App-based Stress Management Intervention for Students with Stress Symptoms

Master Thesis Regarding the Impact of an App-based Stress Management Intervention in Students with Stress Symptoms

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Abstract

Background: In the Netherlands, a significant portion of students endure persistent and excessive stress stemming from academic and non-academic sources. Unfortunately, the availability, accessibility, and acceptability of traditional counseling services often fall short, leaving many students without effective and timely treatment. However, addressing and mitigating stress is paramount for preventing adverse effects and promoting well-being. Digital interventions have emerged as a promising approach for managing stress, offering potential benefits in stress reduction and overall well-being.

Objective: The aim of this study is to assess the effectiveness of an app-based stress management intervention aimed at stress reduction in students as well as students' adherence, and user experience (UX) of the intervention.

Methods: Repeated measures ANOVAs and linear mixed modeling analyses were utilized to assess the effect of the app-based stress management intervention on daily mood, stress management self-efficacy, sleep quality, and stress. Additionally, linear mixed modeling analyses were conducted to explore the relationship between adherence to the intervention and its effectiveness. N=1 analyses were employed to further examine the individual-level patterns in outcomes during app use. Pearson correlations were calculated to evaluate the associations between sleep quality and daily mood, stress management self-efficacy and perceived stress, stress and daily mood, as well as stress and sleep quality to evaluate the appropriateness of the selected variables. Descriptive statistics were employed to analyze the quantitative UX data. A qualitative approach was employed to analyze the qualitative UX data, focusing on summarizing the suggestions of participants to improve the intervention.

Results: The repeated measures ANOVAs and linear mixed modeling analyses did not find a significant effect of the intervention on daily mood, stress management self-efficacy, sleep quality, and stress over the three-week intervention period. However, daily mood, stress management self-efficacy, and sleep quality had a tendency towards a favorable effect. Similarly, adherence to the intervention did not significantly impact its effectiveness according to the linear mixed modeling analyses. However, the n=1 analyses revealed that the high adherent participant showed a higher effect of the intervention on daily mood, stress management self-efficacy, and sleep quality compared to the low adherent participant. Pearson correlations indicated significant relationships between daily mood and sleep quality, stress management self-efficacy and stress, and stress and daily mood. The results of UX showed that the majority of participants perceived the intervention as of high quality, meeting their expectations and needs. They found it beneficial and expressed a likelihood of recommending it to others and using it again in the future. Participants reported moderate satisfaction with the help received and recognized the intervention's effectiveness in improving problem-solving skills.

Conclusions: The findings of the present study might give directions to future research on the benefits of the intervention. The observed favorable but modest effects on daily mood, stress management self-efficacy, and sleep quality underscore the need for further investigation into the intervention's effectiveness. In spite of a lack of statistical confirmation, findings do give preliminary support in favor of a potential preventive effect of the intervention, which warrants reconsideration in future research.

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Introduction

According to the World Health Organization (WHO), mental health disorders are one of the leading causes of disability worldwide (Abdel Wahed & Hassan, 2017). Health surveys show that especially adolescents between the ages of 12 and 25 have inadequate levels of psychological health (Windfuhr et al., 2008; Thapar et al., 2012). Additionally, multiple studies (e.g. Pedrelli, et al., 2014; Duffy et al., 2020; Cage et al., 2021) have reported a strong relationship between these inadequate levels of psychological health and students. Therefore, students, in particular, belong to a high-risk group of experiencing psychological discomfort arising from both academic and non-academic factors (Abdel Wahed & Hassan, 2017).

Stress is considered an important indicator of psychological discomfort (Ramón-Arbués et al., 2020). In the Netherlands, 40% of pupils and students between the ages of 12 and 25 experience excessive and continuous stress on a regular basis arising from both academic and non-academic factors, including socio-cultural, environmental, and psychological attributes (Bedewy & Gabriel, 2015; Kloosterman, 2021). Academic stress may include stressors such as pressure to perform, the number of assignments, competition with other students, failures, or poor relationships with other students and lecturers. Non-academic stress may include poor relationships with family, problems at home, or financial difficulties (Bhargava & Trivdei, 2018). Additionally, enduring a critical transitory period in which this group is going from adolescence to adulthood contributes to stressful moments in their lives (Abdel Wahed & Hassan, 2017).

Thus, students face a wide range of ongoing stressors. If not handled effectively, these stressors can negatively impact day-to-day psychological functioning and contribute to long-term mental health problems. Chronic and high stress may decrease academic achievement, reduce motivation and increase the risk of school dropout. In the long term, impacts of chronic and high stress may consist of reduced likelihood of sustainable employment and high economic costs. Ongoing stress may also contribute to cardiovascular diseases, immune system dysfunction, chronic pain conditions, respiratory problems, sleep disorders, metabolic dysregulation, accelerated aging, and the development of more serious mental health problems, such as anxiety and depression, and poorer well-being and Quality of Life (QoL) (Pascoe et al., 2019; Hwang, 2022).

Understanding the various ways in which stress has been studied is essential in comprehending its impact on individuals and developing effective strategies for its management and prevention. Stress has generally been studied in the following three ways: as an external stimulus or event, as a psychological interaction between the external stimulus event and the individual's cognitive and emotional traits, or as a physical or biological reaction (Morrison & Bennett, 2016). When considering stress as a biological reaction, one focuses on the physiological response involving the nervous and endocrine systems. It triggers the release of stress hormones like cortisol and adrenaline, increasing heart rate, blood pressure, and respiration rate. It also affects glucose levels, immune function, and can lead to muscular tension (Kemeny, 2003). When considering stress as a stimulus, one focuses on the stressful events themselves as well as the external environment. This approach takes into account the impact of a wide variety of stressors on individuals. Catastrophic or major life events are considered to require adjustment of the individual (Morrison & Bennett, 2016). In addition to major life events, the stressful nature of daily hassles has been underlined by research. Kanner et al. (1981) defined hassles as "irritating, frustrating, distressing demands that to some degree characterize everyday transactions with the environment" (Kanner et al. (1981, p. 3). Generally, hassles do not require major adjustment by the individual experiencing it, but the impact of hassles is thought to be noticeable in particular if the hassle occurs frequently, chronically, or repeatedly over a certain period of time (Holahan et al., 1984; Morrison & Bennett, 2016). Multiple studies found stronger associations between hassles and health outcomes compared to major life events and health outcomes (Kanner et al., 1981; Lazarus & Folkman, 1984). Additionally, Pérez and Matud (2022) showed effects of life stage and gender on the perception and appraisal of hassles.

Transactional Model of Stress and Coping

According to psychological theory, stress is a subjective experience in which appraisal is central to whether or not an event is experienced as a stressor (Morrison & Bennett, 2016). Psychological stress, therefore, consists of the relationship between the individual and the environment that is appraised by the individual as taxing or exceeding his or her available coping resources and endangering his or her well-being (Lazarus & Folkman, 1984). This can be further explained by the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984). According to Lazarus and Folkman (1984), stress can be defined as "a mental or physical phenomenon formed through one's cognitive appraisal of the stimulation and is a result of one's interaction with the environment" (Bhargava & Trivdei, 2018, p. 108). Based on prior experiences with stressful situations and their level of resilience, the negative impact of stress may differ significantly per individual. According to The Transactional Stress Theory (Lazarus & Folkman, 1984), environmental stressors are experienced as threats to one's well-being, leading to strains and stress is viewed as a transaction between individuals and their environment.

This definition of stress of Lazarus and Folkman (1984) shows two central concepts, consisting of appraisal and coping. Appraisal refers to an individual's evaluation of the importance of what is happening for their well-being, whereas coping refers to an individual's efforts in thought and action to manage demands that are appraised as taxing or exceeding their resources. It explains in what ways stressors influence an individual and how the perspective of the individual influences whether or not the stressor has detrimental effects in terms of health and well-being (Stevenson & Harper, 2006; Dijkstra & Homan, 2016). Folkman and Lazarus (1984) define coping as "the cognitive and behavioural efforts made to master, tolerate, or reduce external and internal demands and conflicts among them" (Berjot & Gillet, 2011, p. 2). The majority of coping research follows this definition of Folkman and Lazarus.

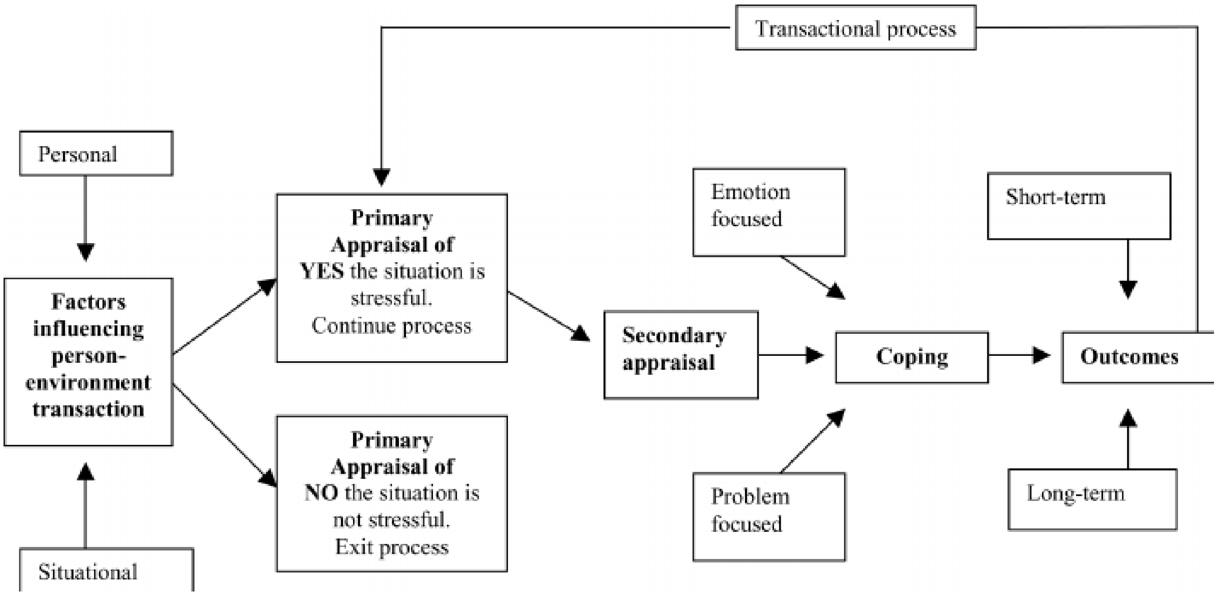
Thus, stress is associated with the way an individual appraises situations and the adopted coping strategies. Taking into consideration the detrimental effects of stress, it is crucial to understand the process of effective coping with stress in order to enable a reduction in its psychological, physical, and economic consequences.

Appraisal

According to the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984), when confronting a new or challenging environment, individuals engage in a process of primary and secondary appraisal (see Figure 1). Primary appraisal consists of the consideration of the quality and nature of the stimulus event. Lazarus and Folkman (1984) distinguish the following stressors, consisting of stressors that pose harm, stressors that threaten, and stressors that set a challenge (Morrison & Bennett, 2016). Harm refers to the damage or loss that already occurred. Threat refers to the belief that harm may be imminent. Challenge is a result of demands that an individual feels confident about mastering. These types of stress are intertwined with specific types of emotional reactions (Morrison & Bennett, 2016). Simultaneously to primary appraisal, these emotions occur which affect the way of coping with the stressor. According to Lazarus and Folkman (1984), subsequently, secondary appraisal occurs in which one assesses their resources and capacities to cope with the stressor. Based on their model, stress is therefore caused by a mismatch between perceived demands and resources.

Figure 1

Transactional Model of Stress and Coping (Lazarus and Folkman, 1984)



Coping

Taxonomies of coping differentiate between problem-focused and emotion-focused coping and between approach-oriented coping and avoidance (Roth & Cohen, 1986; Baker & Berenbaum, 2007). Problem-focused coping consists of efforts to change the problem at hand by generating options to solve the problem and implementing steps to solve the problem. Problem-coping efforts are directed at the stressor in order to either reduce its demands or increase one's resources. Strategies include examining how to change the stressor or how to behave to control or deal with the stressor by for instance seeking practical or informational support. Emotion-focused coping mainly aims at managing the emotional response that is related to the stressor. Strategies include positively reappraising the stressor, acceptance, or seeking emotional support (Morrison & Bennett, 2016). Approach-oriented coping refers to the cognitive and emotional activity that is oriented toward the threat, whereas avoidance consists of the cognitive and emotional activity that is oriented away from the threat.

Three factors play an important role when evaluating coping effectiveness, consisting of the point of time at which the effectiveness is evaluated, the controllability of the stressful situation, and the fit between the coping strategy and the demands of the stressful situation. With regard to the first important factor, Muller and Suls (1982) found that avoidance strategies were effective when the outcome measure was short term, whereas approach strategies were more effective when the outcome measure was long term. Additionally, Lazarus (1983) stated that avoidance may be effective only in a limited time frame and especially valuable during a period when emotional resources are limited. With regard to the second important factor, avoidance is better when the situation is uncontrollable, whereas approach is better in case there is potential control, since approach enables the individual to take advantage of opportunities for control (Lazarus, 1983). With regard to the third important factor, Cohen and Roth (1984) found that surgery patients whose treatment condition was consistent with their preferred coping strategy experienced less stress compared to those for whom this was not the case. Nevertheless, coping should be considered as a dynamic process which varies according to the context, event, personal goals, resources, and demands. An individual may use different coping strategies depending on these factors (Morrison & Bennett, 2016). Additionally, above mentioned coping strategies are often interdependent and form the overall coping response of an individual. It is therefore difficult to predict which coping strategies are most effective in which situations.

