Original Paper

The Effectiveness of a Nonguided Mindfulness App on Perceived Stress in a Nonclinical Dutch Population: Randomized Controlled Trial

Leonieke W Kranenburg[1], PhD; Jamie Gillis[1], MSc; Birgit Mayer[2], PhD; Witte J G Hoogendijk[3], MD, PhD

[1]Section of Medical Psychology, Department of Psychiatry, Erasmus University Medical Center, Rotterdam, Netherlands

[2]Department of Psychology, Education and Child studies, Erasmus University Rotterdam, Rotterdam, Netherlands

[3]Department of Psychiatry, Erasmus University Medical Center, Rotterdam, Netherlands

Corresponding Author:
Leonieke W Kranenburg, PhD
Section of Medical Psychology
Department of Psychiatry
Erasmus University Medical Center
PO Box 2040
Rotterdam, 3000 CA
Netherlands
Phone: 31 10 7040139
Email: l.kranenburg@erasmusmc.nl

Abstract

Background: Mindfulness has become increasingly popular, and positive outcomes have been reported for mindfulness-based interventions (MBIs) in reducing stress. These findings make room for innovative perspectives on how MBIs could be applied, for instance through mobile health (mHealth).

Objective: The aim of this study is to investigate whether a nonguided mindfulness mobile app can decrease perceived stress in a nonclinical Dutch population over the course of 8 weeks, with follow-up at 6 months.

Methods: A randomized controlled trial was performed to compare an experimental group that made use of a structured 8-week mHealth mindfulness program and a control group after 8 weeks, with follow-up after 6 months. Participants were recruited via a national television program. The primary outcome measure was perceived stress as measured by the Perceived Stress Scale, secondary outcomes were symptoms of burnout (measured using the visual analog scale [VAS]) and psychological symptoms (measured using the Four-Dimensional Symptom Questionnaire [4DSQ] at follow-up). Outcomes were analyzed using a multilevel regression model.

Results: At baseline, 587 respondents were included. Results showed no postintervention differences between groups for the level of perceived stress. With regard to the secondary outcome measures, the VAS for *emotional exhaustion* and *physical exhaustion* showed significantly lower scores for the experimental group after 8 weeks (*P*=.04 and *P*=.01, respectively), but not at follow-up. There were no differences between groups for psychological symptoms measured using the 4DSQ.

Conclusions: These findings do not support our hypothesis that using the mindfulness app would reduce stress levels. However, our findings related to diminished exhaustion at 8 weeks are encouraging and require further investigation.

Trial Registration: ClinicalTrials.gov NCT05246800; https://clinicaltrials.gov/show/NCT05246800

KEYWORDS

mHealth; mindfulness; stress; burnout; non-clinical population; nonclinical

Introduction

Mindfulness practice has become increasingly popular, both in the general public [1,2] and in health care [3]. Mindfulness derives from Buddhism and can be defined as an ability to observe one's bodily sensations, feelings, and thoughts with an open, nonjudgmental, and accepting mind toward one's experiences [4]. Mindfulness has been found to alleviate intense

emotional states [5,6] and enhance emotional coping mechanisms in response to stress [7], and it is believed to induce shifts in processing of negative emotions under stress [8]. The core principles of mindfulness are incorporated in a variety of psychological treatments that are referred to as mindfulness-based interventions (MBIs).

