in the study; this allowed no interference in investigating user engagement in the prolonged use of the app. This study was conducted in accordance with the principles of the Declaration of Helsinki and the Convention on Human Rights and Biomedicine (Oviedo Convention). Moreover, it was considered minimal-risk (as defined by the National Research Council of the Academies of Science) and, as such, was positively assessed by the local commission of the Psychology Department of the University of Milano-Bicocca for minimal-risk studies (RM-2021-434). The data that support the findings of this study are available from the authors upon reasonable request.

Participants

Overall, 98 participants (74%; intervention: $n = 46$; control: $n = 52$) completed both the pre (T0) and the post-test (T1) assessments, and their results were included in the analysis. Participants' age ranged from 18 to 32. No extreme outliers were detected, and age was evenly distributed across groups (Mean age = 22.9, $SD = 3.05$; intervention: $M = 22.9$, $SD = 2.33$; control: $M = 22.9$, $SD = 3.59$). Of them, 80% were female (intervention: $n = 37$; control: $n = 41$), and only 19% were male (intervention: $n = 9$, control: $n = 11$). 42% of the students attended bachelor's ($n = 41$; intervention: $n = 19$; control: $n = 22$) while 58% attended master's ($n = 57$; intervention $n = 27$; control $n = 30$) degrees. Moreover, only 19% of the participants ($n = 19$; intervention $n = 8$; control $n = 11$) declared that they had already used a smartphone app to manage stress or promote well-being. A Chi-square and t-test analysis was run to exclude differences between students who completed all the surveys and those who dropped out after the baseline. Results indicated that there were no differences based on gender ($\chi 2$ ($N = 132$) = 1.06, $p = .588$) and age ($t(96) = -0.046$, $p = .964$), while we found a significant difference based on degree attended ($\chi 2$ ($N = 132$) = 10.1, $p = .001$). T-test analysis on constructs of interest (perceived stress, psychosomatic malaise, psychological capital, and life satisfaction) showed no statistically significant differences between those who completed all the surveys and those who dropped out after the baseline.

Smartphone Application

WellBe! is a smartphone application developed for Android devices by Bicapp, the mobile and wearable technology research and development center of the University of Milano-Bicocca. *WellBe!* is based on positive psychology, mindfulness, and self-compassion principles. It aims to give university students suggestions and instruments to manage stress and promote their well-being. The intervention consisted of using this app for 15 days, from Monday to Friday, for 3 weeks. The app offered 15 exercises, and every day, excluding Saturday and Sunday, an exercise lasting between 5 and 10 min was made available to participants. Each exercise included content related to training and techniques for promoting resources and developing coping strategies for managing stress and ameliorate well-being. Each week the following exercises were proposed: an exercise on good intentions to allow participants to establish achievable objectives during the week, a mindfulness exercise whose content varied over the three weeks, an exercise relating to gratitude, an exercise which suggests good practice for stress coping, and finally an exercise that allowed the promotion of well-being through physical exercise. This logic was chosen because the objective was to give participants the opportunity, by repeating the same types of exercises despite the slightly different content, to familiarize themselves with the exercises and internalize the related principles. Exercises

were borrowed and adapted from intervention protocols such as mindfulness, positive psychology and national guidelines for promoting well-being at work. At the end of each exercise, they were asked to evaluate the usefulness of this exercise in improving their well-being. In addition, the app allowed participants to monitor their well-being through a daily questionnaire and the relative dashboard to gain a badge for each exercise completed and to listen to podcasts related to self-compassion techniques. Participants could only get feedback from the app through a dashboard that showed their results, a daily well-being questionnaire, and badges obtained after completing daily exercises. Overall, participants were required to use the app for approximately 10 min per day. Participation and subsequent access to the app were encouraged every morning, from Monday to Friday, by sending a daily notification. Data collection was conducted through two modalities: primary and secondary outcome measures were collected via Qualtrics links sent directly to participants, while in-app data -including daily well-being responses, and exercise evaluations- were captured via embedded iframes that transmitted information directly to the Qualtrics platform.

Measures

Primary Assessment

At baseline (T0) and after (T1) the intervention, participants were administered the Italian versions of the following self-assessment scales.

Perceived Stress Scale (Mondo et al., 2021), a 5-point Likert scale (from 0="*never*" to 4="*very often*"), was selected to measure perceived stress. A sample item is: "*In the last month*, *how often have you been able to control irritations in your life*?". The scale reliability, calculated using Cronbach's Alpha, is 0.86 at T0 and 0.87 at T1.

General Health Questionnaire-12 (Fraccaroli & Schadee, 1993), was used to measure the perception of psychosomatic malaise through a 4-point Likert scale (from 0="*better than usual/more so than usual*" to 3="*much less than usual/much less useful*" for positively worded items and 0="*not at all*" to 3="*much more than usual*" for negatively worded items). A sample for positively worded items is: "*felt that you are playing a useful part in things?*" and for negatively worded items "*been feeling unhappy and depressed?*". We used a modified scoring method, called Goodchild and Duncan-Jones's method (CGHQ), as it demonstrated superior construct validity and greater sensitivity with respect to the traditional scoring method of GHQ (Whaley et al., 2005). On the basis of this method, the scoring of negative items is 0, 1,1, 1. The scoring of positive items is 0, 0, 1, 1. The scale reliability, calculated using Cronbach's Alpha, is 0.83 at T0 and 0.83 at T1.

Psychological Capital Questionnaire – Short Version (Avey et al., 2011) was selected to measure psychological capital. It comprises four dimensions: hope, self-efficacy, optimism, and resilience. As there is no official Italian validation of the short version, we selected the corresponding 12 items from the full Italian version by Alessandri et al. (2015). This is a faithful translation of the original PCQ, and the item wording has been adapted for the context of university students. Moreover, in line with previous studies (Djourova et al., 2019) aiming to maintain a balanced representation of the four core factors, we added one additional item to the optimism dimension (i.e., *When things are uncertain in my academic path*, *I usually expect the best*) to ensure that each dimension was assessed with an equal number of items. All dimensions were addressed through a 6-point Likert scale (from 1="*completely disagree*" to 6="*completely agree*"). A sample item is: "*If I were to find myself in difficulty in my studies*, *I could think of many ways to get out of it*". The overall scale reliability, measured using Cronbach's Alpha, is 0.91 at T0 and 0.92 at T1. Specifically, the reliability of the hope subscale is 0.86 at both T0 and T1; for the resilience subscale, it is 0.71 at T0 and 0.74 at T1; for the optimism subscale, it is 0.84 at T0 and 0.87 at T1; and for the self-efficacy subscale, it is 0.82 at T0 and 0.80 at T1.