As mentioned before, students, in particular, belong to a high-risk group of experiencing psychological discomfort arising from both academic and non-academic factors, which may negatively impact their psychological functioning and contribute to long-term mental health problems. This aligns with the core tenets of the theory of stress, which recognizes that stressors, such as academic demands and social pressures, can exert a significant influence on individuals' well-being and psychological outcomes. Previous research consistently demonstrates that students face various challenges that can result in negative daily mood, low stress management self-efficacy, and poor sleep quality (Bolger et al., 1989; Morin et al., 2003; Sawatzky et al., 2012). These factors often intertwine with the experience of stress, as outlined by the theory of stress and coping. When students encounter demanding situations or perceive their academic workload as overwhelming, it can trigger psychological and physiological reactions associated with stress. Consequently, these stress-related symptoms may further exacerbate their negative mood, self-efficacy beliefs, and sleep patterns. The findings suggest a causal relationship between stress management self-efficacy and stress, indicating that higher levels of self-efficacy are associated with lower levels of stress (Sawatzky et al., 2012). Furthermore, stress is found to have a causal influence on daily mood, with higher stress levels being linked to more negative mood states (Bolger et al., 1989). Additionally, stress is found to have a causal impact on sleep quality, whereby increased stress levels are associated with poorer sleep quality (Morin et al., 2003). The variables of daily mood, stress management self-efficacy, and sleep quality among students will be elucidated and examined in greater detail.

Daily Mood

Coping strategies play a crucial role in influencing daily mood. When individuals effectively cope with stress, they are more likely to experience positive daily moods. Effective coping helps individuals manage stressors, reduce negative emotions, and enhance their overall well-being, leading to more positive daily mood experiences (Stone et al., 1993).

In a study of Shermeyer et al. (2018), two theoretical dimensions of coping behaviour were considered, consisting of problem-focused versus emotion-focused coping and engagement versus disengagement coping. In their study, it was assessed in what extent students approached their problems versus emotions associated with their daily stressors, and in what extent students engaged versus disengaged from these stressors. As a result, four types of coping were constructed: problem-focused engagement (PFE), emotion-focused engagement (EFE), problem-focused disengagement (PFD), and emotion-focused disengagement (EFD). PFE involves behaviours such as problem solving and cognitive restructuring, whereas EFE is characterized by behaviours such as emotion expression and seeking social support. PFD involves behaviours such as problem avoiding and wishful thinking, whereas EFD consists of behaviours such as self-criticism and social withdrawal.

In a study of Park et al. (2004), students' daily coping with stress was examined with online daily diaries over 28 days. Participants were asked to report their most stressful daily event, perceived control over this event, which coping strategies were used to manage the stress, and positive and negative mood. Results showed that EFE and PFD were associated with lower daily mood. Moreover, results of the study of Shermeyer et al. (2018) showed that the use of PFE by students was linked to lower negative mood and higher positive mood and QoL. EFE, PFD, and EFD were linked to poorer daily functioning and higher negative mood. These findings suggest that students benefit most in resolving or managing their stress when applying PFE and actively engage with their everyday stressors.

Stress Management Self-efficacy

Research regarding resilience and self-efficacy shows that stress management is one of the most efficient means of improving mental health (Sawatzky et al., 2012). Self-efficacy can be defined as "the beliefs or confidence that students have in their ability to successfully manage their stress" (Sawatzky et al., 2012, p. 14). The experience of stress can either enhance or constrain resilience (Sawatzky et al., 2012). Relevant findings showed that students who do not experience stress or that stress affects their performance reported more stress management self-efficacy and less psychological discomfort compared to other students (Frazier et al., 2018). In their study, Frazier et al. (2018) reported that the GPAs of students who perceived stress as negatively affecting their academic performance were significantly lower compared to the GPAs of students who did not experience stress. additionally, the GPAs of students who experienced stress but did not perceive this as negatively affecting their academic performance were highest. These findings show that there is a curvilinear relation between stress and GPA in a way that low levels of stress have a positive effect on GPA, while high levels of stress negatively affect GPA. Here, the absence or presence of stress management self-efficacy is indirectly of importance in such a way that the absence of it contributes to higher experienced stress and therefore, lower GPAs and the presence of it contributes to lower experienced stress and therefore, higher GPAs. Stressors which are perceived as goal-relevant and manageable may increase motivation, performance, and well-being, while stressors which are perceived as unmanageable or hindering may adversely affect performance (Travis et al., 2020).

Given the fact that stress management self-efficacy is related to a reduced perception that stress affects academic performance and to an improvement of academic performance, intervening to improve stress management self-efficacy would be beneficial for students (Frazier et al, 2018).

Sleep Quality

Additionally, stress and sleep quality are interrelated and have a reciprocal relationship, in which increased levels of sleep negatively affect sleep quality, whereas poor sleep quality can increase stress as well. This is related to lower academic performance, since sleep deprivation is associated with diminished cognitive performance (Herawati & Gayatri, 2019). Individuals who suffer from poor sleep often report that daily life stress negatively affects their sleep onset (Konjarski et al., 2018). A study of Morin et al. (2003) reported that individuals who suffered from symptoms of insomnia experienced more stress compared to individuals who did not. Students, in particular, struggle to keep their sleep needs optimally, due to having a lot of activity and stressors, leading to a higher risk of poor sleep quality. A study of Herawati and Gayatri (2019) reported that students with poor sleep quality were 4.7 times more likely to experience more stress compared to students with sufficient sleep quality. This research recommended to apply stress management in order to enhance sleep quality.

Furthermore, sleep and daily mood are interrelated, such that sleep is essential in maintaining optimal homeostasis of affective functioning and poor sleep quality adversely alters one's emotional state (Konjarski et al., 2018). This contributes to a heightened negative affect, for instance sadness or anger, and a dampened positive affect, for instance happiness or joy in individuals who experience poor sleep. At the same time, impaired affective states such as stress, anxiety or sadness can cause the initiation of poor sleep quality or contribute to further impairment of sleep quality and hamper the ability to fall asleep (Konjarski et al., 2018).

mHealth Interventions for Stress

Based on the aforementioned information, it becomes evident that stress management is of importance in preventing the adverse consequences of stress. Despite the importance of stress management and the increasing need for treatment of common mental health problems such as stress among students, many of them do not receive effective and timely treatment due to the low availability, accessibility, and acceptability of traditional counseling (Ha & Kim, 2020). Additionally, the younger population belongs to the age group with a decreased likelihood of seeking treatment or support services when suffering from psychological discomfort (Venkatesan et al., 2021), is more receptive to online mental health treatments and more likely to seek help online compared to face-to-face (Huberty et al., 2019). However, education is of utter importance in order to learn how to cope with this psychological discomfort and avoid negative side effects. Taking this into consideration and given the prevalence of stress among students, there is a clear need for a brief, inexpensive, and effective intervention.

A technique often used aimed at managing stress consists of psychoeducation (PSE). PSE aims at offering support to acquire competencies to manage stress and preserve mental health by offering knowledge and the acquisition of skills to cope with stress (Van Daele et al., 2011). It can be defined as a "systematic didactic-psychotherapeutic intervention, designed to inform patients and their relatives about the disorder and to promote coping" (Lincoln et al., 2007, p. 233). Psychoeducational interventions consist of interventions in which elements are combined of Cognitive Behavioural Therapy (CBT), group therapy, and education, which aims at the development of overall knowledge about the psychological problem as a tool to help people deal with it (Tursi et al., 2013). In the last few decades, PSE has proven to be a helpful and effective form of psychotherapy for those who suffer from psychological discomfort, such as stress (Donker et al., 2009; Sarkhel et al., 2020).

Harrer et al. (2021) reported the feasibility, acceptability, and effectiveness of providing such interventions in an internet-based or mobile-based way. Given the pervasiveness of mobile apps, these forms of media could possibly offer a highly convenient, anonymous, and accessible means to offer PSE and promote mental health on a large scale to populations at a low cost who would otherwise not seek support due to for instance financial constraints, inconvenience, stigma, or a desire for self-management of symptoms (Mak et al., 2018). Furthermore, Harrer et al. (2018) highlighted that internet- and mobile-based interventions may be suitable for student populations in particular, considering the higher preference for help-seeking through the internet in younger and well-educated individuals. Proudfoot et al. (2010) reported that most individuals are interested in using a mobile app for self-management of symptoms such as anxiety, depression, and stress. Furthermore, considering the increasing utilization of mobile phones, mobile interventions are becoming a feasible option to provide support by educating individuals about mental health and to promote well-being (Mak et al., 2018). The use of mobile health apps improves the efficiency of health care delivery and the effectiveness of treatment (Huberty et al., 2019).

Based on a review of the existing literature, it is evident that several digital interventions have demonstrated efficacy in treating mental health disorders, including reducing stress. For example, an 8-week intervention with the mobile app Calm, which is a mobile app focused on mindfulness meditation, in university students in the United States showed a significantly greater degree of stress reduction compared to a control group who was placed on a waitlist and showed promise as an effective intervention for enhancing sleep quality, specifically by reducing sleep disturbance (Huberty et al., 2019). In addition, Hwang et al. (2022) reported the effectiveness on the degree of stress in people with work-related stress of a similar intervention, called The BetterLife app, which is a program developed for stress management. The program incorporates evidence-based manuals for CBT and problem-solving therapy. The intervention also improved work engagement and contributed to an improvement of QoL (Hwang et al., 2022). Another study of Venkatesan et al. (2021) reported a significant and reliable reduction in perceived stress in individuals after following an app-based mental health intervention, called the VIDA Health digital MBSR program. Individuals received one-on-one weekly remote video sessions with a coach combined with tailored digital content based on core concepts of mindfulness practice.

Despite the advantages of disseminating interventions via mHealth technologies, one challenge consists of a lack of quality control standards and information on which apps for stress management and psychological self-care work in an oversaturated market (Huberty et al., 2019; Lau et al., 2020). WHO developed a guideline on digital health interventions. This guideline aims at the adoption of evidence-based interventions by strengthening health systems based on the benefits, harms, acceptability, feasibility, resource use, and equity considerations. In practice, only a minority of the available apps have been tested in research settings and the available apps are highly variable regarding the inclusion of evidence-based content (Lau et al., 2020). In a study of Lau et al. (2020), the treatment content, user ratings, costs, and the evidence base in support of publicly available stress management apps were reviewed. Lau et al. (2020) found the following treatment strategies as evidence-based: mindfulness meditation; mood and symptom monitoring; CBT; positive psychology; relaxation; planning and goal setting; journaling; and educational materials. Mindfulness can be defined as “a moment-to-moment awareness that is cultivated by purposefully paying attention to the present experience, with a non-judgmental attitude” (Khoury et al., 2015, p. 519). One example of mindfulness focusing on stress reduction consists of mindfulness-based stress reduction (MBSR). MBSR aims at changing the relationship with stressful thoughts and events by teaching the individual to observe situations and thoughts in a nonjudgmental, nonreactive, and accepting way by means of body scan, sitting meditation, and yoga (Khoury et al., 2015). Khoury et al. (2015) reported that MBSR provides moderate effects on depression, anxiety, and distress, and a major reduction in stress and enhancement in QoL. CBT consists of a form of psychotherapy aimed to help individuals recognizing and altering destructive or disturbing thought patterns that negatively affect their behaviour and emotions. It promotes more balanced thinking to enhance the ability to cope with stress (Nakao et al., 2021).

Despite promising results of stress management interventions aimed at reducing perceived stress levels, literature on the effects of an evidence-based app-based stress management intervention aimed at stress reduction in students is still limited. With evidence for app-based stress management interventions aimed at reducing work-related stress levels, there seems to be a literature gap specifically for app-based stress management intervention studies on effectiveness in stress reduction in students. Therefore, research is necessary on the development and effectiveness of these interventions.

WeMind Balance

WeMind Balance is a stress management app and aims at reducing perceived stress levels in students in order to improve their well-being by combining different evidence-based treatment strategies, which are also reported in the study of Lau et al. (2020). By offering and combining evidence-based strategies in one place to the individual, the intervention offers an app which consists of treatment strategies tested in research settings and tackles the problem of the lack of the inclusion of evidence-based content in the oversaturated market of stress management apps. WeMind Balance combines evidence-based treatment strategies of psychoeducation, mindfulness meditation, CBT, and relaxation. These elements are subdivided into different categories, consisting of courses, mental work outs, and challenges. Courses consist of educational materials regarding different topics about stress, its causes, and consequences, aimed for the user to better understand themselves and reflect on their own situation. Mental works outs consist of exercises, aimed at reducing acute stress levels by finding a moment of calmness, and helping the user to work towards a balanced life. Challenges serve as reflective materials, aimed at gaining more control over one's perceived stress and stressors. Courses consist of education covering the following topics: what is stress, lifestyle and stress, long-term physical consequences, and the body and stress. Mental work outs focus on breath breaks, grounding, moments of gratitude, peace of mind, and to get energized. Challenges focus on tackling worries, keeping focus, dealing with hopelessness, establishing overview, reflecting on procrastination, and creating overview in chaos. The courses are provided in text form. The mental work outs and challenges are provided in audio form. The content of the app is provided in Dutch as well as English. WeMind Balance offers users the flexibility to choose when and how they engage with it, allowing them to have control over their usage patterns and content selection. This evidence-based intervention has potential to help students to gain more understanding and control over their stressors and perceived stress, and may, therefore, contribute to a decrease in perceived stress levels in students. Conducting an effectiveness study is therefore desirable in order to confirm these predictions.