MBIs are traditionally delivered face to face. New types of applications include web-based programs and mobile health (mHealth) [9]. Advantages of digital applications of MBIs include their availability and accessibility, avoiding waiting lists, saving travelling time, reduced costs, being able to work in one's own environment, and nonrequirement of a therapist [10,11]. Especially during the current COVID-19 outbreak, these are favorable assets. Reviews of studies on the efficacy of these web-based MBIs found up to moderate effects on stress and depression [7,12-16]. A recent meta-analysis on the efficacy of mindfulness meditation apps on users' well-being and mental health–related outcomes concluded that mindfulness apps seemed promising in improving well-being and mental health, but those results should be interpreted with caution [17]. The strongest effects were observed on stress, depression, and burnout. However, regarding burnout, only 3 studies could be included, indicating that this may be a relatively new outcome variable in this research field. The findings of Gál et al [17] are interesting in this respect as chronic stress, burnout, and depression can be viewed as a continuum. Chronic stress can lead to burnout and a great overlap exists between burnout and depression, with shared features including motivational problems and exhaustion [18,19]. In total, 17% of all employees in the Netherlands report burnout symptoms [20], and 5% of all Dutch adults are annually affected by depression [21]. During the COVID-19 pandemic, these numbers may even be higher, as reports worldwide point to increased mental health complaints for various population subgroups, such as health care professionals, teachers, and those working from home [22-25]. The strain on mental health care budgets and practices, characterized by long waiting lists and shortness of qualified personnel, make it even more important to invest in new technologies to reduce mental health problems in the general population [22]. Therefore, the aim of this study is to investigate whether a nonguided mindfulness mobile app can decrease perceived stress levels and burnout symptoms in a nonclinical Dutch population.

Methods

Design and Recruitment

A randomized controlled trial with follow-up measures at 6 months was performed. Participants were recruited through the television (TV) program *Kassa*, in the context of 4 broadcasts on the topic "stress" in March 2018. The study was announced during this TV show, and in that particular moment, viewers were invited to visit the program's website and click the weblink with more information about the study and the possibility to apply for it. There were no eligibility criteria, other than being an adult. After having read and accepted the terms and conditions (informed consent), participants were referred to the web-based questionnaires. Randomization took place after they

had filled out the baseline (T0) questionnaires and was performed with a built-in randomization algorithm. The experimental group was provided access to the mindfulness mobile app, which contained an 8-week nonguided mindfulness program developed to reduce stress symptoms. The control group was suggested to read information about stress and burnout on the *Kassa* website. Participants were not blinded to their condition, as they knew whether or not they received access to the mindfulness app. There were three time points of measurement: T0 (baseline, before randomization), T1 (at the end of the program, 8 weeks after randomization), and T2 (6 months after randomization).

Intervention

The mindfulness application was developed by Minddistrict, an eHealth company in the Netherlands. The content of the app was developed by professionals in the field of mental health care and in accordance with the principles of mindfulness-based stress reduction and mindfulness-based cognitive therapy [4,26]. This mindfulness mobile app was the first app version derived from the one already existing web-based mindfulness program at the time used in mental health care settings. The app consisted of a structured program, with chapters on psycho-education on mindfulness and the importance of practicing; acting on auto-pilot, conscious attention; nonjudgmental attention, awareness; doing versus being mode; attention for breath and body, conscious response; acceptance; a mindful attitude toward thoughts; and applying mindfulness in daily life and staying mindful. Each chapter started with a short explanation of a specific mindfulness principle and was followed by relevant exercises, such as the body scan, Raisin Exercise, breath exercises, and sitting meditation. After completion of the exercises, participants were asked about their experiences, and the participant received an encouraging standard feedback message to keep practicing the exercises for optimal mindfulness training. There was no real-life contact (either in person or on the internet) with a mindfulness trainer. There was the possibility to create a personal program with favorite exercises.

Measures

Demographics

Participants age, sex, level of education, and occupation were assessed.

Perceived Stress Scale

The PSS measures perceived stress levels [27]. The 14-item Dutch version was used in this study. All items are rated on a 4-point Likert scale, with higher scores indicating more perceived stress. Cronbach α ranges between .84 and .86 [27] and overall psychometric properties are evaluated as acceptable [28]. The Cronbach α for this sample was >.89 for all measurement time points.

Visual Analogue Scale

Burnout symptoms were assessed using 8 visual analogue scales (VASs). The symptoms measured were as follows: *control over emotions*, *memory and concentration*, *sleep*, *work interest*, *work performance*, *interest in others*, *emotional exhaustion*, and

physical exhaustion. Each symptom was rated on a 0-100 scale, with higher scores indicating higher difficulty.