To measure the perception of life satisfaction, the Satisfaction With Life Scale (Di Fabio & Palazzeschi, 2012) was used. The instrument is a 7-point Likert scale (from 1="*totally disagree*" to 7="*totally agree*"). A sample item is "*In most ways my life is close to my ideal*". The scale reliability, calculated using Cronbach's Alpha, is 0.81 at T0 and 0.86 at T1.

Secondary Assessment

At the end of the intervention (T1) were also administered the 10-item System Usability Scale, SUS (Brooke, 1996), which was used to measure users' usability (Cronbach's Alpha = 0.71), and the 12-item User Engagement Scale (UES)-Short form (O'Brien et al., 2018), which was used to assess users' engagement (Cronbach's Alpha = 0.87). Both are 4-point Likert scales ranging from 1="*strongly disagree*" to 5="*strongly agree*". However, there is still no gold standard for evaluating Usability and User Engagement in mental health app-based interventions (Lemon et al., 2020). For this reason, qualitative methods were used to verify these dimensions in addition to quantitative methods. Participants in the intervention condition were asked to express their feedback on usability and user engagement, scoring each exercise during the intervention period and

giving general qualitative feedback in the post-intervention assessment.

Statistical Analysis

Statistical analyses were conducted using SPSS 29. Descriptive analyses were performed, including mean and standard deviation. A mixed-design ANOVA was conducted to examine changes in the dependent variables over time and across groups. The within-subjects factor was time (T0 and T1), and the between-subjects factor was condition (intervention vs. control). This enabled us to test the main effects, as well as the interaction between time and condition, which indicates whether changes over time differed between the two groups. An alpha level of 0.05 was chosen to indicate statistical significance. Partial Eta-squared (η_p^2) was used to measure effect sizes: 0.01 indicates a small effect size, 0.09 indicates a medium effect size, and 0.25 means a large effect size (Ansley et al., 2021). Where significant interaction effects emerged, post hoc comparisons were conducted with Bonferroni correction to control for Type I error. Finally, the perceived usability and user engagement relating to the *Wellbe!* app were calculated using data collected at T1.

Results

Table 1 presents the means and standard deviations of health and psychological outcomes, as well as personal resources, providing an overview of the key variables analyzed in the study.

Table 1 Means and standard deviations of health and psychological outcomes and personal resources

Measure	Control Group (n=52) Mean (SD)	Intervention Group (n=46) Mean (SD)	Overall Sample (n=98) Mean (SD)
Perceived Stress T0	21.94 (6.81)	22.61 (7.08)	22.26 (6.91)
Perceived Stress T1	21.24 (6.30)	20.39 (6.48)	20.83 (6.37)
Psychological Capital T0	4.00 (0.80)	3.85 (0.90)	3.92 (0.85)
Psychological Capital T1	3.91 (0.80)	4.05 (0.83)	3.97 (0.81)
Optimism T0	3.61 (1.06)	3.43 (1.14)	3.52 (1.09)
Optimism T1	3.72 (0.98)	3.72 (1.06)	3.72 (1.01)
Hope T0	4.11 (0.86)	3.85 (1.15)	3.98 (1.00)
Hope T1	3.88 (0.89)	4.03 (0.96)	3.95 (0.92)
Resilience T0	4.31 (0.93)	4.11 (0.81)	4.21 (0.87)
Resilience T1	4.22 (0.93)	4.29 (0.79)	4.25 (0.86)
Self-efficacy T0	3.98 (1.13)	4.02 (1.05)	4.00 (1.08)
Self-efficacy T1	3.91 (1.09)	4.15 (0.97)	4.03 (1.03)
Satisfaction with Life T0	4.46 (1.18)	4.09 (1.24)	4.28 (1.18)
Satisfaction with Life T1	4.42 (1.18)	4.33 (1.34)	4.37 (1.25)
Psychosomatic Malaise T0	0.45 (0.26)	0.51 (0.25)	0.48 (0.26)
Psychosomatic Malaise T1	0.48 (0.26)	0.45 (0.27)	0.47 (0.26)

Primary Aim

Perceived Stress (H1)

On the basis of the hypothesis H1, students in the intervention group were expected to report a greater reduction in levels of perceived stress after the intervention. The analysis revealed a significant main effect of time on stress levels, $F(1,94)=5.49$; $p=.021$; $\eta_p^2=0.055$, indicating that stress levels changed significantly from T0 to T1 in the overall sample. However, the interaction effect between time and condition was not significant ($F(1,94)=1.48$; $p=.23$, $\eta_p^2=0.016$), suggesting that the change in stress levels over time did not differ between the intervention group and the control group. Therefore, Hypothesis H1 was not confirmed.

Psychological Capital (H2)

According to hypothesis H2, students in the intervention group should report a greater increase in Psychological Capital after the intervention. Coherently, a statistically significant interaction emerged between time and experimental group ($F(1,93)=8.56$, $p=.004$, $\eta_p^2=0.084$), indicating that the change in Psychological Capital differed between the control and intervention groups (Fig. 2). Post hoc pairwise comparisons showed that only participants in the intervention group reported a significant increase in Psychological Capital from pre- ($M=3.85$, $SD=0.90$) to post-intervention ($M=4.05$, $SD=0.83$; M_{diff} = -0.196, $p=.006$), whereas no significant change was observed in the control group (M_{diff} = 0.086, $p=.201$).

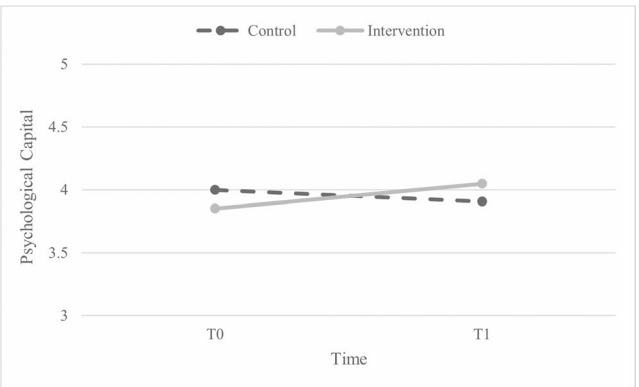

Fig. 2 Difference in psychological capital level by condition over time

Specifically, to understand which dimensions of psychological capital were responsible for this result, we conducted ANOVAs for each of the dimensions considered.