Adherence to Intervention

In research studies, reporting adherence to interventions is widely recognized as essential for interpreting results (Nagpal et al., 2021). Taking into account adherence to the intervention provides an indication of effectiveness, particularly in the absence of a control group. When adherence is low, the effectiveness of the intervention may be compromised, highlighting the need for caution in interpreting the outcomes. Conversely, high adherence indicates that the results are more likely to reflect the true response to the intervention. It is important to note that there is no explicit definition distinguishing low from high adherence in interventions. Typically, high adherence in interventions is defined as ≥ 70% adherence, while low adherence is defined as < 70%. However, adherence is not a dichotomous variable and can vary at both the individual and intervention levels (Nagpal et al., 2021).

Four scenarios can be considered when interpreting adherence results in interventions. In scenario 1, low adherence and no significant effect suggest that caution should be exercised in drawing conclusions. Scenario 2 involves high adherence without a significant effect, indicating the need to explore the intervention design further. In scenario 3, low adherence combined with favorable outcomes raises questions about the contribution of other variables. Lastly, in scenario 4, high adherence and favorable outcomes support the effectiveness of the intervention design (Nagpal et al., 2021). Overall, measuring and reporting adherence is crucial for understanding the representativeness of the intervention and ensuring the internal validity of the study.

UX of eHealth

Given the growing importance of user-centered approaches and the significance of User Experience (UX) in the effectiveness of digital interventions, it is crucial to include an investigation of UX in the study as well to gain valuable insights into the app's usability, acceptability, and overall user satisfaction (Richardson et al., 2021). According to the literature, there are three important user experience components, consisting of the user, the product, and the company. The user is seen to be in the center of UX. In order to be able to develop a successful intervention that satisfies users, it is important to get an in-depth understanding of users' expectations, emotions and needs. Furthermore, predicting the role of a product in the user's life contributes to designing positive user experiences. These UX components can be used as guidelines in the design of the intervention. Problems and complications can be identified and feedback from the user can be implemented in the further development of the intervention (Richardson et al., 2021). Taking the importance of UX into consideration, UX of WeMind Balance was assessed in the present study as well.

Aim of Present Study

This pilot study used a single-case experimental design (SCED). SCEDs aim to test the effectiveness of an intervention using a small number of participants in which individual behaviour is repeatedly measured in the absence as well as the presence of the intervention. This enables the researcher to reflect each individual's performance at baseline, prior to the introduction of the intervention, and after the introduction of the intervention. SCEDs can be useful in the early developmental phase of research as well as in refining the application of research findings to individuals (Krasny-Pacini & Evans, 2017). This type of design is used prior to the start of an intervention, enables high quality research with small numbers of participants, and can detect an intervention effect within the variability of the performance of the participant. Studying a small number of participants intensely and comprehensively enables to get insight into mediating effects of the intervention. By conducting the study over a period of three weeks and using daily measurements, a SCED captures the participants' experiences in their natural environment. This enhances the ecological validity of the study, as the participants' daily lives and routines are reflected in the data collected (Smith, 2012). Therefore, a SCED is suitable for the present study to measure the effectiveness of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and stress in students.

In the present study, a SCED was used aimed at exploring potential effectiveness of WeMind Balance on stress reduction in students. Participants were asked to repeatedly and frequently fill out a survey in order to measure the outcome in all phases (baseline (phase A) and intervention phase (phase B)) of the study. The included questions in the surveys in phase A aimed at measuring daily mood, stress management self-efficacy, sleep quality, and perceived stress in general to form a baseline. In phase B, the same questions of phase A were used and a question measuring app use of WeMind Balance was included to measure the adherence to the intervention as well as the effectiveness of the intervention on daily mood, stress management self-efficacy, sleep quality, and perceived stress in general. Additionally, a survey to measure UX of WeMind Balance was included and filled in after completion of the intervention. Thus, the research questions were:

1. What is the impact of an app-based stress management intervention on daily mood, stress management self-efficacy, sleep quality, and stress in general in students over time (1 – 3; 4 – 12; 13 – 21 days)?
2. Does the level of adherence to the app-based stress management intervention influence the impact of it?
3. Is there a correlation between stress and daily mood, stress management self-efficacy and stress, stress and sleep quality, and stress and daily mood?
4. How do participants experience the app-based stress management intervention?

It is expected that participants experience increased stress management self-efficacy, daily mood, and sleep quality. In addition, it is expected that participants experience a reduction in perceived stress in general. Lastly, it is expected that participants experience the intervention as positive and valuable.

Method

Design

The present study used a SCED in which the experience sampling method (ESM) was used. A questionnaire survey design was used to obtain measurements of the corresponding variables as well as demographic data. Quantitative data were collected from participants during the study. Demographic data were collected pre-intervention. Quantitative data were collected on a daily basis for a period of three weeks. The study setting was entirely online and data were collected via participants' phone using the research software Twente Intervention and Interaction Machine (TIIM), developed and owned by the BMS lab of the University of Twente. Participants were requested to download the TIIM app and received access to the study using a code. The study got ethical permission from the Ethics Committee BMS at the University of Twente (230359).

Participants

The sample of this study was selected by means of convenience sampling. Beforehand, it was aimed for a sample size of at least 20 participants. According to van Berkel et al. (2017), a median number of 19 participants provides a representative insight into ESM practices. Participants were recruited at the University of Twente. Additional participants were selected through personal acquaintances of the researcher. The inclusion criteria were as follows: (1) being a registered student; (2) a minimum age of 18 years; (3) being proficient in the English language; (4) owning a smartphone with either an iOS or Android operating system considering the compatibility requirements of TIIM used in this study.

The present study involved a sample size of 32 participants. The demographic characteristics of the sample, including age, gender, highest degree or level of education, and type of study were examined to provide a comprehensive overview of the participants (see Table 1). The average age of the participants in the sample was 23.6 years (Age – $M_{age} = 23.6$, $SD_{age} = 3.6$, $Min_{age} = 18$, $Max_{age} = 32$). The sample comprised 21 males and 11 females. 26 participants were registered university students and six participants were registered students at a university of applied sciences. 12 participants were doing a Social Sciences study and 20 participants were doing a Natural Sciences study.

Table 1

Demographic Variables of Participants at Baseline

Baseline characteristics	n	%
Gender		
Male	21	65.6
Female	11	34.4
Type of study		
Social sciences (Alpha)	12	37.5
Natural sciences (Beta)	20	62.5
Highest degree or level of education		
University of applied sciences (HBO)	6	18.8
University (WO)	26	81.2

Materials

All participants received the same intervention for a period of three weeks, consisting of WeMind Balance. TIIM was used to create the online survey and to collect data from participants, which is part of the research software provided and maintained by the BMS lab of the University of Twente. It provides researchers to create sets of measurement items and present them to participants, and to study participants long term or repeatedly. The choice of using an app for data collection contributed to an optimized response rate, considering the fact that students are highly accustomed to using mobile phones.

Measures

The quantitative data were collected via daily surveys in TIIM, consisting of 22 modules. Phase A, which was the baseline phase, consisted of the first three modules, in which four different variables were measured: daily mood, stress management self-efficacy, sleep quality and perceived stress in general. Phase B, which was the intervention phase, consisted of the followed 18 modules, in which, additional to the four variables in phase A, app use of WeMind Balance was added and examined. Subsequently, module 22 examined UX, which was measured only post-measurement.

Quantitative Measures

Daily Mood. To measure daily mood, the Single Item Mood Scale (SIMS-Verbal) was used (Gertler & Tate, 2020). The SIMS-Verbal consists of a single-item numeric rating scale and provides a comprehensive assessment of daily mood. It is designed to capture the daily experiences and fluctuations in mood in a naturalistic setting. The SIMS-Verbal has been extensively validated and demonstrated good reliability in measuring mood states. It has been used in various research studies and has shown to be a valid and reliable instrument for assessing mood. Participants were asked to daily rate the following item: "Please indicate your mood of today on a scale of zero to ten with zero representing your worst mood and ten representing your best mood." By assessing mood on a daily basis, it can capture subtle shifts and fluctuations in mood that may occur within the three-week period. This allows for the detection of immediate effects of WeMind Balance on daily mood.

Stress Management Self-efficacy. Stress management self-efficacy was measured by means of a self-created one-item scale based on the Brief Resilience Scale (BRS) (Smith et al., 2008). The BRS has a good internal consistency and test-retest reliability and is created to measure the ability to bounce back or recover from stress and consists of six items. Taking into consideration the potential burden for participants when using multiple items to measure the construct of stress management self-efficacy, a single-item scale was created. Participants were asked to daily indicate the extent to which they agreed with the following statement by using a 5-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree: "I was able to apply suitable coping strategies to effectively deal with stressful events that occurred throughout the day."

Sleep Quality. To measure sleep quality, the Sleep Quality Scale (SQS) was used (Snyder et al., 2018). The SQS is a one-item scale and measures the overall quality of sleep over a seven-day recall period and has been validated and widely used in sleep research. It assesses various dimensions of sleep quality, such as sleep duration, latency, disturbances, and overall satisfaction, providing a comprehensive evaluation of sleep quality. The SQS demonstrates good reliability, indicating consistent results when administered multiple times. In the present study, participants were asked to rate the following item: "Please rate your sleep quality of last night on a scale of zero to ten, according to the following five categories: 0 = terrible, 1-3 = poor, 4-6 = fair, 7-9 = good, 10 = excellent. Please take the following core components of sleep quality into consideration when rating your sleep quality: how many hours of sleep you had, how easily you fell asleep, how often you woke up during the night, how often you woke up earlier than you had to in the morning, and how refreshing your sleep was." (Snyder et al., 2018).

Perceived Stress. To measure perceived stress, the Stress Numerical Rating Scale-11 (SNRS-11) was used. The SNRS-11 is a brief assessment tool of current stress, consisting of one item. It has shown good validity as a measure of subjective stress levels and requires participants to respond to the question: "On a scale of zero to ten, with zero being no stress and ten being worst stress possible, what number best describes your level of stress right now?" (Karvounides et al., 2016). Taking into consideration the desire to minimize the effort and time to respond and to increase response probability, and the length of the SNRS-11, this assessment tool was suitable to measure perceived stress.

Client Satisfaction. To measure participants' UX with the intervention, the Client Satisfaction Scale (CSQ-I) was used once post-intervention. The CSQ-I measures global satisfaction regarding web-based interventions (Boß et al., 2016). Participants were asked to rate eight items on a 4-point Likert scale: 1= does not apply to me, 2 = does rather not apply to me, 3 = does partly apply to me, 4 = does totally apply to me. The CSQ-I consisted of the following items: 1) The intervention I followed was of high quality, 2) I received the kind of intervention I wanted, 3) The intervention has met my needs, 4) I would recommend this intervention to a friend, if he or she were in need of similar help, 5) I am satisfied with the amount of help I received through the intervention, 6) The intervention helped me deal with my problems more effectively, 7) In an overall, general sense, I am satisfied with the intervention, 8) I would come back to such an intervention if I were to seek help again. Additionally, participants were asked to write down any suggestions to improve WeMind Balance.

Procedure

Participants were recruited two weeks till one day prior to the study. Participants were instructed to install the TIIM app upon recruitment for the study. The TIIM app provided a short introduction of the study. At this point of time, informed consent was obtained as well from all participants prior to the intervention, in which was emphasized that collected data was confidential and processed anonymously; participation was completely voluntary and participants could withdraw at any time from the study without any reason. This was followed by the collection of demographics of the participant, consisting of gender, age, type of study (natural sciences (Alpha) or social sciences (Beta)), and highest degree or level of education (university or university of applied sciences). Individuals meeting all the inclusion criteria received access to the study in TIIM.

The study took place over a course of three weeks in total. Data was obtained using signal-contingent sampling. Phase A of the study consisted of the first three days of the study, serving as the baseline data collection period regarding the primary outcome variables. During phase A, participants filled out a daily survey in TIIM consisting of the SIMS-Verbal, the self-created one-item scale based on the BRS, the SQS, and the SNRS-11. From the initiation of the intervention (phase B), participants were instructed to start using WeMind Balance and were requested to use WeMind Balance for a period of 18 days. The intervention was accessible via a web application. This study length is also in line with similar ESM studies (van Berkel et al., 2017). During phase B, each participant was able to determine the app use intensity and content used of WeMind Balance and continued filling out the survey used in phase A in the TIIM app once a day measuring the variables of daily mood, stress management self-efficacy, sleep quality, and perceived stress of the participant. Additionally, the survey in phase B contained a question to examine whether or not the participant used WeMind Balance on that specific day. Participants received a daily notification in TIIM to fill out the survey. Post-intervention, participants were requested to once fill out the CSQ-I via TIIM.