Four-Dimensional Symptom Questionnaire

The Four-Dimensional Symptom Questionnaire (4DSQ) consists of 50 items rated on a 4-point Likert scale [29]. The 50 items can be grouped into four dimensions: Distress (n=16), Depression (n=6), Anxiety (n=12), and Somatization (n=16). Sum scores are calculated for each dimension. The reliability of these dimensions was good, with Cronbach α>.79 for all subscales [30]. The Cronbach α for this sample was >.88 for all subscales. This measure was applied at T2 only.

Statistical Analyses

The experimental group and the control group were compared using a multilevel regression analysis, with participants as the upper level and their repeated measures as the lower level. Time (repeated measures at T0, T1, and T2), treatment group (experimental or control), and the time–group interaction were postulated as fixed effects. The difference in change in the PSS and VAS between the groups at follow-up is considered the primary contrast. At T2, differences between groups for the 4DSQ were analyzed with an independent samples *t* test (2-tailed). Two-sided *P* values of <.05 were considered significant. Data were analyzed using descriptive statistics in SPSS (version 25; IBM Corp).

Ethical Considerations

The study was approved by the Erasmus University Medical Ethical Committee and evaluated as not subject to the Dutch act on medical scientific research involving human subjects (METC 2017-1117).

Results

Participants

The final sample at T0 included 587 participants. This sample consisted mostly of highly educated (64.5%), employed (74.7%), and female (74.6%) individuals with a mean age of 46.05 (SD 13.64) years. More detailed information about the initial and final sample is provided in Table 1. Figure 1 provides the participant randomization flowchart.

Table 1. Demographic variables.

Variables	Time points	
	T0	T2
Age (years), mean (SD)	45.86 (13.69)	47.70 (12.80)
Sex, n (%)		
Female	435 (74.1)	137 (74.8)
Male	152 (25.9)	36 (25.2)
Education, n (%)		
Elementary school	2 (0.3)	1 (0.7)
Middle and high school	72 (12.3)	14 (9.8)
Secondary education	129 (22.0)	34 (23.8)
Higher education	384 (65.4)	94 (65.7)
Employment status, n (%)		
Social welfare	7 (1.1)	3 (2.1)
Informal care	9 (1.5)	0 (0)
Unemployed	14 (2.4)	6 (4.2)
Volunteers	21 (3.6)	5 (3.5)
Domestic household	21 (3.6)	4 (2.8)
Retired	34 (5.8)	11 (7.7)
Sick leave	38 (6.5)	13 (9.1)
Part-time	206 (35.0)	47 (32.9)
Full-time	237 (40.0)	54 (37.8)

Figure 1. Flowchart of inclusion and dropout.
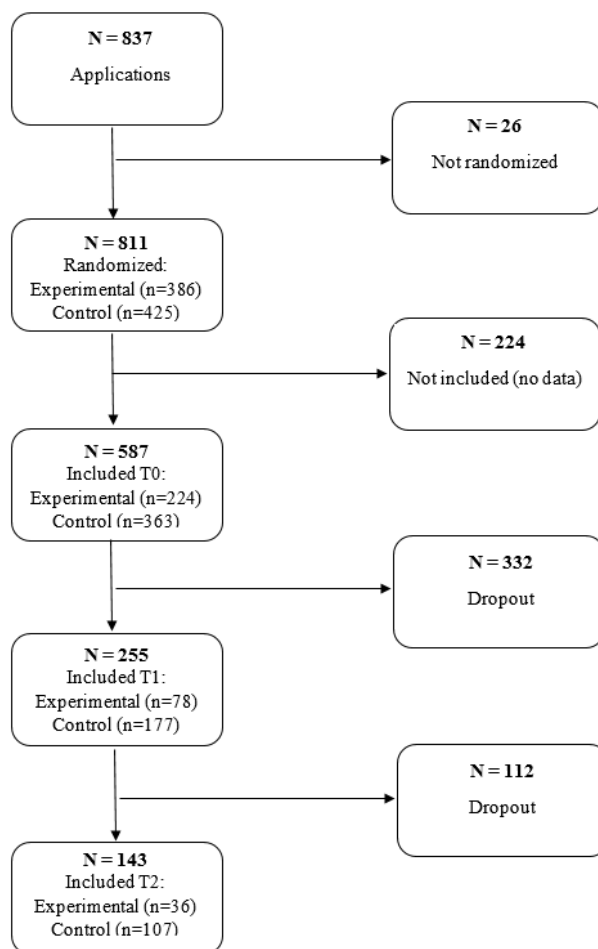
Primary Outcomes