The results revealed a statistically significant interaction between time and group regarding the dimensions of hope ($F(1,94)=9.85$, $p=.002$, $\eta_p^2=0.095$) and resilience ($F(1,94)=4.30$, $p=.041$, $\eta_p^2=0.044$). For hope (Figure 3), the control group showed a significant reduction from T0 to T1 ($M_{diff}=0.235$, $p=.012$), while the intervention group maintained stable hope levels ($M_{diff}=-0.18$, $p=.063$). For resilience (Figure 4), the intervention group showed a non-significant trend toward improvement from T0 to T1 ($M_{diff}=-0.181$, $p=.061$), whereas the control group remained stable ($M_{diff}=0.093$, $p=.311$). In contrast, no statistically significant differences were found in Optimism ($F(1,93)=1.60$; $p=.210$, $\eta_p^2=0.017$) and Self-efficacy ($F(1,94)=1.71$, $p=.19$, $\eta_p^2=0.018$) levels between the two groups over time.

Therefore, only Hypotheses H2b and H2c were partially confirmed.

Satisfaction with Life (H3)

Regarding the hypothesis that participants in the smartphone-based intervention group would show improvements in levels of life satisfaction compared to those in the control group, the results revealed a significant interaction between time and group ($F(1,94)=5.17$, $p=.025$, $\eta_p^2=0.052$), indicating that changes in life satisfaction over time differed between the intervention and control groups (see Fig. 5). Post-hoc analyses showed that life satisfaction significantly increased from pre- to post-intervention in the intervention group ($M_{diff}=0.24$, $p=.009$), whereas no significant change was observed in the control group ($M_{diff}=0.04$, $p=.616$). However, there were no significant differences between groups at either pre- or post-intervention. Therefore, Hypothesis H3 was partially confirmed.

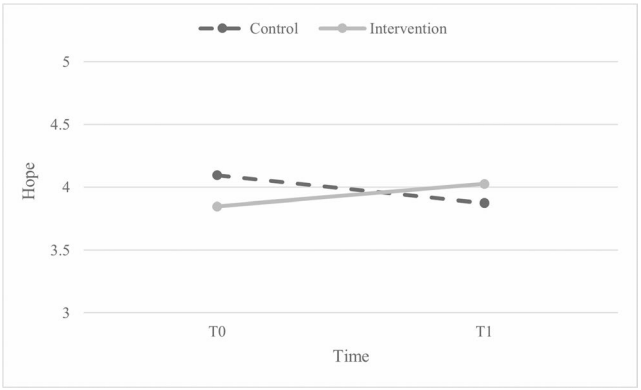

Fig. 3 Difference in hope by condition over time

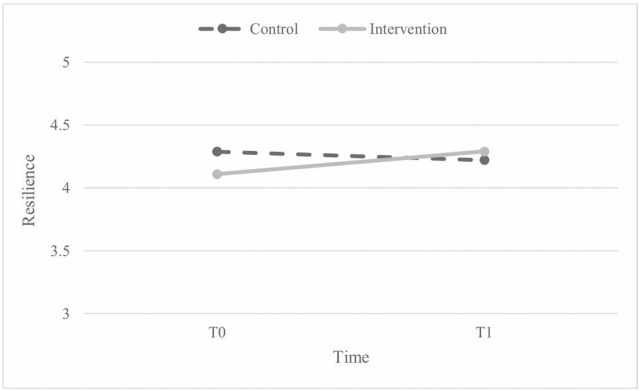

Fig. 4 Difference in resilience by condition over time

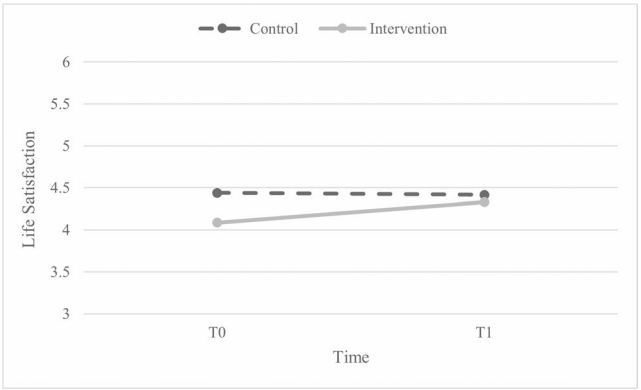

Fig. 5 Difference in life satisfaction by condition over time

Psychosomatic Malaise (H4)

Regarding the hypothesis according to which students in the intervention group would have reported a greater reduction in levels of psychosomatic distress after the intervention, the interaction between time and experimental group was only marginally significant ($F(1,94)=3.92$, $p=.051$, $\eta_p^2=0.040$), indicating a trend towards differences over time in the levels of psychosomatic malaise between the intervention group and the control group. However, neither the within-group nor the between-group pairwise comparisons reached statistical significance. Although participants in the smartphone-based intervention group showed a tendency towards reduced levels of psychosomatic malaise after the intervention compared to participants in the control group (see Fig. 6), this result did not reach conventional levels of statistical significance. Therefore, Hypothesis H4 was only partially supported.

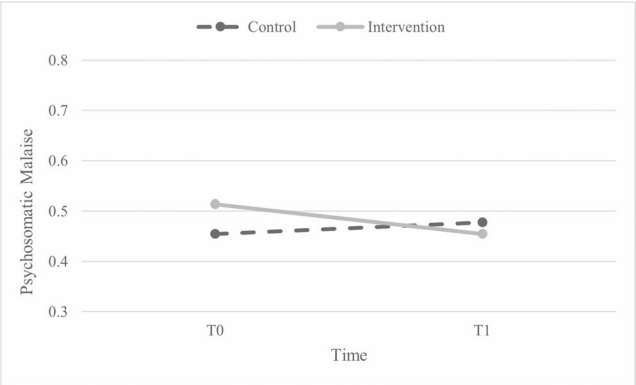

Fig. 6 Difference in psychosomatic malaise by condition over time

Secondary Aim

Usability (O1)

An average usability score of 79.6 (SD = 11.3) emerged. Based on previous research, a SUS score above 68 would be considered above average (Brooke, 1986). A SUS score of 79 falls at around the 85th percentile, indicating that this score would result in the beginning of the A range, that is to say, the top 15% of all applications tested (Ferreira et al., 2018).