Analysis

The data were analyzed via IBM SPSS Statistics 27. Initially, the data set was exported from TIIM and transferred into Microsoft Excel to structure the data into a coherent dataset. In this study, the measurement points over the three-week period were divided into three distinct phases: the baseline phase (day 1 – 3), intervention phase 1 (day 4 – 12), and intervention phase 2 (day 13 – 21). To facilitate the data analyses, the average scores per individual were calculated for each phase. These average scores were then used for the subsequent statistical analyses. Subsequently, the data were imported into SPSS Statistics 27.

First, descriptive statistics regarding the distribution of the descriptive data were analyzed to get insight into the participants' demographic data. To gain insights into the distribution of the data, boxplots were generated. The boxplots included data from a total of 13 participants (N=13) who had complete data available for all three phases of the study.

To evaluate the impact of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and perceived stress, repeated measures ANOVAs were conducted for each variable. The analyses involved specifying the within-subjects factor consisting of time and examining the main effect of time, which indicated whether there were significant differences in the dependent variables across the different time points. The repeated measures ANOVAs included data from a total of 13 participants as well (N=13). This N value reflects the number of participants for whom complete data was available and included in the analysis. Participants who had missing data for any of the three phases of the study were excluded from the analysis to ensure the integrity and accuracy of the results.

In addition to repeated measures ANOVAs, linear mixed modeling analyses were conducted to further investigate the effects of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and stress in general, with the dummy-coded variable time as the fixed covariate. Linear mixed modeling is a flexible statistical approach that can handle missing data and account for individual variability by including random effects. This modeling technique is particularly useful in longitudinal studies with repeated measures and can provide more accurate estimates of treatment effects compared to traditional repeated measures ANOVA (Krueger & Tian, 2004). In the linear mixed modeling analyses, the dataset consisted of a total of 32 participants. This included participants with complete data as well as those with missing data, as the linear mixed modeling approach is able to handle missing data effectively. By employing both repeated measures ANOVA and linear mixed modeling, a comprehensive understanding could be gained of the impact of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and stress.

Furthermore, Repeated Measures ANOVAs were conducted to examine the impact of adherence on the effects of WeMind Balance. A dichotomous adherence variable was added to the dataset. This additional column in the dataset served to classify participants into two distinct groups: high adherent and low adherent. High adherence was determined as using the app a minimum of ten times out of the total 22 available usage instances. On the other hand, low adherence was defined as using the app less than ten times. In the adherence column, a value of 1 indicated high adherence and a value of 0 indicated low adherence. This dichotomous adherence variable enabled the comparison of outcomes between the two adherence groups and facilitated the assessment of any differential effects of the intervention based on the level of adherence.

Furthermore, n=1 analyses were conducted on two participants. One participant was randomly selected from both the low adherence group and the high adherence group. The data of both participants for the dependent variables were plotted in graphs and visually inspected to identify any discernible patterns in the course of the data that could indicate a response to the intervention.

Additionally, particular attention was given to possible differences between weekdays and weekends in terms of the dependent variables. For each participant, a linear line was plotted to illustrate the course of their data over time. This visual representation provided insights into the trajectory of the dependent variables for each individual participant. By plotting the data points and connecting them with a line, any noticeable trends or changes in the variables could be easily identified. The n=1 analysis holds unique value as it allows for a comprehensive examination of individual-level data, considering all measurement points throughout the study period, unlike the other conducted analyses that relied on reduced data. In the n=1 analysis, the complete dataset of each participant was taken into account, enabling a thorough exploration of their specific responses to the intervention.

Additionally, cross-sectional Pearson correlation analyses were conducted to examine the relationships between sleep quality and daily mood, between stress management self-efficacy and perceived stress, between stress and daily mood, and between stress and sleep quality, using the data from the baseline phase. The Pearson correlation analyses to examine the relationships between sleep quality and daily mood and between stress management self-efficacy and stress were conducted in order to assess whether the findings in the present study aligned with previous research suggesting a potential association between these variables. By examining these relationships in the current dataset, it aimed to determine if the observed associations hold true in the specific context of the present study. Additionally, the Pearson correlation analyses between stress and daily mood, and stress and sleep quality were conducted to explore the relationships between stress and its potential outcomes to evaluate the appropriateness of the selected variables. It is well-established in the literature that stress can have an impact on daily mood and sleep quality. Thus, by assessing the correlation between stress and these variables, the study aimed to further understand the extent of their associations and shed light on the interplay between stress and its related factors, which can contribute to the knowledge of how stress influences individuals' well-being and inform interventions for managing stress effectively.

Lastly, descriptive statistics were employed to analyze the data of the CSQ-I. A qualitative approach was employed to analyze the qualitative UX data, focusing on summarizing the suggestions of participants. Through these diverse analyses, a comprehensive understanding of the associations and effects of WeMind Balance on the various variables was achieved. A significance level of .05 – .10 was regarded as marginally significant, indicating a trend towards statistical significance. Conversely, a significance level of $p < .05$ was considered the threshold for statistical significance.

Results

This results section presents the findings of the statistical analyses conducted.

Daily Mood

The boxplots visually depict the course of daily mood scores over time (see Figure 2). The baseline phase demonstrated a relatively wide range of scores, with a mean of 7.2 and a standard deviation of 2.2 (see Table 2). This indicates variability in daily mood levels among participants during the initial phase of the study. The minimum score for daily mood was 2.3, indicating a relatively low level, which stood out as significantly lower compared to subsequent phases. Additionally, the standard deviation was notably higher during the baseline phase, reflecting greater variability in participants' baseline mood measurements. In intervention phase 1, the mean daily mood score increased slightly to 7.4, accompanied by a decrease in the standard deviation to 1.4. The narrower distribution suggests a more consistent daily mood experience among participants during this phase compared to the baseline phase. During intervention phase 2, the mean daily mood score remained stable at 7.4, with a slightly higher median of 7.6. The standard deviation further decreased to 1.3, indicating even less variability in daily mood scores during this phase compared to both the baseline and intervention phase 1.

Figure 2

Boxplots of Daily Mood for Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

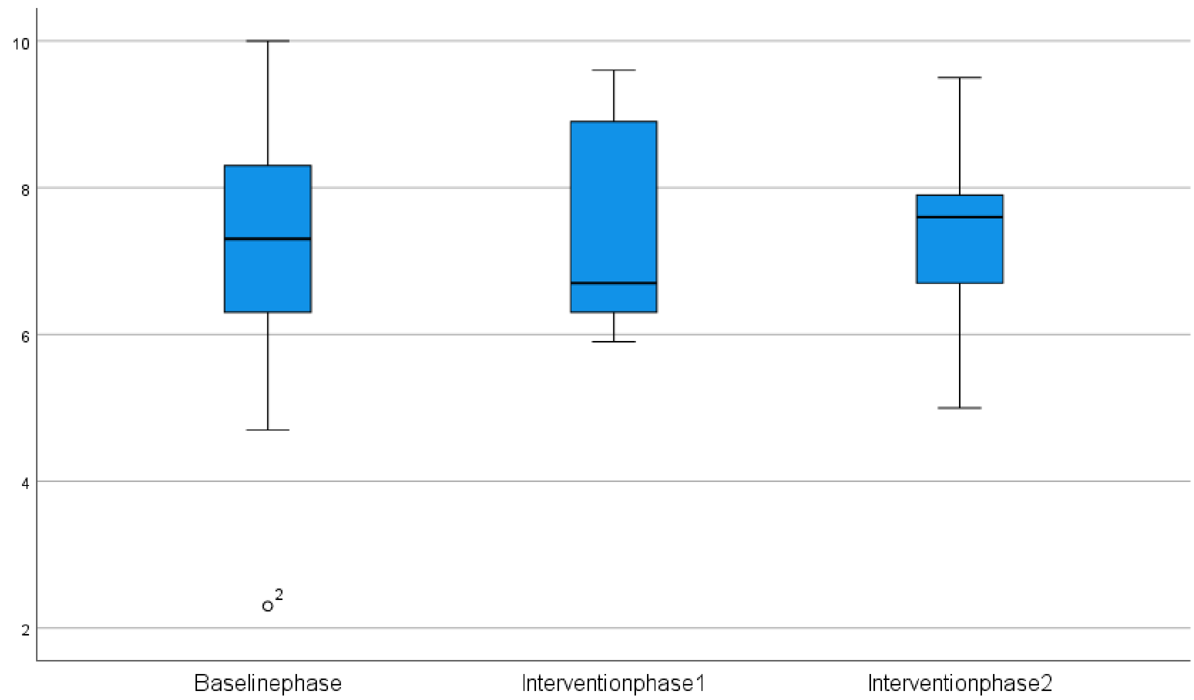


Table 2

Descriptive Statistics of Daily Mood for the Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

	Baseline phase	Intervention phase 1	Intervention phase 2
Mean	7.2	7.4	7.4
Median	7.3	6.7	7.6
SD	2.2	1.4	1.3
Minimum	2.3	5.9	5
Maximum	10	9.6	9.5

Repeated Measures ANOVA Daily Mood

A repeated measures ANOVA was conducted to examine the impact of WeMind Balance on daily mood over the baseline phase, intervention phase 1, and intervention phase 2 (see Figure 2 for the boxplots of daily mood). The statistical analysis employed Wilks' Lambda as the test statistic, with a significance level of $\alpha = 0.05$. The observed power was calculated to determine the study's statistical power. The Mauchly's test of sphericity was conducted, yielding a *p*-value of .018. This result indicates a violation of the assumption of sphericity.

The results of the repeated measures ANOVA revealed that there was no statistically significant effect of WeMind Balance on daily mood, as indicated by Wilks' Lambda = .97, $F(2, 45) = .18$, $p = .845$, $\eta^2 = .03$ (N=13). The observed power of the study was .07, indicating a low statistical power to detect a significant effect. Based on these findings, it can be concluded that WeMind Balance did not result in a significant improvement in daily mood over the three-week intervention period.

Linear Mixed Modeling Daily Mood

Table 3

Results of Post-hoc Test of Linear Mixed Model with Time as Fixed Factor and Its Effect on Daily Mood (With Intervention Phase 2 as Reference Category) (N=32)

	Estimated mean	95% CI	*p*
Baseline phase	6.3	4.0 – 8.3	.096
Intervention phase 1	6.7	4.3 – 7.9	.295
Intervention phase 2	7.4	6.3 – 8.5	-

Note. P-values between .05 – .10 are considered marginally significant. *P*-values less than .05 are considered significant.

Likewise, the results of the linear mixed modeling analysis revealed that there was no significant effect of WeMind Balance on daily mood ($p > .05$, F = 1.43) (see Table 3). However, it is noteworthy to mention that the increase from baseline to the second follow-up was shown marginally significant ($p = .096$). The scores did show a moderate enhancement over time, suggesting a positive trend over time. This implies that although the app did not yield statistically significant improvements in daily mood, there was a noticeable positive shift in participants' mood scores throughout the intervention period.

Stress Management Self-efficacy

The boxplots visually depict the course of stress management self-efficacy scores over time (see Figure 3). In the baseline phase, participants reported a moderate level of stress management self-efficacy, with a mean score of 3.7 and a standard deviation of .9 (see Table 4). The relatively wide range of scores, as evidenced by the minimum and maximum values, indicates variability in individuals' perceived self-efficacy in managing stress at the beginning of the study. During intervention phase 1, there was a slight increase in the mean stress management self-efficacy score to 3.8, accompanied by a decrease in the standard deviation to .6. This suggests a trend towards slightly higher levels of perceived self-efficacy in stress management among participants during this phase compared to the baseline phase. In intervention phase 2, the mean self-efficacy score remained stable at 3.8, with a slightly higher median of 3.9. The standard deviation increased slightly to .7, indicating a relatively consistent level of perceived self-efficacy in stress management during this phase.