Perceived stress was measured with the PSS at T0, T1, and T2. Table 2 provides descriptive statistics of the PSS over time for both groups. Changes between groups over time were analyzed with a multilevel regression model. The interaction between group and time was not a significant predictor of perceived stress measured using the PSS at T1 ($F_{1,501.26}=0.70$, $P=.40$) and T2 ($F_{1,490.35}=1.36$, $P=.24$; Table 3).

Table 2. Descriptive statistics of the perceived stress scale (PSS).

Group	PSS score, mean (SD)	Participants, n
T0		
Control	29.33 (8.32)	363
Experimental	30.10 (7.67)	224
T1		
Control	27.51 (9.21)	174
Experimental	26.59 (8.83)	73
T2		
Control	26.30 (9.98)	107
Experimental	26.00 (9.72)	36

Table 3. Estimates of the fixed effects measures of the perceived stress scale (PSS; dependent variable: PSS score).

Interaction	Estimate (95% CI); SE	P value
Group×T1	–0.71 (–2.38 to 0.96); 0.85	.40
Group×T2	–1.29 (–3.47 to 0.89); 1.11	.24

Secondary Outcomes

There were 8 VASs measuring burnout symptoms at T0, T1, and T2. Changes between groups over time were measured with a multilevel regression model. The VAS scales of *emotional exhaustion* and *physical exhaustion* were both significant at T1 ($F_{1,520.41}$=4.16, P=.04 and $F_{1,528.76}$=6.29, P=.01, respectively), for the time–group interaction, with the experimental group presenting lower exhaustion scores. Upon 6-month follow-up (T2), this effect was not maintained with the outcomes ($F_{1,510.18}$=0.03, P=.87 and $F_{1,520.06}$=0.04, P=.84, respectively). Changes between the two groups over time for the other 6 VAS scales did not differ at T1 and T2. Outcomes for the 4DSQ subscales at T2 showed no significant differences between both groups.

Discussion

Principal Findings

Our primary research question served to investigate whether an 8-week nonguided mindfulness mobile app can decrease perceived stress levels in a nonclinical Dutch population. Our findings do not support our hypothesis that using a nonguided mindfulness app reduces perceived stress levels. Not observing an effect on stress in this study might be explained by the complete lack of personal contact in this study; that is, there was no mindfulness trainer reachable through the app, nor was there the possibility to engage in social contact with other participants. This potential hypothesis is supported by the recent review of Borghouts [31], which points toward a generally higher engagement for guided (vs unguided) interventions and to the importance of social connectedness as a facilitator of user engagement. In addition, a recent meta-analysis [32] focusing specifically on web-based mindfulness found that web-based MBIs resulted in higher effect sizes for stress when offered guidance. As there was also no personal contact between the research team and the respondents, one could say that our study results may be similar to what one might expect to find in a real-world user situation, where despite high levels of app download, only a small portion of users actually use the apps for a longer period [33,34].