User Engagement (O2)

WellBe! user engagement got an average score of 2.9 on 5 (SD = 0.58) on the UES-SF scale (O'Brien et al., 2018). Notably, the subscale score related to endurability, novelty and involvement feeling present the higher score (M = 3.22; SD = 0.87).

Users' Feedback

During the interventions, participants were asked to rate their satisfaction at the end of each daily activity. Exercises got an average evaluation of 3.67 out of 5 (SD = 0.97). The most appreciated activity (M = 4.32; SD = 0.56) was a positive psychology exercise that promoted coping strategies, while the worst-performing exercise was the third repetition of an activity aimed at stimulating well-being through physical exercise (M = 3.26; SD = 0.98). In addition, at the end of the 3-week intervention, intervention group participants were asked for feedback about (1) issues occurring during the app usage, (2) features or contents particularly appreciated or, on the contrary, which were considered useless or unpleasant, (3) features to change or add, or contents to integrate. Concerning (1), participants reported three main issues: (a) limitations with exercises, including the inability to complete more than one activity per day or to recover from missed activities; (b) podcasts lacking stop, rewind or duration features; and (c) in some cases, notification issues. Concerning the second aspect we mentioned above (2), there was a significant heterogeneity in what participants appreciated or not. Contents were generally appreciated with differences within exercises. Also, podcasts for which participants reported issues regarding stop and rewind were considered generally pleasant. Activities repetition over several weeks and the lack of exercise monitoring were not always appreciated, as well as how the well-being was monitored. The badges were not particularly appreciated since they were not sufficiently linked with the activity. Finally, participants shared their thoughts about possible new features (3). The leading suggestions were related to activities and the possibility of adding new ones, giving a chance to have more than one exercise in a day and recovering the "lost" ones, diversifying between pre-determined activities and training to do in "case of needs". In addition, several participants deemed that the app should be more interactive with more practical activities and the possibility of tracking their results in an in-app diary. The theme of notification was still present, and participants suggested the possibility of setting up personalized notifications, such as one specifically to remind activities, daily questionnaires, or exercise evaluations. Lastly, other improvements were proposed, such as more personalized activity badges, questionnaires to track daily mood, and, in general, a more attractive design.

Discussion

The primary aim of the study was to explore the relationship between m-health intervention and perceptions of stress, psychosomatic malaise, personal resources, and life satisfaction. Regarding the first hypothesis (H1), contrary to what was presented in previous studies (Harrer et al., 2018; Huberty et al., 2019; Schulte-Frankenfeld et al., 2022), it was not possible to confirm a significant difference in perceived stress levels based on the intervention's participation. Indeed, although both groups showed a reduction in stress levels over time, the interaction effect between time and condition was not statistically significant, and the change was comparable across groups. These results could be explained due to the limited duration of the study. As suggested in a paper by Champion and colleagues (2018), a longer duration of the intervention may lead to a more significant reduction in perceived stress in students belonging to the intervention group.

Concerning the second hypothesis (H2), results showed that *WellBe!* was able to promote improvements in some—but not all—dimensions of Psychological Capital. Specifically, a significant time x group interaction was observed

for both hope and resilience. For hope, participants in the control group showed a statistically significant decrease over time, while those in the intervention group maintained stable levels. For resilience, the intervention group showed a non-significant trend toward improvement, whereas the control group remained stable. Although the intervention did not lead to statistically significant increases in these personal resources, the pattern suggests a potential protective effect, as it appeared to buffer against the decline observed in the control group. These findings align with previous studies (Flett et al., 2019; Truhlar et al., 2022) that have found modest effects of brief digital interventions on psychological capital components. The other dimensions of psychological capital did not show a similar pattern of significance. For example, the optimism dimension appeared to increase over time, but this change was not related to the study condition. Consistent with the findings of Harrer et al. (2018), no statistically significant differences emerged over time or between the two conditions for the self-efficacy dimension. Once again, it is possible that the duration of the intervention was not sufficient to produce significantly different effects between the two groups. This study contributes to the growing body of research on smartphone-based interventions aimed at enhancing psychological capital in university students. Given that psychological capital is not only negatively correlated with perceived stress and psychological distress, but also enhances performance, supports learning, and promotes engagement, strengthening this resource represents an essential factor in promoting student success and well-being (Sun et al., 2022).

Concerning the third hypothesis (H3) relating to the construct of life satisfaction, a statistically significant interaction emerged between time and group. Specifically, participants in the intervention group showed an increase in life satisfaction over time, while those in the control group experienced a slight decrease. The effect size, however, was in the small-to-medium range, and post-hoc comparisons indicated that the increase in life satisfaction was significant only for the intervention group. These results partially diverge from previous literature (Howells et al., 2016), in which no significant effects on life satisfaction were found with a similarly limited intervention duration. Further research with larger samples and extended follow-up is recommended to confirm these preliminary findings.

As for the fourth hypothesis (H4), related to psychosomatic malaise, the analysis showed a time x group interaction approaching statistical significance (p=.051) with a small effect size. In the intervention group, levels of psychosomatic malaise decreased over time, while they increased slightly in the control group. However, post-hoc comparisons did not reach statistical significance, suggesting that the hypothesis is only partially supported. These findings are only partially consistent with Kajitani et al. (2020), who observed improvements in GHQ-12 after a two-week smartphone-based intervention. Given the borderline significance and the absence of significant post-hoc results, the beneficial effect of *WellBe!* on psychosomatic distress should be interpreted with caution and further examined in future studies.

The secondary aim of this work was mainly related to users' feedback about the use of technology and was aimed only at intervention group participants. Different from the review of Haan and colleagues (2019), which reported that 51% of studies on digital interventions for university students presented no satisfactory usability results, *WellBe!* usability (O1) obtained a positive score and acceptable results in this research, and it was considered above average (Brooke, 1986). Usability tells us about the ease with which users can use a technological device to achieve a certain goal (Coursaris et al., 2011). Based on these findings and in line with the study by Zapata and colleagues (2015), it can be stated that usability evaluation is a critical component in establishing the feasibility, effectiveness, and generalizability of a health-related digital intervention (Lattie et al., 2019). Despite this, the participants found the well-being monitoring graph not intuitive and the podcast section not very usable, although the general idea about this content was appreciated.