Figure 3

Boxplots of Stress Management Self-efficacy for Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

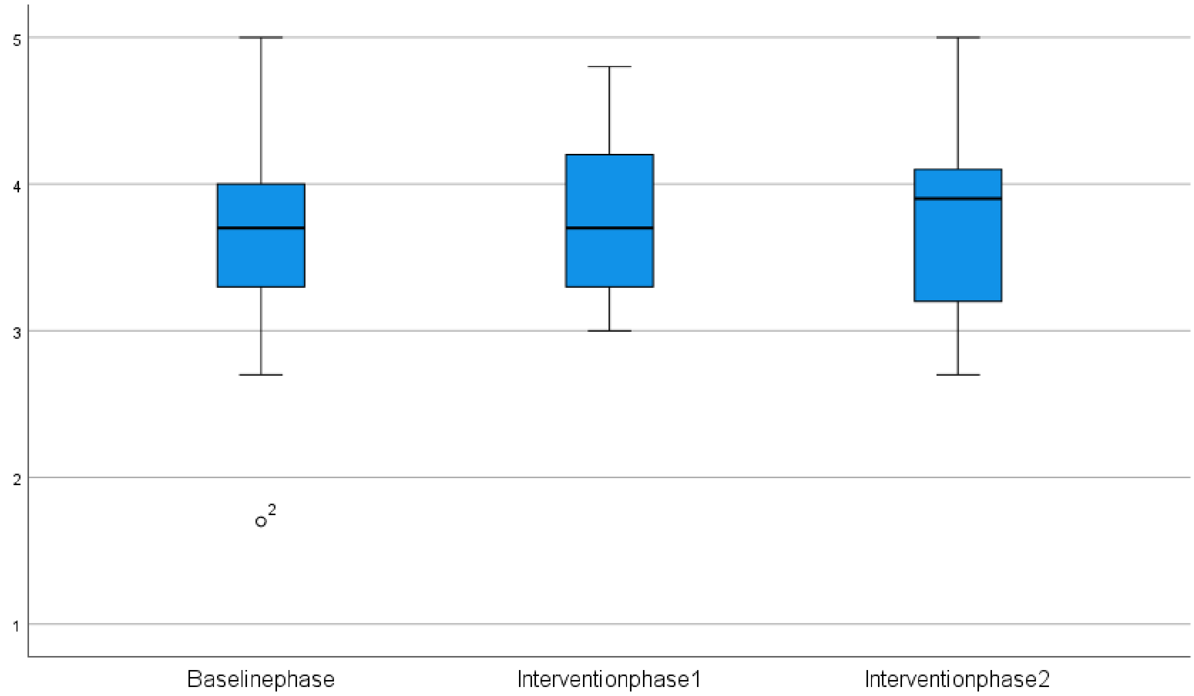


Table 4

Descriptive Statistics of Stress Management Self-efficacy for Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

	Baseline phase	Intervention phase 1	Intervention phase 2
Mean	3.7	3.8	3.8
Median	3.7	3.7	3.9
SD	.9	.6	.7
Minimum	1.7	3	2.7
Maximum	5	4.8	5

Repeated Measures ANOVA Stress Management Self-efficacy

The results of the repeated measures ANOVA indicated a non-significant effect of WeMind Balance on stress management self-efficacy, Wilks' Lambda = .96, $F(2, 45) = .23$, $p = .803$, $\eta^2 = .04$ (N=13) (see Figure 3 for the boxplots of stress management self-efficacy).

The observed power of the study was found to be .08, indicating limited statistical power to detect a significant effect. These findings suggest that WeMind Balance did not have a significant impact on stress management self-efficacy over the three-week period. The Mauchly's test of sphericity was conducted, yielding a *p*-value of .189. This result indicates that there is no significant violation of the assumption of sphericity.

Linear Mixed Modeling Stress Management Self-efficacy

Table 5

Results of Post-hoc Test of Linear Mixed Model with Time as Fixed Factor and Its Effect on Stress Management Self-efficacy (With Intervention Phase 2 as Reference Category) (N=32)

	Estimated mean	95% CI	*p*
Baseline phase	3.4	2.5 – 4.4	.192
Intervention phase 1	3.6	2.6 – 4.5	.465
Intervention phase 2	3.8	3.3 – 4.2	-

Note. P-values between .05 – .10 are considered marginally significant. *P*-values less than .05 are considered significant.

Similarly, the results of the linear mixed modeling analysis revealed no significant effect of the app on stress management self-efficacy ($p > .05$, F = .89) (see Table 5). Nevertheless, the scores demonstrated a moderate enhancement, indicating a favorable trend in participants' perceived ability to manage stress.

Sleep Quality

The boxplots visually depict the course of sleep quality over time (see Figure 4). In the baseline phase, participants reported an average sleep quality score of 6.9, with some variability indicated by the standard deviation of 2.0 (see Table 6). The range of scores, as evidenced by the minimum and maximum values, reflects the diversity of sleep quality among participants at the beginning of the study. During intervention phase 1, there was a slight increase in the mean sleep quality score to 7.0, accompanied by a decrease in the standard deviation to 1.3. This suggests a trend towards improved sleep quality among participants during this phase compared to the baseline phase. In intervention phase 2, there was a further improvement in sleep quality, with the mean score reaching 7.3 and a higher median of 7.6.

The standard deviation increased slightly to 1.5, indicating some variability in sleep quality during this phase.

Figure 4

Boxplots of Sleep Quality for Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

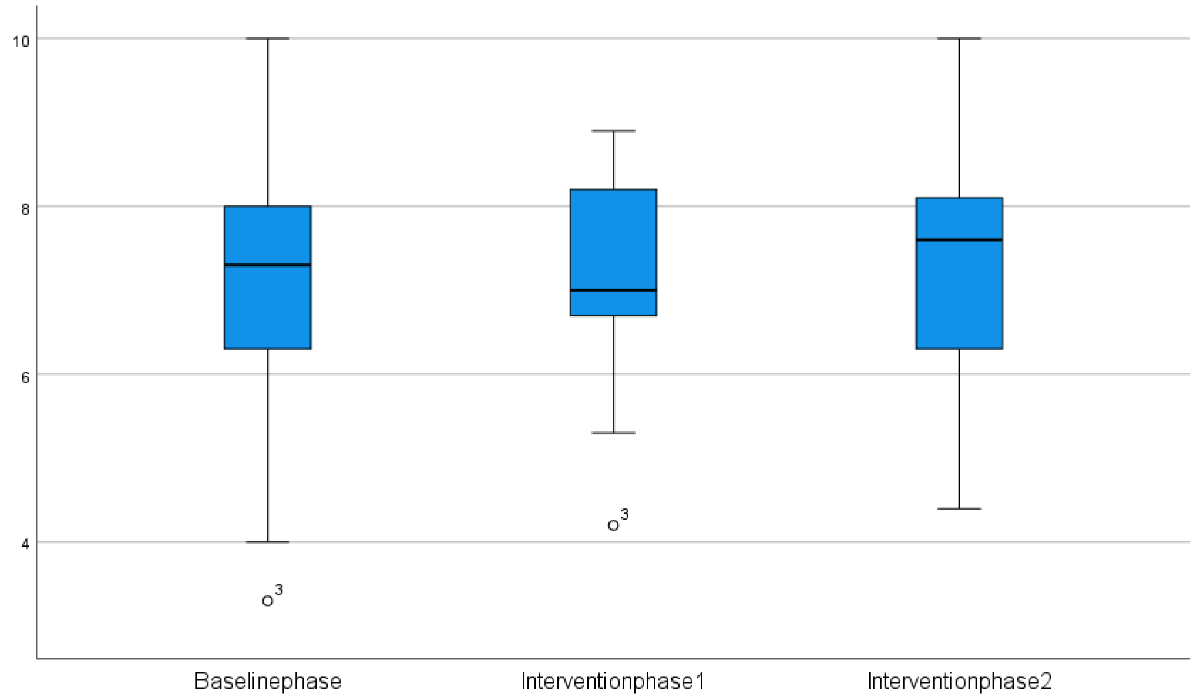


Table 6

Descriptive Statistics of Sleep Quality for Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

	Baseline phase	Intervention phase 1	Intervention phase 2
Mean	6.9	7.0	7.3
Median	7.3	7.0	7.6
SD	2.0	1.3	1.5
Minimum	3.3	4.2	4.4
Maximum	10	8.9	10

Repeated Measures ANOVA Sleep Quality

The results of the repeated measures ANOVA revealed that WeMind Balance did not yield a significant effect on sleep quality, as indicated by Wilks' Lambda = .93, F(2, 45) = .32, p = .681, η^2 = .07 (N=13) (see Figure 4 for the boxplots of sleep quality). The observed power of the study was .10, suggesting a low statistical power to detect a significant effect. Based on these findings, it can be concluded that WeMind Balance did not produce statistically significant improvements in sleep quality over the three-week intervention period. The Mauchly's test of sphericity was conducted, and the resulting p-value was .016. This significant p-value suggests a violation of the assumption of sphericity.

Linear Mixed Modeling Sleep Quality

Table 7

Results of Post-hoc Test of Linear Mixed Model with Time as Fixed Factor and Its Effect on Sleep Quality (With Intervention Phase 2 as Reference Category) (N=32)

	Estimated mean	95% CI	*p*
Baseline phase	6.2	3.8 – 8.6	.089
Intervention phase 1	6.4	4.0 – 8.9	.198
Intervention phase 2	7.3	6.2 – 8.4	-

Note. P-values between .05 – .10 are considered marginally significant. *P*-values less than .05 are considered significant.

Furthermore, the linear mixed modeling analysis revealed no significant effect of the app on sleep quality (p > .05, F = 1.51) (see Table 7). However, it is noteworthy to mention that the increase from baseline to the second follow-up was shown marginally significant (p = .089). The scores exhibited a moderate enhancement, indicating a positive trend in sleep quality over time**.**

Stress

The boxplots visually depict the course of stress over time (see Figure 5). In the baseline phase, participants reported an average stress level with considerable variability, as indicated by the standard deviation of 2.7 (see Table 8). The range of scores, represented by the minimum and maximum values, demonstrates the diversity of stress levels among participants at the beginning of the study. During intervention phase 1, there was a slight increase in the mean stress level to 4.3, accompanied by a decrease in the standard deviation to 2.1. This suggests a trend towards slightly higher stress levels among participants during this phase compared to the baseline phase. In intervention phase 2, there was a further increase in stress levels, with the mean score reaching 4.6 and a higher median of 5.6. The standard deviation increased to 2.8, indicating increased variability in stress levels during this phase.

Figure 5

Boxplots of Stress for Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

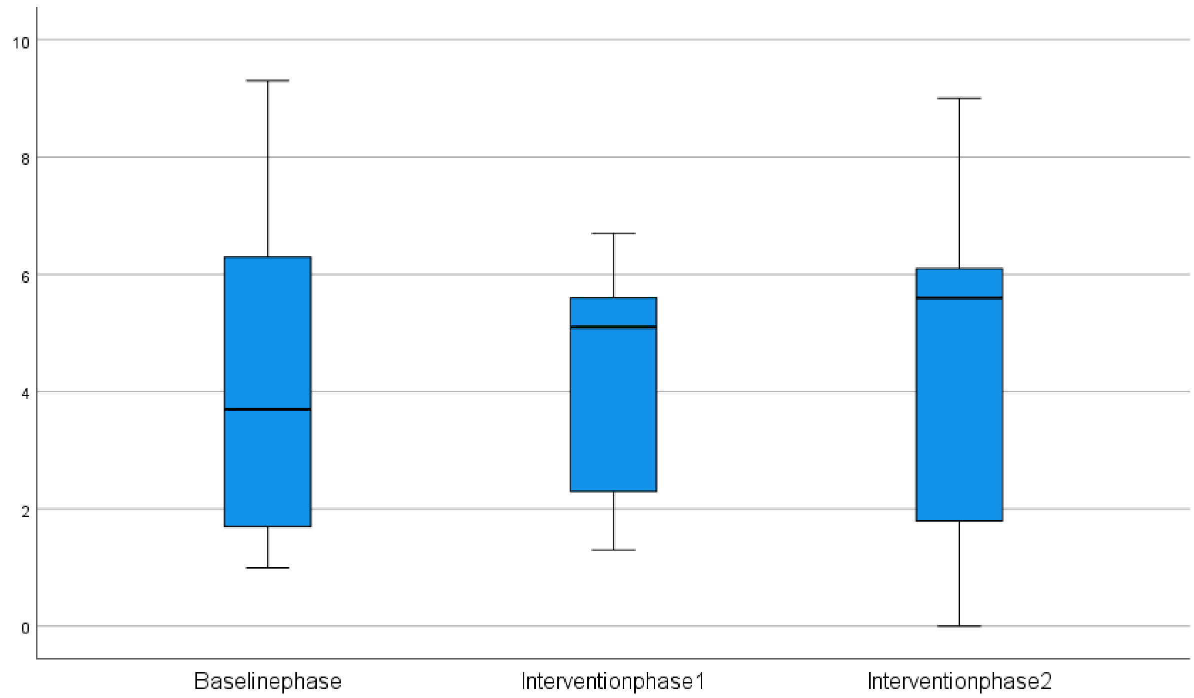


Table 8

Descriptive Statistics of Stress for Baseline Phase, Intervention Phase 1, and Intervention Phase 2 (N=13)

	Baseline phase	Intervention phase 1	Intervention phase 2
Mean	4.2	4.3	4.6
Median	3.7	5.1	5.6
SD	2.7	2.1	2.8
Minimum	1	1.3	0
Maximum	9.3	6.7	9

Repeated Measures ANOVA Stress

The results of the repeated measures ANOVA revealed no statistically significant effect of WeMind Balance on stress, with Wilks' Lambda = .96, F(2, 45) = .15, p = .778, η^2 = .05 (N=13) (see Figure 5 for the boxplots of stress). The observed power for the study was .08, indicating a low statistical power to detect a significant effect. In light of these findings, it can be concluded that WeMind Balance did not result in a significant reduction in stress levels over the three-week intervention period. The Mauchly's test of sphericity was performed, and the resulting p-value was .003. This significant p-value indicates a violation of the assumption of sphericity.

Linear Mixed Modeling Stress

Table 9

Results of Post-hoc Test of Linear Mixed Model with Time as Fixed Factor and Its Effect on Stress (With Intervention Phase 2 as Reference Category) (N=32)

	Estimated mean	95% CI	*p*
Baseline phase	4.8	2.0 – 7.6	.844
Intervention phase 1	4.4	1.5 – 7.2	.457
Intervention phase 2	4.9	3.7 – 6.2	-

Note. P-values between .05 – .10 are considered marginally significant. *P*-values less than .05 are considered significant.

Likewise, no significant effect of the app on perceived stress was found in the linear mixed model analysis (p > .05, F = .38) (see Table 9). The scores displayed a moderate increase, indicating a negative trend in participants' perceived stress levels. However, this increase was non-significant, indicating that stress remained relatively stable throughout the intervention period.