Another finding of our study was that the experimental group reported lower levels of both emotional and physical exhaustion after 8 weeks of using the app. This finding is particularly interesting, as different definitions of burnout all share exhaustion as a central component [35-38]. For instance, according to Schaufeli et al [38], burnout is conceptualized as a state of mental exhaustion, leading to both an inability and an unwillingness to act. Furthermore, in the process model of burnout, emotional exhaustion is one of the first symptoms to develop [39]. Dealing with stressors in everyday life can result in the depletion of cognitive and emotional resources, and these can cause exhaustion [40-42]. It is striking that the possible gain of the app may lie in reducing feelings of exhaustion in the broad sense. This might be related to the role mindfulness plays in autonomous self-regulation [43], which preserves vitality and energy [44]. Hence, a better spending and preservation of cognitive and emotional resources through increased self-regulation might have resulted in a reduction of physical

and emotional exhaustion after 8 weeks. This finding is in line with other studies that reported that mindfulness interventions are related to a reduction of emotional exhaustion, both in health care professionals [45,46] and other employees [47]. However, when it comes to mobile mindfulness apps, to our best knowledge, only one previous study specifically reported on exhaustion outcomes. In this study, significant effects were found for reduced emotional exhaustion [48]. These findings might indicate that a mindfulness app has the potential to be used as preventive intervention for burnout in a nonclinical population.

Clinical Implications and Directions for Future Research

Future research on the effects of mobile mindfulness apps on burnout is warranted. Given the long waiting lists for mental health care, an ideal setting for further testing this or other mobile mindfulness apps would be general practitioner clinics and mental health care institutions. That is, driven by these long waiting lists, it has become more common to offer patients bridge interventions with low personnel costs, including eHealth modules. This provides a great opportunity to implement a study design with conditions that vary in the amount and type of personal contact. Such a design could even be advanced by using randomization schemes that allow for including patient preferences with regard to these aspects. Next, given our findings that both mental and physical exhaustion decreased in the app user group, it would be of great interest to conduct frequent measures of individual stress and burnout symptoms with an experience sampling method [49]. This can help build general networks of how burnout symptoms develop and worsen over time [50]. By drawing on such data, future app-based interventions could be personalized to increase effectiveness. Building a user-friendly experience sampling method incorporated in the mindfulness app would then be the next challenge for app developers. In addition, build-in measures for actual time spent on practicing mindfulness exercises would also contribute to the field, as until now such data are limited [1]. Of course, such new features should first be subjected to acceptability and feasibility studies.

Limitations

The fact that participants were unequally distributed between the experimental and the control group was a limitation of this study. This was owing to a previously unnoticed error in the automated randomization algorithm, which could unfortunately not be repaired afterward. Another limitation is the lack of an adherence measure, which makes it impossible to look at a possible dose-response relationship [1]. Furthermore, the open kind of recruitment via a TV program may have biased our sample. For instance, it could be that extravert persons were more likely to spontaneously act upon the invitation to visit the website and register for the study. As extraversion is a barrier for user engagement of digital mental health interventions [31], the way participants were recruited could have biased our sample. This of course is only a hypothesis, as we have no data on personality traits of our sample, or on other relevant user characteristics, such as mental health status and previous

experiences with mindfulness or meditation, which may have influenced both user engagement and the outcomes.

Conclusions

Our study did not find an effect of using a mindfulness app on perceived stress levels in a nonclinical Dutch population. However, this may be owing to the type of respondent recruitment and a lack of control on adherence levels. Our results show diminished emotional and physical exhaustion in the app user group after 8 weeks. These findings are encouraging as they suggest that a mindfulness app has potential to be used as a preventive intervention for burnout.

Acknowledgments

Authors' Contributions

LWK designed the study, collected and analyzed the data, and drafted the manuscript. JG analyzed the data and drafted the manuscript. BM supervised coauthor JG and drafted, reviewed, and edited the manuscript. WJGH designed the study and drafted, reviewed, and edited the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

CONSORT-eHEALTH checklist (V 1.6.1).
[PDF File (Adobe PDF File), 16993 KB-Multimedia Appendix 1]

References

1. Taylor H, Strauss C, Cavanagh K. Can a little bit of mindfulness do you good? A systematic review and meta-analyses of unguided mindfulness-based self-help interventions. Clin Psychol Rev 2021 Nov;89:102078. [doi: 10.1016/j.cpr.2021.102078] [Medline: 34537665]