In relation to the user experience objective (O2), users overall perceived the *WellBe!* app as positive with respect to user experience. Notably, the subscale endurability, novelty, and involvement feeling presented a mean score higher than the general scale mean score. The user engagement score allows us to understand how involved the user felt in using the app (O' Brien et al., 2018). Improving the usability of the app and user-centered design is fundamental, as they are two dimensions that can lead to low engagement, poor efficiency in achieving objectives and rejection of the tool (Torous et al., 2018).

The participants suggested integrating the possibility of tracking habits and activities carried out directly within the app to have an account of what was carried out. Further suggestions included adding more than one exercise per day, allowing users to reopen an exercise they had already completed or to make it up if they had missed it the previous day. Furthermore, it was proposed that the app's customisation be increased through activities, notifications, summary graphs of the daily mood, and rewards for activities already carried out. Finally, it was suggested that more attention be paid to making the design more attractive.

Conclusions

The present study developed a smartphone-based intervention for reducing stress and promoting personal resources in university students, intending to verify its effectiveness and study users' perception of usability and user engagement. While the findings are modest, they suggest that digital interventions may represent a useful complement to traditional psychological support, particularly by addressing barriers such as stigma, accessibility, and reluctance to seek help. What emerged could encourage universities to integrate traditional interventions with innovative mental health apps. Such a combined approach could enhance the management of students' mental health, offering accessible and cost-effective support options. Moreover, the limited effects observed highlight the importance of publishing studies with null or modest findings, which contribute to scientific transparency and help counter publication bias (Franco et al., 2014). Reporting such outcomes is crucial for building a cumulative and realistic understanding of intervention efficacy, especially in early-stage or exploratory research. Therefore, the present study contributes to the expansion of the existing literature on the effectiveness of smartphone-based interventions for promoting the well-being of university students and encourages further development of empirical evidence relating to smartphone-based interventions with the aim of improving the psychological well-being of university students, considered a vulnerable population (Ferrari et al., 2022).

Limits and Suggestions for Future Research

The study has some limitations from which we can draw inspiration for future research. First, although it is a randomized controlled trial, the results may not be generalizable to all university students due to the small final sample size. Connected to this, the final sample was predominantly composed of women (80%), suggesting a possible gender bias. This phenomenon has already been documented in the literature and may reflect a greater willingness on the part of female students to participate in research on topics related to psychological well-being and stress management (e.g. Groot et al., 2023). Furthermore, since it was a voluntary recruitment, the sample could include students particularly interested in the topic of stress, or who were going through a critical period. For these reasons, future research should seek to increase the sample size and balance the gender distribution. Furthermore, some participants faced technical problems such as not receiving notifications and the impossibility of carrying out some exercises; these could have influenced the constant carrying out of the intervention and, consequently, its effectiveness. A further limit concerns the short duration of the intervention, since, based on the reference literature, traditional interventions have a duration that varies from 8 to 12 weeks and some researchers suggest that improvements in stress levels require a minimum of 4 weeks (Baer et al., 2016). It is important to note that the small effect sizes observed in our study further reflect these limitations. Although some statistically significant improvements were detected, the magnitude of the effects was modest, suggesting a limited practical impact. In this regard, a recent meta-analysis by Ferrari et al. (2022) found that digital interventions had small-to-medium overall effects on psychological outcomes such as stress, depression, and anxiety. Therefore, while the results are encouraging as a preliminary signal of potential efficacy, they must be interpreted with caution, and future studies should aim to optimize both the delivery format and duration to enhance impact, as well as provide human support. As Mohr et al. (2011) suggested, incorporating human support elements can enhance user satisfaction and the effectiveness of digital interventions. Similarly, fostering a sense of community can encourage greater engagement and help users feel less isolated.

Furthermore, the stability and durability of the results found in the T1 post-intervention questionnaire were not tested using a follow-up questionnaire. It is also important to note that, given that stress levels can fluctuate due to acute life events, the use of only pre- and post-intervention assessments may have overlooked transient effects. Future research should investigate the long-term effects of the *WellBe!* smartphone app and include multiple follow-up assessments. Moreover, our sample had relatively low levels of stress and high levels of pre-existing resources. This suggests that the participants were not representative of individuals with significant psychological needs, as they did not demonstrate a strong need for the intervention. Consequently, this may have limited the ability to observe the full potential effectiveness of the intervention, as it was tested on a group with an inherently lower susceptibility to stress-related challenges. Future research should aim to include participants with a wider range of stress levels and psychological needs to better assess the impact of the intervention. Another important limitation to highlight is the limited accessibility of the application, in fact, *WellBe!* is a smartphone application developed only for Android devices. This means that a relevant part of smartphone users couldn't participate in the study (i.e. iOS users), and it could be possible that Android users have different characteristics from users of other app stores. Future research should be more inclusive and involve more generally all the different users of app stores. Finally, while the waitlist control condition is still commonly employed in the initial evaluation of interventions (Groot et al., 2023), incorporating an active control

group is a valuable approach for future research (Laws et al., 2022). While participants were only generally informed that the study evaluated changes in stress and well-being, they may still have experienced expectancy effects due to their awareness of receiving (or not receiving) the app. An active control group would enable the effectiveness of the intervention to be measured and could support the legitimacy of the approach adopted in this study.

Practical Implications and Future Directions

While our findings should be interpreted with caution, due to small effect sizes, this study can potentially contribute to the literature relating to smartphone-based interventions and their effectiveness in managing stress and promoting well-being in the university student population in several ways. Firstly, despite the short duration of the intervention and limitations previously pointed out, preliminary results emerged regarding psychological capital and satisfaction with life, along with a tendency toward reduced psychosomatic malaise. Therefore Wellbe! could be considered as a promising low-cost option, potentially useful when integrated within broader student support programs. Secondly, the study confirms the importance of evaluating the app's perceived usability and user engagement as they can provide important elements for improving the app itself and its ease of use; these are, therefore, important elements to include in the development of apps for managing the psychophysical health of students. As a consequence, our results could represent a starting point for developing apps that can be used by support services in stress management and promotion of well-being in the universities.