In summary, the analyses did not identify any statistically significant effects of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and perceived stress. However, it is important to note that the scores consistently demonstrated moderate enhancements in daily mood, stress management self-efficacy, and sleep quality, with some changes from the baseline phase to intervention phase 2 reaching marginal significance, suggesting a positive trend over time.

Impact of Adherence on Effect of WeMind Balance

It was hypothesized that higher levels of adherence would be associated with a greater effect on the intended outcomes compared to lower levels of adherence. The average adherence rate in the sample was 22.5% (Mean = 5, SE = 6.4), indicating a moderate level of engagement with the app. Participants' adherence levels highly varied. To investigate the relationship between adherence and effectiveness, separate repeated measures ANOVAs were performed for daily mood, stress management self-efficacy, sleep quality, and stress in general, and n=1 analyses comparing two individuals were conducted.

Daily Mood

Table 10

Descriptive Statistics of Daily Mood for Low Adherent Group and High Adherent Group (N=13)

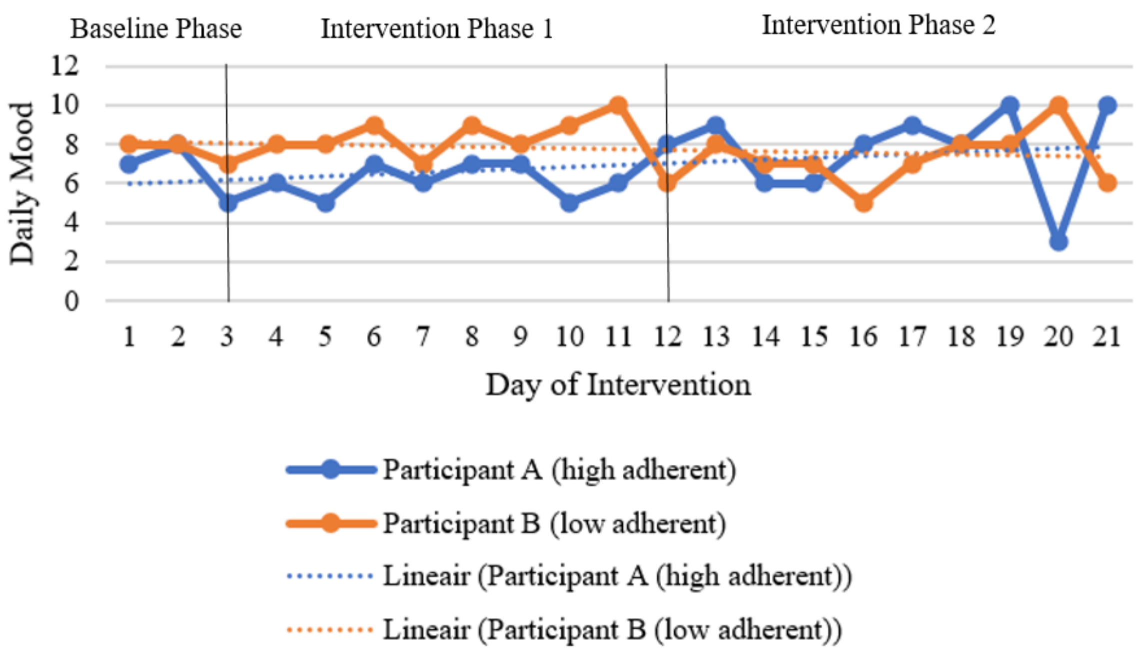
		$\text{Adherence}_{\text{low}}$	$\text{Adherence}_{\text{high}}$
Baseline	Mean	7.4	7.0
phase	SD	2.1	2.4
Intervention	Mean	7.6	7.3
phase 1	SD	1.5	1.3
Intervention	Mean	7.3	7.5
phase 2	SD	1.8	1.0

The results of the repeated measures ANOVA for daily mood revealed that there were no significant differences in daily mood between participants with high adherence and those with low adherence to WeMind Balance over time (p = .846). These findings indicate that the level of adherence, whether high or low, did not have a statistically significant effect on participants' daily mood.

N=1 Analysis Daily Mood

Figure 6

Daily Mood of Participant A (High Adherent) and Participant B (Low Adherent) for Baseline Phase, Intervention Phase 1, and Intervention Phase 2



Upon visual inspection of the graph (see Figure 6), no clear pattern indicative of an immediate response to the intervention was observed. The graph displayed scattered data points for both participants, suggesting individual variability in daily mood experiences. Specifically, there were no noticeable differences between the baseline phase and the intervention phase, indicating that the app did not result in an immediate distinct change in daily mood. Nevertheless, when examining the linear line of the high adherent participant's data, a slight improvement in daily mood over time was observed. In contrast, the linear line representing the low adherent participant's data did not exhibit a noticeable trend of improvement. Furthermore, no notable differences were found in the data between weekdays and weekends, suggesting that the app's effect on daily mood did not vary depending on the day of the week. Based on the visual inspection of the graph, the level of adherence to the app appeared to influence the extent of improvement, with higher adherence associated with greater enhancements in daily mood.

Stress Management Self-efficacy

Table 11

Descriptive Statistics of Stress Management Self-efficacy for Low Adherent Group and High Adherent Group (N=13)

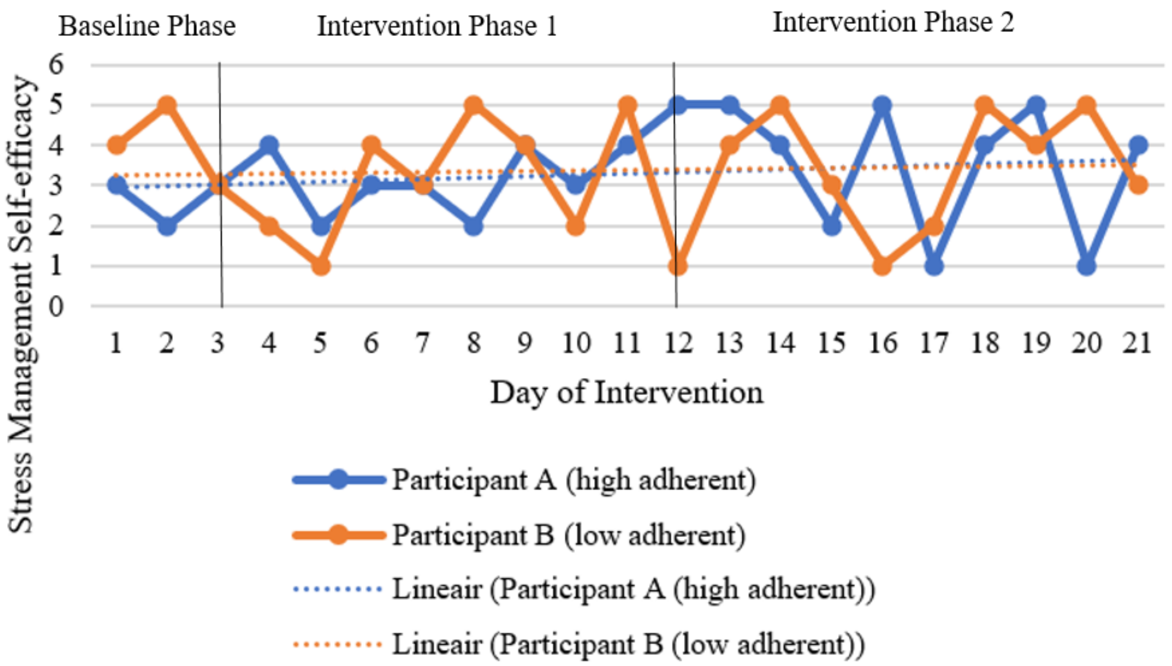
		Adherence_{low}	Adherence_{high}
Baseline	Mean	4.1	3.3
phase	SD	.8	.9
Intervention	Mean	3.9	3.7
phase 1	SD	.7	.5
Intervention	Mean	4.0	3.6
phase 2	SD	.6	.7

The repeated measures ANOVA revealed no significant difference in stress management self-efficacy between the high adherent group and the low adherent group. The mean stress management self-efficacy score for the high adherent group was not significantly different from the mean score for the low adherent group over time (p = .216).

N=1 Analysis Stress Management Self-efficacy

Figure 7

Stress Management Self-efficacy of Participant A (High Adherent) and Participant B (Low Adherent) for Baseline Phase, Intervention Phase 1, and Intervention Phase 2



Upon visual inspection of the graph (see Figure 7), no clear pattern emerged in the data, suggesting that there were no noticeable differences between the baseline phase and the intervention phase in terms of stress management self-efficacy. This indicates that the app did not yield an immediate impact on participants' stress management self-efficacy levels. The data of both participants appeared scattered, indicating varying levels of stress management self-efficacy throughout the study period. However, when examining the linear line of the data for the high adherent participant, a trend of slight improvement in stress management self-efficacy compared to the low adherent participant was observed. Additionally, there were no notable differences in the stress management self-efficacy data between weekdays and weekends, suggesting that the app's effect on stress management self-efficacy was consistent across different time periods.

Sleep Quality

Table 12

Descriptive Statistics of Sleep Quality for Low Adherent Group and High Adherent Group (N=13)

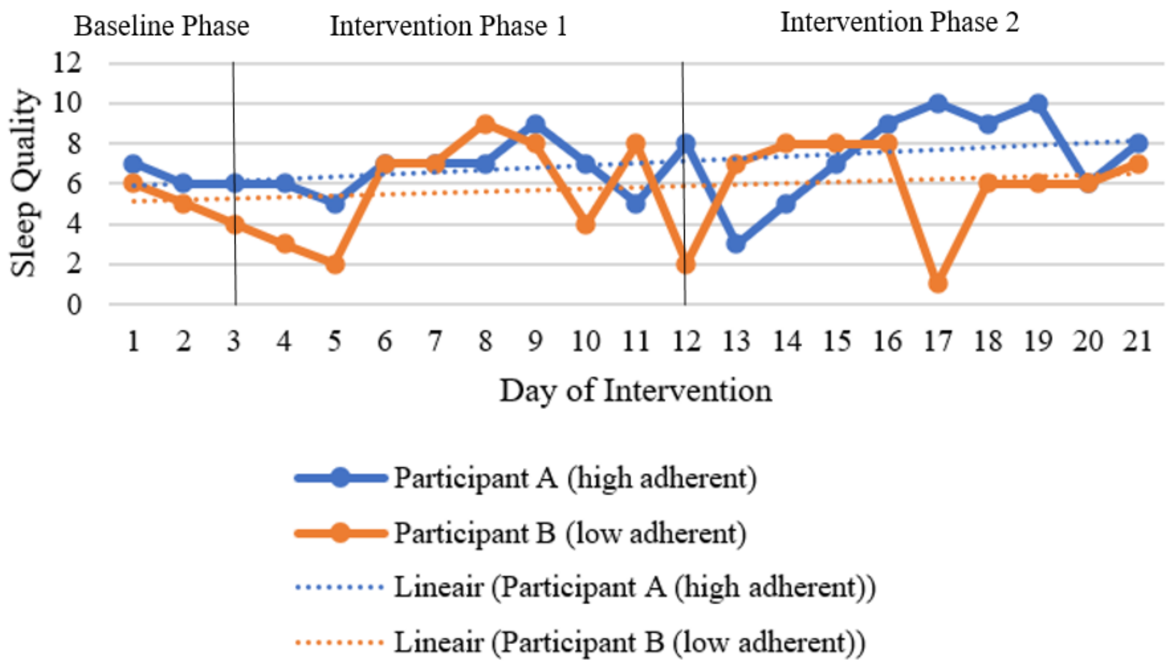
		$Adherence_{low}$	$Adherence_{high}$
Baseline	Mean	6.6	7.3
phase	SD	2.9	.9
Intervention	Mean	6.7	7.3
phase 1	SD	1.6	1.2
Intervention	Mean	7.6	7.1
phase 2	SD	1.7	1.5

The repeated measures ANOVA for sleep quality revealed no significant difference in sleep quality between the high adherent group and low adherent group over time. The *p*-value of .702 indicates that the difference in sleep quality between high adherent and low adherent participants is not statistically significant over time. Therefore, based on the available data, there is insufficient evidence to conclude that adherence to the intervention has a significant impact on sleep quality.

N=1 Analysis Sleep Quality

Figure 8

Sleep Quality of Participant A (High Adherent) and Participant B (Low Adherent) for Baseline Phase, Intervention Phase 1, and Intervention Phase 2



Upon visual inspection of the graph (see Figure 8), it was observed that both participants demonstrated a notable improvement in sleep quality after day 5 of the intervention, which was day 2 of intervention phase 1. From this point onwards, sleep quality consistently improved for both cases for a period of 3 to 4 days. This observation suggests that the app may have elicited an immediate, short-term response in sleep quality, specifically considering that the intervention phase started at day 4. Starting from approximately day 13/14 until the end of the intervention, another trend of improvement in sleep quality was evident for both individuals. However, it is important to note that there was a notable negative outlier for the low adherent participant towards the end of the intervention. No notable differences in sleep quality were found between weekdays and weekends for both individuals. Overall, both individuals showed slight improvements in sleep quality. However, when examining the linear trend lines, the data of the high adherent participant displayed more improvement compared to the low adherent participant. Based on the visual inspection of the graph, the level of adherence to the app appeared to influence the extent of improvement, with higher adherence associated with greater enhancements in sleep quality.