2. Mrazek AJ, Mrazek MD, Cherolini CM, Cloughesy JN, Cynman DJ, Gougis LJ, et al. The future of mindfulness training is digital, and the future is now. Curr Opin Psychol 2019 Aug;28:81-86. [doi: 10.1016/j.copsyc.2018.11.012] [Medline: 30529975]

3. Gotink RA, Chu P, Busschbach JJV, Benson H, Fricchione GL, Hunink MGM. Standardised mindfulness-based interventions in healthcare: an overview of systematic reviews and meta-analyses of RCTs. PLoS One 2015;10(4):e0124344 [FREE Full text] [doi: 10.1371/journal.pone.0124344] [Medline: 25881019]

4. Kabat-Zinn J. Full Catastrophe Living, Revised Edition: How to cope with stress, pain and illness using mindfulness meditation. Boston, MA: Little, Brown Book Group; 2013.

5. Baer RA. Mindfulness training as a clinical intervention: A conceptual and empirical review. Clin Psychol 2003;10(2):125-143. [doi: 10.1093/clipsy.bpg015]

6. Keng S, Smoski MJ, Robins CJ. Effects of mindfulness on psychological health: a review of empirical studies. Clin Psychol Rev 2011 Aug;31(6):1041-1056 [FREE Full text] [doi: 10.1016/j.cpr.2011.04.006] [Medline: 21802619]

7. Lyzwinski LN, Caffery L, Bambling M, Edirippulige S. A systematic review of llectronic mindfulness-based therapeutic interventions for weight, weight-related behaviors, and psychological stress. Telemed J E Health 2018 Mar;24(3):173-184. [doi: 10.1089/tmj.2017.0117] [Medline: 28885896]

8. Davidson RJ, Kabat-Zinn J, Schumacher J, Rosenkranz M, Muller D, Santorelli SF, et al. Alterations in brain and immune function produced by mindfulness meditation. Psychosom Med 2003;65(4):564-570. [doi: 10.1097/01.psy.0000077505.67574.e3] [Medline: 12883106]

9. Marcolino MS, Oliveira JAQ, D'Agostino M, Ribeiro AL, Alkmim MBM, Novillo-Ortiz D. The impact of mHealth interventions: systematic review of systematic reviews. JMIR Mhealth Uhealth 2018 Jan 17;6(1):e23 [FREE Full text] [doi: 10.2196/mhealth.8873] [Medline: 29343463]

10. Andersson G, Titov N. Advantages and limitations of Internet-based interventions for common mental disorders. World Psychiatry 2014 Feb;13(1):4-11 [FREE Full text] [doi: 10.1002/wps.20083] [Medline: 24497236]

11. Cuijpers P, Marks IM, van Straten A, Cavanagh K, Gega L, Andersson G. Computer-aided psychotherapy for anxiety disorders: a meta-analytic review. Cogn Behav Ther 2009;38(2):66-82. [doi: 10.1080/16506070802694776] [Medline: 20183688]

12. Spijkerman MPJ, Pots WTM, Bohlmeijer ET. Effectiveness of online mindfulness-based interventions in improving mental health: A review and meta-analysis of randomised controlled trials. Clin Psychol Rev 2016 Apr;45:102-114 [FREE Full text] [doi: 10.1016/j.cpr.2016.03.009] [Medline: 27111302]

13. Jayewardene WP, Lohrmann DK, Erbe RG, Torabi MR. Effects of preventive online mindfulness interventions on stress and mindfulness: A meta-analysis of randomized controlled trials. Prev Med Rep 2017 Mar;5:150-159 [FREE Full text] [doi: 10.1016/j.pmedr.2016.11.013] [Medline: 28050336]

14. Sevilla-Llewellyn-Jones J, Santesteban-Echarri O, Pryor I, McGorry P, Alvarez-Jimenez M. Web-based mindfulness interventions for mental health treatment: systematic review and meta-analysis. JMIR Ment Health 2018 Sep 25;5(3):e10278 [FREE Full text] [doi: 10.2196/10278] [Medline: 30274963]