Author contributions Both authors, Silvia Simbula and Margherita Herold, contributed to all parts of the study including the study design, material preparation, data collection, and analysis. Both authors worked on all versions of the manuscript. The final version of the manuscript is completed, read, and approved by both authors.

Funding Open access funding provided by Università degli Studi di Milano - Bicocca within the CRUI-CARE Agreement. Project developed within the MUSA – Multilayered Urban Sustainability Action – project, funded by the European Union – NextGenerationEU, under the National Recovery and Resilience Plan (NRRP) Mission 4 Component 2 Investment Line 1.5: Strengthening of research structures and creation of R&D "innovation ecosystems", set up of "territorial leaders in R&D".

Data Availability The data that support the findings of this study are available from the authors upon reasonable request.

Declarations

Ethical approval This study was conducted in accordance with the principles of the Declaration of Helsinki and the Convention on Human Rights and Biomedicine (Oviedo Convention). Moreover, it was considered minimal-risk (as defined by the National Research Council of the Academies of Science) and, as such, was positively assessed by the local commission of the Psychology Department of the University of Milano-Bicocca for minimal-risk studies (RM-2021-434).

Informed consent Before participating, the students were given an information sheet and were required to provide their informed consent to the processing of personal data. Therefore, informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare no competing interests.

Clinical trial number Not applicable.

References

Alessandri, G., Borgogni, L., Consiglio, C., & Mitidieri, G. (2015). Psychometric properties of the Italian version of the psychological capital questionnaire. *International Journal of Selection and Assessment*, *23*(2), 149–159. https://doi.org/10.1111/ijsa.12103

Ansley, B. M., Houchins, D. E., Varjas, K., Roach, A., Patterson, D., & Hendrick, R. (2021). The impact of an online stress intervention on burnout and teacher efficacy. *Teaching and Teacher Education*, *98*, 103251. https://doi.org/10.1016/j.tate.2020.103251

Auerbach, R. P., Mortier, P., Bruffaerts, R., Alonso, J., Benjet, C., Cuijpers, P., WHO WMH-ICS Collaborators. (2018). WHO World Mental Health Surveys International College Student Project: Prevalence and distribution of mental disorders. *Journal of Abnormal Psychology, 127*(7), 623–638. https://doi.org/10.1037/abn0000362

Avey, J. B., Reichard, R. J., Luthans, F., & Mhatre, K. H. (2011). Meta-analysis of the impact of positive psychological capital on employee attitudes, behaviors, and performance. *Human Resource Development Quarterly, 22*(2), 127–152. https://doi.org/10.1002/hrdq.20070

Baer, R. (2016). Assessment of mindfulness and closely related constructs: Introduction to the special issue. *Psychological Assessment*, *28*(7), 787. https://doi.org/10.1037/pas0000309

Balducci, C. (2015). *Gestire Lo stress Nelle organizzazioni*. Il Mulino.

Barkham, M., Broglia, E., Dufour, G., Fudge, M., Knowles, L., Percy, A., Turner, A., Williams, C., & SCORE Consortium. (2019). Towards an evidence-base for student wellbeing and mental health: Definitions, developmental transitions and data sets. *Counselling and Psychotherapy Research, 19*(4), 351–357. https://doi.org/10.1002/capr.12227

Batterham, P. J., & Calear, A. L. (2017). Preferences for internet-based mental health interventions in an adult online sample: Findings from an online community survey. *JMIR Mental Health*, *4*(2), e26. https://doi.org/10.2196/mental.7722

Bidargaddi, N., Almirall, D., Murphy, S., Nahum-Shani, I., Kovalcik, M., Pituch, T., & Strecher, V. (2018). To prompt or not to prompt? A microrandomized trial of time-varying push notifications to increase proximal engagement with a mobile health app. *JMIR mHealth and uHealth*, *6*(11), e10123. https://doi.org/10.2196/10123

Brooke, J. (1986). SUS: A "quick and dirty" usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & I. L. McClelland (Eds.), *Usability Evaluation in Industry* (pp. 189–194). Taylor & Francis.

Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability evaluation in industry, 189*(194), 4–7.

Carr, A., Cullen, K., Keeney, C., Canning, C., Mooney, O., Chinseallaigh, E., & O'Dowd, A. (2021). Effectiveness of positive psychology interventions: A systematic review and meta-analysis. *The Journal of Positive Psychology*, *16*(6), 749–769. https://doi.org/10.1080/17439760.2020.1818807

Champion, L., Economides, M., & Chandler, C. (2018). The efficacy of a brief app-based mindfulness intervention on psychosocial outcomes in healthy adults: A pilot randomized controlled trial. *PLoS ONE, 13*(12), Article e0209482. https://doi.org/10.1371/journal.pone.0209482

Choudhury, A., Kuehn, A., Shamszare, H., & Shahsavar, Y. (2023). Analysis of mobile app-based mental health solutions for college students: A rapid review. *Healthcare*, *11*(2), 272. https://doi.org/10.3390/healthcare11020272

Coursaris, C. K., & Kim, D. J. (2011). A meta-analytical review of empirical mobile usability studies. *Journal of Usability Studies, 6*(3), 117–171. https://doi.org/10.1145/1240866.1241005

Da, S., He, Y., & Zhang, X. (2020). Effectiveness of psychological capital intervention and its influence on work-related attitudes: Daily online self-learning method and randomized controlled trial design. *International Journal of Environmental Research and Public Health*, *17*(23), 1–19. https://doi.org/10.3390/ijerph17238754

Demirel, S., Roke, Y., Hoogendoorn, A., Hoefakker, J., Hoeberichts, K., & van Harten, P. (2024). Assessing the effectiveness of STAPP@Work, a self-management mobile app, in reducing work stress and preventing burnout: Single-case experimental design study. *Journal of Medical Internet Research, 26*, Article e48883. https://doi.org/10.2196/48883

Di Fabio, A., & Palazzeschi, L. (2012). The Satisfaction With Life Scale (*SWLS*): *Un contributo alla validazione italiana con lavoratori adulti* [The Satisfaction With Life Scale (SWLS): A contribution to Italian validation with adult workers]. *Counseling: Giornale Italiano di Ricerca e Applicazioni, 5*(2), 207–215.