Stress

Table 13

Descriptive Statistics of Stress for Low Adherent Group and High Adherent Group (N=13)

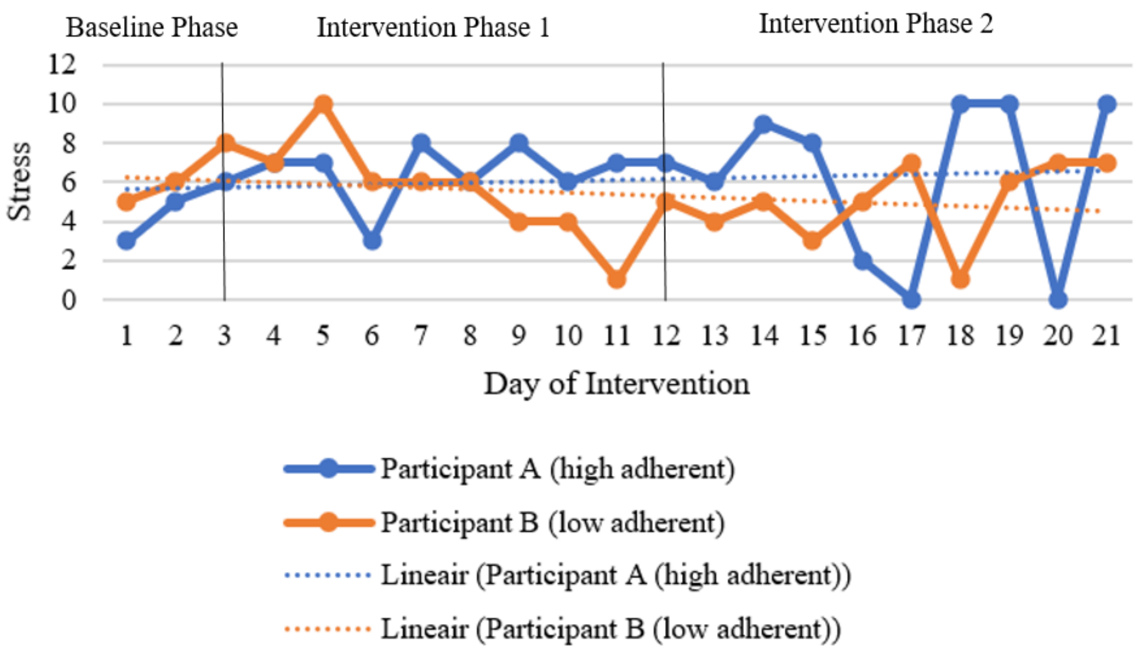
		Adherence_{low}	Adherence_{high}
Baseline	Mean	4.1	4.6
phase	SD	2.4	3.2
Intervention	Mean	4.3	4.7
phase 1	SD	2.1	2.0
Intervention	Mean	5.2	4.7
phase 2	SD	2.9	2.6

The repeated measures ANOVA for stress revealed no significant difference in stress between the high adherent group and low adherent group ($p = .904$). The non-significant *p*-value suggests that any observed differences in perceived stress between the high and low adherent group could be due to random variation or chance. Therefore, it cannot be concluded that adherence to the app has a significant effect on perceived stress.

N=1 Analysis Stress

Figure 9

Stress of Participant A (High Adherent) and Participant B (Low Adherent) for Baseline Phase, Intervention Phase 1, and Intervention Phase 2



Upon visual inspection of the graph (see Figure 9), a notable reduction in stress was observed during intervention phase 1 for the low adherent participant. This suggests that the app had an immediate positive impact on reducing stress levels for this individual during the initial phase of the intervention. In contrast, for the high adherent participant, a notable reduction in stress was observed during intervention phase 2. However, it is important to note that some peaks in stress were observed towards the end of the intervention period for this participant. The data of both participants appeared scattered, indicating variability in stress levels over time. When examining the linear lines of the data, it appeared that the low adherent participant experienced a greater reduction in stress compared to the high adherent participant. No notable differences in stress levels were found between weekdays and weekends for both individuals, suggesting that stress patterns were consistent throughout the week.

Correlations between Variables

Correlation Sleep Quality and Daily Mood

The results of the Pearson correlation analysis to examine the relationship between sleep quality and daily mood revealed a significant positive correlation between sleep quality and daily mood ($r = .50$, $p < .001$), indicating a moderate-to-strong positive association.

Correlation Stress Management Self-efficacy and Stress

The results of the Pearson correlation analysis to examine the relationship between stress management self-efficacy and stress revealed a significant negative correlation between these variables ($r = -.76$, $p < .001$), indicating a strong negative association.

Correlation Stress and Sleep Quality

The results of the Pearson correlation analysis to examine the relationship between sleep quality and stress indicated a weak negative correlation between the two variables (r = -.21, $p = .258$). This correlation was not statistically significant, suggesting that there is no conclusive evidence of a significant relationship between sleep quality and stress.

Correlation Stress and Daily Mood

The results of the Pearson correlation analysis to examine the relationship between stress and daily mood revealed a strong negative correlation between the two variables ($r = -.58$, $p < .001$). The negative correlation suggests that as levels of stress increase, daily mood tends to decrease.

User Experience

Table 14

Item Means and Distribution of Scores on Client Satisfaction Questionnaire (CSQ-I) Items (N=10)

Item	Mean (SD)	"Does not apply to me" n (%)	"Does rather not apply to me" n (%)	"Does partly apply to me" n (%)	"Does totally apply to me" n (%)
The intervention I followed was of high quality	3.1 (.32)	0	0	9 (90)	1 (10)
I received the kind of intervention I wanted	3.3 (.67)	0	1 (10)	5 (50)	4 (40)
The intervention has met my needs	3.1 (.57)	0	1 (10)	7 (70)	2 (20)
I would recommend this intervention to a friend, if he or she were in need of similar help	3.1 (.88)	0	3 (30)	3 (30)	4 (40)
I am satisfied with the amount of	2.9 (.57)	0	2 (20)	7 (70)	1 (10)

Item	Mean (SD)	"Does not apply to me" n (%)	"Does rather not apply to me" n (%)	"Does partly apply to me" n (%)	"Does totally apply to me" n (%)
help I received through the intervention					
The intervention helped me deal with my problems more effectively	3.2 (.79)	0	2 (20)	4 (40)	4 (40)
In an overall, general sense, I am satisfied with the intervention	3.2 (.79)	0	2 (20)	4 (40)	4 (40)
I would come back to such an intervention if I were to seek help again	3.3 (.95)	0	3 (30)	1 (10)	6 (60)

The results of the UX evaluation provide valuable insights into the experience and satisfaction of WeMind Balance by the participants (see Table 14). Participants assigned a score of 3.1 on a scale of 4 on the quality of the intervention, indicating that they perceived the intervention as of high quality. Participants assigned a score of 3.3 on a scale of 4 to the second item, indicating that they received the kind of intervention they wanted. Participants assigned a score of 3.1 on a scale of 4 on the third item, indicating that the intervention effectively met their needs. Participants assigned a score of 3.1 on a scale of 4 to the fourth item, indicating that they would recommend the intervention to a friend. Participants assigned a score of 2.9 on a scale of 4 to the fifth item, indicating a moderate level of satisfaction with the amount of help they received. Participants assigned a score of 3.2 on a scale of 4 to the sixth item, indicating that the intervention helped them deal with their problems more effectively. Participants assigned a score of 3.2 on a scale of 4 on the seventh item, indicating a generally high level of satisfaction with the intervention. Participants assigned a score of 3.3 on a scale of 4 on the eighth item, indicating a strong inclination to come back to such an intervention if they were to seek help again.

Additional to the quantitative data regarding UX, participants provided valuable feedback and suggestions for improving WeMind Balance. Several themes emerged from their responses, which are summarized below. Some participants expressed the desire for the app to send daily reminders to encourage consistent use. They also suggested incorporating a feature that allows users to track their perceived stress levels over time. This would provide them with more insight into their stress patterns and help identify effective strategies to cope with stress. Some participants noted that converting the app into a mobile phone application could enhance its accessibility. They felt that having the app readily available on their mobile devices would increase the likelihood of using the stress management tools regularly. Additionally, participants mentioned that they often overlooked the app because it was accessed through a website, which they did not frequently visit. Some participants expressed an interest in the app including a feature to monitor and track their sleep quality. They highlighted the importance of understanding their sleep patterns and having the app provide information on the progression of their sleep quality over time. This feedback suggests that integrating sleep tracking functionality could be beneficial for users. Some participants emphasized the need for the app to offer specific information and resources on preventing stress, particularly tailored to the context of students. They expressed a desire for educational materials that address stress management techniques and provide guidance on stress prevention strategies that are relevant to their daily lives as students. Some participants suggested incorporating more short exercises, lasting 3 to 5 minutes, that can be easily performed when individuals are feeling stressed but have limited time. These on-the-go exercises would provide quick relief and help users manage stress effectively, even when they are busy with other tasks.

Discussion

The purpose of this SCED pilot study was to assess the effectiveness of an app-based stress management intervention aimed at stress reduction in students. The study assessed the impact of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and stress. Additionally, the study assessed the impact of the level of adherence, the correlations between stress and daily mood, stress management self-efficacy and stress, stress and sleep quality, and stress and daily mood. Lastly, the study assessed the UX of WeMind Balance.

Main Findings

Contrary to the expectations, the findings of the present study indicate that WeMind Balance did not demonstrate a significant effect on daily mood, stress management self-efficacy, sleep quality, and stress. This lack of observed impact can be attributed to several factors that warrant discussion. Firstly, the study sample displayed relatively high baseline levels of daily mood, stress management self-efficacy, and sleep quality, while exhibiting a low baseline level of stress. This suggests that participants in the study may have already possessed relatively strong mental well-being and coping abilities prior to the intervention. As a result, the potential for improvement or significant change in these variables may have been limited. The sample may have required a more intensive or targeted intervention to elicit further enhancements in these areas compared to a sample with lower baseline levels. It is important to consider the implications of these findings in the context of the intervention design and the characteristics of the study population. WeMind Balance may have been effective for individuals with lower initial levels of daily mood, stress management self-efficacy, and sleep quality, as well as higher levels of stress.

Additionally, other factors such as the duration and intensity of the intervention should be taken into account. The current study employed a relatively short intervention period of three weeks, which may have limited the extent of change that could be achieved within the given timeframe. A longer intervention period or a more intensive treatment approach may have yielded different results and led to more noticeable improvements in the targeted outcomes. It is important to consider that changes in psychological and physiological variables such as mood, self-efficacy, sleep quality, and stress may take time to manifest and stabilize. A study conducted by Caldwell et al. (2010) provides valuable insights into the impact of a mindfulness intervention on similar variables over a longer duration. In their study, they measured self-regulatory self-efficacy, mood, perceived stress, and sleep quality in students over a period of 15 weeks. Their findings revealed significant improvements in all of these variables over time, suggesting that a longer intervention duration may be necessary to observe significant changes. The short intervention duration might have limited the opportunity for participants to fully engage with the app and experience its potential benefits. It is possible that a longer intervention period would have allowed participants to develop a more consistent routine, establish stronger app adherence, and subsequently experience improvements in daily mood, stress management self-efficacy, sleep quality, and stress. Moreover, a longer intervention duration could provide more opportunities for participants to integrate the app into their daily lives and develop sustainable habits and skills that contribute to positive outcomes. This aligns with the notion that behavioral changes and psychological adjustments often require time and repeated practice to be effective (Kwasnicka et al., 2016).

It is worth noting that while the present study did not identify significant effects, the observed trends indicated slight improvements in daily mood, stress management self-efficacy, and sleep quality over the three-week period. The lack of statistical significance does not necessarily imply a lack of any effect of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and stress in general. These changes may still hold practical significance and suggest the potential benefits of WeMind Balance in supporting overall well-being. These findings imply that while the app may not have produced significant changes in the included variables under investigation, it had a tendency towards a favorable impact, albeit modest, on participants' experiences and perceptions related to daily mood, stress management self-efficacy, and sleep quality. Furthermore, the results revealed a notable pattern of marginal effects in these variables from the baseline phase to intervention phase 2. This pattern of marginal effects supports the presence of a delayed response to the intervention.

While adherence did not demonstrate a significant impact on the app's effectiveness in this study, further investigation is warranted to better understand the complex interplay between adherence and the outcomes of the intervention targeting daily mood, stress management self-efficacy, sleep quality, and stress. Firstly, it is important to consider the measurement and assessment of adherence in this study. The used self-reported adherence measure may have been subject to recall bias or social desirability bias, leading to inaccuracies in reporting actual app usage (Althubaiti, 2016). Moreover, the intervention duration might not have been sufficient to capture the full potential effects of adherence on the outcomes. It is also important to note that the definition of high and low adherence used in this study influenced the classification of participants into high and low adherence groups and subsequently impacted the results. The definition of high and low adherence used in this study was based on a minimum threshold of ten out of 22 app usage instances. Alternative cut off points could have yielded different results.

Additionally, clarification is required to better understand the inconsistency observed between the outcomes of the repeated measures ANOVAs and the n=1 analyses regarding the impact of adherence on the effect of the intervention. One possible explanation could be related to the nature of the analyses and the sample size. The repeated measures ANOVA, which included a larger group of participants, may have resulted in a larger variance due to individual differences within each group. As a result, the overall effect of adherence on the app's effectiveness may have been diluted or masked by the variability among participants. Therefore, the statistical analysis did not find a significant impact of adherence on the app's effect. Additionally, the difference in data inclusion could be another possible explanation. In the repeated measures ANOVAs, only average scores per phase were used, which may have attenuated the individual-level effects. On the other hand, the n=1 analysis included all data points over the intervention period, allowing for a more detailed examination of individual responses. This could explain the observed higher effect of the app on daily mood, stress management self-efficacy, and sleep quality on the high adherent individual compared to the low adherent individual in the n=1 analysis. However, it is important to note that these explanations are speculative and should be interpreted with caution, as they are based on data from only two individuals. The limited sample size restricts the generalizability of the findings and increases the potential influence of individual differences.

The positive correlation coefficient between sleep quality and daily mood suggests that higher levels of sleep quality were associated with more positive daily mood ratings. This finding is in line with the literature (Konjarski et al., 2018) and suggests that individuals who reported better sleep quality tended to experience more positive daily moods compared to those with poorer sleep quality. These findings emphasize the significant relationship between sleep quality and daily mood. It suggests that sleep quality plays a crucial role in influencing individuals' emotional well-being and highlights the potential impact of sleep on daily mood fluctuations and the importance of an intervention contributing to prevent sleep disturbance.

The high negative correlation observed between stress management self-efficacy and perceived stress suggests a strong association between individuals' beliefs in their ability to manage stress and their reported levels of stress. The negative correlation coefficient indicates that higher levels of stress management self-efficacy were associated with lower levels of perceived stress. This finding is in line with the literature (Sawatzky et al., 2012) and underscores the importance of considering individuals' beliefs in their stress management abilities and highlights the potential benefits of an intervention targeting stress management self-efficacy in reducing perceived stress levels.

However, it is important to consider the potential influence of the measurement instrument used to assess stress management self-efficacy on this correlation. The measurement instrument utilized in this study posed a question to participants in a retrospective manner, asking them to reflect on how well they actually succeeded in coping effectively on that particular day. This approach may have introduced a limitation in accurately capturing participants' overall stress management self-efficacy, as it focused on passed behaviour, rather than their expectancy of future behaviour, and a narrow timeframe rather than a broader and more general sense of self-efficacy in stress management. As a result, participants' responses to the self-efficacy measure may have been influenced by their current state of stress. When participants rated their stress levels as low on a specific day, there is a high likelihood that they automatically rated their stress management self-efficacy as high, given the association between perceived stress and self-efficacy beliefs. This could have contributed to the inflated correlation observed between stress management self-efficacy and perceived stress.

The Pearson correlation analysis to explore the relationship between daily mood and stress revealed a strong negative correlation between the two variables. These results highlight the importance of managing stress levels to promote better daily mood. Individuals who experience high levels of stress may benefit from an intervention aimed at stress reduction, which in turn could lead to improvements in their daily mood.

The lacking correlation between sleep quality and stress suggests that sleep quality alone may not be a strong predictor of stress levels in this particular sample, and vice versa. Additional factors or variables may contribute to stress experiences beyond sleep quality alone.

The UX results of WeMind Balance can be interpreted using the Unified Theory of Acceptance and Use of Technology (UTAUT) model. The UTAUT model provides insights into the factors that drive users' acceptance and usage behavior, allowing researchers to identify areas for improvement in technology design, implementation, and user support to enhance technology acceptance and usage outcomes (Momani, 2020).

Participants' assessment of the intervention as being of high quality, as being the kind of intervention they wanted, and as meeting their needs align with the construct of performance expectancy within the UTAUT model (Momani, 2020). These findings indicate that participants held positive perceptions regarding the intervention's capability to deliver desired outcomes and provide valuable support. The high quality rating signifies participants' confidence in the intervention's ability to perform effectively, while the assessment of the intervention as being the kind of intervention they wanted demonstrates a congruence between their expectations and the actual intervention received. Furthermore, the intervention's successful fulfillment of participants' needs suggests its efficacy in addressing their specific concerns and challenges.

Participants' willingness to recommend the intervention to others, their satisfaction with the intervention in general, and their inclination to return to the intervention if they were to seek help again reflect the construct of effort expectancy within the UTAUT model (Momani, 2020). These findings indicate that participants perceived the intervention as user-friendly, convenient, and easy to use, thereby reducing the effort required to engage with it. Moreover, their expressed willingness to return to the intervention indicates that they perceived it as a valuable resource, further highlighting its ease of use and the perceived benefits gained.

The participants' moderate satisfaction with the amount of help received reflects the construct of facilitating conditions within the UTAUT model (Momani, 2020). Participants' moderate satisfaction with the amount of help received indicates that while they found the level of assistance satisfactory, there may be room for improvement in terms of providing additional support or resources. These results highlight the importance of facilitating conditions in promoting the acceptance and use of technology-based interventions, as the availability of necessary resources and support can enhance user experience and increase the likelihood of future engagement.

Although the study incorporated elements of a SCED by implementing multiple phases and measuring outcomes over time, it is important to acknowledge that the study deviated from a traditional SCED in terms of data utilization. Specifically, not all the collected data points were used in the majority of the analyses as the measurement points were reduced to three distinct phases: the baseline phase, intervention phase 1, and intervention phase 2. Consequently, the study can be considered as departing from a strict SCED due to the selective use of data. This departure from a SCED can have implications for the interpretation and validity of the findings. By reducing the number of measurement points and condensing the data into distinct phases, the study potentially limits the granularity and precision of the analyses. A more comprehensive SCED would typically utilize all available data points to capture the dynamics and individual variability in the variables of interest throughout the study duration. By employing a reduced number of measurement points, the study may overlook important fluctuations or patterns within and between phases, potentially masking important insights into the intervention's effects. In a true SCED, the use of all available data points allows for a more thorough examination of within-participant changes, making it possible to assess individual response patterns and identify potential sources of variability (Krasny-Pacini & Evans, 2017). The utilization of the complete dataset would have enabled to draw more robust conclusions about the effectiveness and impact of the intervention. While the decision to reduce the data points into distinct phases has been driven by practical considerations, it is essential to acknowledge that this departure from a strict SCED may limit the study's internal validity.

Strengths and Limitations

The present study has several strengths and limitations. One strength of the study was the use of an app-based data collection method, considering the high frequency of smartphone usage among students and the intervention being app-based as well. By utilizing an app to collect data, the study took advantage of students' extensive use of smartphones, making the data collection method highly compatible with their daily routines. As the stress management intervention itself was delivered through an app, employing a separate app to collect data on the dependent variables provided a congruent and cohesive research design.

Another strength of the study was the comprehensive examination of multiple facets of mental health. By investigating daily mood, stress management self-efficacy, sleep quality, and general stress levels, the study covered a broad spectrum of mental health indicators, providing a holistic understanding of the impact of WeMind Balance.

The present study has several limitations as well. Firstly, the short baseline phase of three days in the present study can be considered a limitation. The baseline phase of only three days might not have been sufficient to capture participants' true baseline levels accurately. Psychological and physiological variables, such as daily mood, stress management self-efficacy, sleep quality, and stress, can fluctuate naturally from day to day. Additionally, the specific day and time that participants initiated the study could have influenced their initial state, potentially skewing the representation of their baseline measurements. For example, if participants started the study on a particularly stressful or relaxed day, it could lead to an overestimation or underestimation of their baseline stress levels. Furthermore, the short baseline phase may not have fully captured potential week patterns, such as variations in the dependent variables during weekdays versus weekends. This limitation raises concerns about the accuracy and representativeness of the baseline data, which could impact the interpretation of the study findings and the ability to accurately assess the effectiveness of the intervention. By having a longer baseline phase, a more stable and representative measure of participants' baseline status could have been obtained, reducing the influence of day-to-day variability.

Another limitation of this study is that the intervention period was short. Therefore, this study can only indicate the effect of the stress management app limited and cannot give information regarding the effect over a longer period of time. Multiple comparable studies examining the effects of self-management interventions have demonstrated that achieving significant effects in interventions targeting variables such as daily mood, stress management self-efficacy, sleep quality, and stress requires a longer intervention period spanning several months (Huberty et al., 2019; Venkatesan et al., 2021; Hwang et al., 2022). These findings highlight the importance of considering the duration of the intervention when evaluating its effectiveness.

Likewise, the present study did not investigate whether the intensity of the stress management app led to stronger effects, since analyses only used a dichotomous variable indicating whether the app was used or not.

Another limitation of this study consists of the high study dropout rates, which may be attributed to the frequent action required by the participants throughout the duration of the study. These high dropout rates could have implications for the generalizability and internal validity of the findings. Additionally, individuals who dropped out of the study may have differed in important ways from those who completed it, leading to potential selection bias and limiting the generalizability of the results. Furthermore, missing data resulting from the high dropout rates were also encountered in this study. The presence of missing data could have impacted the precision and accuracy of the statistical analyses and affected the validity and generalizability of the findings (Kang, 2013). Furthermore, the imputed values based on the available data in the linear mixed modeling analyses may not have accurately represented the true values that would have been observed with complete data, potentially introducing bias and affecting the precision of the estimates. Therefore, the reliance on imputed values raises concerns about the generalizability and internal validity of the findings as well.

The use of self-reported measures to assess the effect of the app over time is another limitation of this study. In this study, relying solely on self-reported measures may have introduced potential inaccuracies and subjectivity in assessing the impact of the app on the outcomes. One limitation associated with self-reported measures is the possibility of response bias (Althubaiti, 2016). Participants' responses may have been influenced by factors such as social desirability or memory recall biases. Additionally, self-reported measures rely on participants' ability to accurately perceive and report their experiences, which can vary based on individual differences and subjective interpretations. Another limitation of self-reported measures is the potential for measurement error (Althubaiti, 2016). The accuracy and reliability of self-report data might be influenced by factors such as participant misunderstanding of the module items, response fatigue, or even unintentional misreporting. These measurement errors might have caused noise and reduced the precision of the obtained results. Furthermore, the self-reported measures might not have captured the complete picture of the app's effects over time. They predominantly reflected participants' subjective interpretations and perceptions, which may not always align with objective changes or subtle variations in their experiences.

Recommendations

Based on the limitations identified in this study, several recommendations can be made for future research in order to further investigate the effect of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and stress in students. Firstly, future studies should consider implementing the intervention of extended duration to better capture the potential enhancement in daily mood, stress management self-efficacy, sleep quality, and stress. This would provide a more comprehensive understanding of the app's effectiveness and its impact on the targeted variables in students' lives. Furthermore, a longer intervention period could provide a clearer understanding of the relationship between adherence and the app's effectiveness.

Additionally, it is recommended to use a longer baseline phase. By extending the baseline phase to a longer duration, a more comprehensive understanding of participants' initial levels and fluctuations in the variables of interest can be obtained. This would provide a more stable and accurate baseline against which to compare the effects of the intervention. Furthermore, future research should aim to include a sample of participants with lower baseline levels of the variables. The current study may have included participants who were already functioning at relatively higher levels in terms of daily mood, stress management self-efficacy, sleep quality, and relatively low levels of stress. By including individuals with a wider range of baseline levels, including those who may have lower initial scores on daily mood, stress management self-efficacy, and sleep quality, and higher initial scores on stress, it would allow for a more thorough examination of the potential effects of the app on different segments of the population. This would provide valuable insights into whether the intervention is effective in improving outcomes for individuals who may be experiencing greater challenges in these areas.

To obtain a more comprehensive understanding of individuals' stress management self-efficacy, future studies should consider utilizing measurement instruments that assess self-efficacy as expectancies regarding the future response. This could involve capturing participants' beliefs in their ability to manage stress across various situations and timeframes, allowing for a more accurate and comprehensive assessment of their overall stress management self-efficacy. By addressing this measurement limitation, future research can provide a more nuanced and accurate understanding of the relationship between stress management self-efficacy and perceived stress, thereby contributing to the development of more effective interventions and strategies to promote stress management and well-being.

Additionally, future research could consider incorporating a larger number of measurement points in the analyses, allowing for a more comprehensive analysis of the intervention's effects over time. This approach would provide a more accurate depiction of the participants' responses and allow for a more reliable evaluation of the intervention’s effectiveness within an SCED framework.

Furthermore, it is recommended to include adherence to the intervention more extensively in the analysis and elucidate which elements of the app lead to improvements to test for a potential dose-response relationship (Jain, et al., 2007). This could be realized by collecting data on user engagement metrics, including the frequency of app usage, duration of usage sessions, and completion of modules or activities.

Lastly, employing incentives and providing reminders throughout the study can help improve participant retention and minimize potential biases associated with high dropout rates. By incorporating these recommendations into future research, a more comprehensive understanding of the effect of WeMind Balance on daily mood, stress management self-efficacy, sleep quality, and stress in students, and the impact of the level of adherence can be achieved.

Conclusion

The present study might give directions to future research on the benefits of WeMind Balance. The small beneficial effects on daily mood, stress management self-efficacy, and sleep quality emphasize the importance to further investigate the effectiveness of WeMind Balance. The findings that no variables significantly aggravated over time during the intervention might even indicate a preventive effect of WeMind Balance. This possibility should be revisited in future research.

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