Djourova, N., Rodriguez, I., & Lorente-Prieto, L. (2019). Validation of a modified version of the psychological capital questionnaire (PCQ12) in Spain. *Revista Interamericana De Psicología Ocupacional*, *37*(2), 93–106. https://doi.org/10.21772/ripo.v37n2a02

Eaton, C., Vallejo, N., McDonald, X., Wu, J., Rodríguez, R., Muthusamy, N., & Riekert, K. A. (2024). User engagement with mHealth interventions to promote treatment adherence and self-management in people with chronic health conditions: Systematic review. *Journal of Medical Internet Research*, *26*, e50508. https://doi.org/10.2196/50508

Ferrari, M., Allan, S., Arnold, C., Eleftheriadis, D., Alvarez-Jimenez, M., Gumley, A., & Gleeson, J. F. (2022). Digital interventions for psychological well-being in university students: Systematic review and meta-analysis. *Journal of Medical Internet Research*, *24*(9), e39686. https://doi.org/10.2196/39686

Ferreira, A., Brändle, N., Widhalm, P., & Olaverri-Monreal, C. (2018). Assessment of trip validation interfaces for smartphone-based travel surveys. *Transportation Research Procedia*, *32*, 126–134. https://doi.org/10.1016/j.trpro.2018.10.025

Flett, J. A. M., Hayne, H., Riordan, B. C., Thompson, L. M., & Conner, T. S. (2019). Mobile mindfulness meditation: A randomized controlled trial of the effect of two popular apps on mental health. *Mindfulness, 10*(5), 863–876. https://doi.org/10.1007/s12671-018-1050-9

Fraccaroli, F., & Schadee, H. M. (1993). L'analisi fattoriale confermativa applicata al General Health Questionnaire. Una comparazione della versione inglese e italiana [Confirmatory factor analysis applied to the General Health Questionnaire: A comparison of the Italian and English versions]. *Giornale Italiano di Psicologia, 20*(2), 319–338.

Franco, A., Malhotra, N., & Simonovits, G. (2014). Publication bias in the social sciences: Unlocking the file drawer. *Science*, *345*(6203), 1502–1505. https://doi.org/10.1126/science.1255484

Groot, J., MacLellan, A., Butler, M., Todor, E., Zulfiqar, M., Thackrah, T., & Ainsworth, B. (2023). The effectiveness of fully automated digital interventions in promoting mental well-being in the general population: Systematic review and meta-analysis. *JMIR Mental Health*, *10*(1), e44658. https://doi.org/10.2196/44658

Haan, M., Lugtig, P., & Toepoel, V. (2019). Can we predict device use? An investigation into mobile device use in surveys. *International Journal of Social Research Methodology*, *22*(5), 517–531. https://doi.org/10.1080/13645579.2019.1593340

Harrer, M., Adam, S. H., Fleischmann, R. J., Baumeister, H., Auerbach, R., Bruffaerts, R., & Ebert, D. D. (2018). Effectiveness of an internet- and app-based intervention for college students with elevated stress: Randomized controlled trial. *Journal of Medical Internet Research*, *20*(4), e136. https://doi.org/10.2196/jmir.9293

Herold, M., Simbula, S., & Gallucci, M. (2024). Can smartphone applications and wearable technologies improve workplace well-being and help manage stress? A systematic review. *Current Psychology, 43*(36), 28650–28673. https://doi.org/10.1007/s12144-024-06534-z

Howells, A., Ivtzan, I., & Eiroa-Orosa, F. J. (2016). Putting the 'app' in happiness: A randomized controlled trial of a smartphone-based mindfulness intervention to enhance wellbeing. *Journal of Happiness Studies, 17*(1), 163–185. https://doi.org/10.1007/s10902-014-9589-1

Huberty, J., Green, J., Glissmann, C., Larkey, L., Puzia, M., & Lee, C. (2019). Efficacy of the mindfulness meditation mobile app "Calm" to reduce stress among college students: Randomized controlled trial. *JMIR Mhealth Uhealth, 7*(6), Article e14273. https://doi.org/10.2196/14273

Inal, Y., Wake, J. D., Guribye, F., & Nordgreen, T. (2020). Usability evaluations of mobile mental health technologies: Systematic review. *Journal of Medical Internet Research*, *22*(1), e15337. https://doi.org/10.2196/15337

International Organization for Standardization. (1998). *Ergonomics of human-system interaction – Part 11: Guidance on usability* (ISO 9241-11)

Kajitani, K., Higashijima, I., Kaneko, K., Matsushita, T., Fukumori, H., & Kim, D. (2020). Short-term effect of a smartphone application on the mental health of university students: A pilot study using a user-centered design self-monitoring application for mental health. *PLoS One, 15*(9), e0239592. https://doi.org/10.1371/journal.pone.0239592

Kowalski, L., Finnes, A., Koch, S., & Bujacz, A. (2024). User engagement with organizational mHealth stress management intervention–A mixed methods study. *Internet Interventions*, *35*, 100704. https://doi.org/10.1016/j.invent.2023.100704

Lahtinen, O., Aaltonen, J., & Kaakinen, J. (2023). The effects of app-based mindfulness practice on the well-being of university students and staff. *Current Psychology, 42*, 4412–4421. https://doi.org/10.1007/s12144-021-01762-z

Lappalainen, A. L., Keinonen, K., Lappalainen, P., Lappalainen, R., Kaipainen, K., Puolakanaho, A., & Kiuru, N. (2024). Promoting youth life satisfaction through a brief online intervention: Individual differences in initial well-being and intervention response.

Child & Family Behavior Therapy. https://doi.org/10.1080/07317107.2024.2437637

Lattie, E. G., Adkins, E. C., Winquist, N., Stiles-Shields, C., Wafford, Q. E., & Graham, A. K. (2019). Digital mental health interventions for depression, anxiety, and enhancement of psychological well-being among college students: Systematic review. *Journal of Medical Internet Research*, *21*(7), e12869. https://doi.org/10.2196/12869

Laure, T., Boffo, M., Engels, R. C., & Remmerswaal, D. (2024). Effectiveness and uptake of a transdiagnostic emotion regulation mobile intervention among university students: Protocol for a randomized controlled trial. *Internet Interventions, 37*, Article 100750. https://doi.org/10.1016/j.invent.2024.100750

Laws, K. R., Pellegrini, L., Reid, J. E., Drummond, L. M., & Fineberg, N. A. (2022). The inflating impact of waiting-list controls on effect size estimates. *Frontiers in Psychiatry*, *13*, 877089. https://doi.org/10.3389/fpsyt.2022.877089

Lemon, C., Huckvale, K., Carswell, K., & Torous, J. (2020). A narrative review of methods for applying user experience in the design and assessment of mental health smartphone interventions. *International Journal of Technology Assessment in Health Care*, *36*(1), 64–70. https://doi.org/10.1017/s0266462319003507

Lister, K., Andrews, K., Buxton, J., Douce, C., & Seale, J. (2023). Assessment, life circumstances, curriculum and skills: Barriers and enablers to student mental wellbeing in distance learning. *Frontiers in Psychology*, *14*, 1076985. https://doi.org/10.3389/fpsyg.2023.1076985

Liu, C. H., Pinder-Amaker, S., Hahm, H. C., & Chen, J. A. (2022). Priorities for addressing the impact of the COVID-19 pandemic on college student mental health. *Journal of American College Health, 70*(5), 1356–1358. https://doi.org/10.1080/07448481.2020.1803882

Maqbool, B., & Herold, S. (2024). Potential effectiveness and efficiency issues in usability evaluation within digital health: A systematic literature review. *Journal of Systems and Software*, *208*, 111881. https://doi.org/10.1016/j.jss.2023.111881

Mohr, D. C., Cuijpers, P., & Lehman, K. (2011). Supportive accountability: A model for providing human support to enhance adherence to eHealth interventions. *Journal of Medical Internet Research*, *13*(1), e30. https://doi.org/10.2196/jmir.1602

Mondo, M., Sechi, C., & Cabras, C. (2021). Psychometric evaluation of three versions of the Italian perceived stress scale. *Current Psychology*, *40*, 1884–1892. https://doi.org/10.1007/s12144-019-0132-8

Morton, S., Mergler, A., & Boman, P. (2014). Managing the transition: The role of optimism and self-efficacy for first-year Australian university students. *Journal of Psychologists and Counsellors in Schools*, *24*(1), 90–108. https://doi.org/10.1017/jgc.2013.29

O'Brien, H. L., Cairns, P., & Hall, M. (2018). A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *International Journal of Human-Computer Studies*, *112*, 28–39. https://doi.org/10.1016/j.ijhcs.2018.01.004

Oskari, L., Jenni, A., Johanna, K., Lena, F., & Jukka, H. (2021). The effects of app-based mindfulness practice on the well-being of university students and staff. *Current Psychology*, 1–10. https://doi.org/10.1007/s12144-021-01762-z

Ponzo, S., Morelli, D., Kawadler, J. M., Hemmings, N. R., Bird, G., & Plans, D. (2020). Efficacy of the digital therapeutic mobile app biobase to reduce stress and improve mental well-being among university students: Randomized controlled trial. *JMIR Mhealth and Uhealth, 8*(4), e17767. https://doi.org/10.2196/17767

Schulte-Frankenfeld, P. M., & Trautwein, F. M. (2022). App-based mindfulness meditation reduces perceived stress and improves self-regulation in working university students: A randomized controlled trial. *Applied Psychology: Health and Well-Being, 14*(4), 1151–1171. https://doi.org/10.1111/aphw.12328

Solmi, M., Radua, J., Olivola, M., Croce, E., Soardo, L., Salazar de Pablo, G., & Fusar-Poli, P. (2022). Age at onset of mental disorders worldwide: Large-scale meta-analysis of 192 epidemiological studies. *Molecular Psychiatry, 27*(1), 281–295. https://doi.org/10.1038/s41380-021-01161-7

Sun, F., Wang, A., Xue, J., Su, J., Hu, C., & Lu, Q. (2022). The mediating effect of psychological capital on the relationship between psychological stress and distress among Chinese nursing students: A cross-sectional study. *BMC Nursing*, *21*(1), 1–9. https://doi.org/10.1186/s12912-022-00915-0

Torous, J., Nicholas, J., Larsen, M. E., Firth, J., & Christensen, H. (2018). Clinical review of user engagement with mental health smartphone apps: Evidence, theory and improvements. *BMJ Mental Health*, *21*(3), 116–119. https://doi.org/10.1136/eb-2018-102891

Truhlar, L. M., Durand, C., Cooper, M. R., & Goldsmith, C. A. W. (2022). Exploring the effects of a smartphone-based meditation app on stress, mindfulness, well-being, and resilience in pharmacy students. *American Journal of Health-System Pharmacy*, *79*(23), 2159–2165. https://doi.org/10.1093/ajhp/zxac240

Valentine, L., Hinton, J. D. X., Bajaj, K., Boyd, Larissa, O'Sullivan, Shaunagh, Sorenson, Rory P.., Bell, Imogen H.., Vega, Miguel Sobredo, Liu, Ping, Peters, Wilma, Mangelsdorf, Shaminka N.., Wren, Thomas W.., Moller, Carl, Cross, Shane, McEnery, Carla, Bendall, Sarah, Nicholas, Jennifer, & Alvarez-Jimenez, Mario. (2025). A meta-analysis of persuasive design, engagement, and efficacy in 92 RCTs of mental health apps. *NPJ Digital Medicine, 8*, Article 229. https://doi.org/10.1038/s41746-025-01567-5

Whaley, C. J., Morrison, D. L., Payne, R. L., Fritschi, L., & Wall, T. D. (2005). Chronicity of psychological strain in occupational settings and the accuracy of the general health questionnaire. *Journal of Occupational Health Psychology*, *10*(4), 310. https://doi.org/10.1037/1076-8998.10.4.310

World Health Organization. (2011). *mHealth: New horizons for health through mobile technologies*. Observatory.

World Health Organization (2018). mHealth: Use of Appropriate Digital Technologies for Public Health (Report by the Director-General).

World Health Organization (2022). *Mental Health and COVID-19: Early evidence of the pandemic's impact: Scientific brief*. https://www.who.int/publications/i/item/WHO-2019-nCoV-Sci_Brief-Mental_health-2022.1

Zapata, B. C., Fernández-Alemán, J. L., Idri, A., & Toval, A. (2015). Empirical studies on usability of mHealth apps: A systematic literature review. *Journal of Medical Systems*, *39*(2), 1–19. https://doi.org/10.1007/s10916-014-0182-2