15. Toivonen KI, Zernicke K, Carlson LE. Web-based mindfulness interventions for people with physical health conditions: systematic review. J Med Internet Res 2017 Aug 31;19(8):e303 [FREE Full text] [doi: 10.2196/jmir.7487] [Medline: 28860106]

16. Victorson DE, Sauer CM, Wolters L, Maletich C, Lukoff K, Sufrin N. Meta-analysis of technology-enabled mindfulness-based programs for negative affect and mindful awareness. Mindfulness 2020 Apr 27;11(8):1884-1899. [doi: 10.1007/s12671-020-01373-y]

17. Gál É, tefan S, Cristea IA. The efficacy of mindfulness meditation apps in enhancing users' well-being and mental health related outcomes: a meta-analysis of randomized controlled trials. J Affect Disord 2021 Jan 15;279:131-142. [doi: 10.1016/j.jad.2020.09.134] [Medline: 33049431]

18. Bianchi R, Schonfeld IS, Laurent E. Burnout-depression overlap: a review. Clin Psychol Rev 2015 Mar;36:28-41. [doi: 10.1016/j.cpr.2015.01.004] [Medline: 25638755]

19. Wurm W, Vogel K, Holl A, Ebner C, Bayer D, Mörkl S, et al. Depression-burnout overlap in physicians. PLoS One 2016;11(3):e0149913 [FREE Full text] [doi: 10.1371/journal.pone.0149913] [Medline: 26930395]

20. Nationale Enquête Arbeidsomstandigheden. Methodologie en globale resultaten. TNO. 2019. URL: https://www.monitorarbeid.tno.nl/nl-nl/publicaties/nea-2019/ [accessed 2022-03-01]

21. Zicht op depressie: de aandoening, preventie en zorg. Kerngegevens uitgelicht. Depressie in Nederland: feiten en cijfers. Trimbos-instituut; 2018. URL: https://www.trimbos.nl/kennis/cijfers/depressie [accessed 2022-11-23]

22. Tement S, Ketiš ZK, Mirošević Š, Selič-Zupančič P. The impact of Psychological Interventions with Elements of Mindfulness (PIM) on empathy, well-being, and reduction of burnout in physicians: a systematic review. Int J Environ Res Public Health 2021 Oct 25;18(21):11181 [FREE Full text] [doi: 10.3390/ijerph182111181] [Medline: 34769700]

23. Leo CG, Sabina S, Tumolo MR, Bodini A, Ponzini G, Sabato E, et al. Burnout among healthcare workers in the COVID 19 era: a review of the existing literature. Front Public Health 2021;9:750529 [FREE Full text] [doi: 10.3389/fpubh.2021.750529] [Medline: 34778184]

24. Vargas Rubilar N, Oros LB. Stress and burnout in teachers during times of pandemic. Front Psychol 2021;12:756007 [FREE Full text] [doi: 10.3389/fpsyg.2021.756007] [Medline: 34899498]

25. Johnson MS, Skjerdingstad N, Ebrahimi OV, Hoffart A, Johnson SU. Parenting in a pandemic: parental stress, anxiety and depression among parents during the government-initiated physical distancing measures following the first wave of COVID-19. Stress Health 2021 Dec 13. [doi: 10.1002/smi.3120] [Medline: 34902219]

26. Segal Z, Williams M, Teasdale J. Mindfulness-Based Cognitive Therapy for Depression (2nd edition). New York, NY: Guilford Publications; 2018.

27. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav 1983 Dec;24(4):385-396. [Medline: 6668417]

28. Lee E. Review of the psychometric evidence of the perceived stress scale. Asian Nurs Res (Korean Soc Nurs Sci) 2012 Dec;6(4):121-127 [FREE Full text] [doi: 10.1016/j.anr.2012.08.004] [Medline: 25031113]

29. Terluin B, Rijmen F, van Marwijk H, Stalman W. Waarde van de Vierdimensionale Klachtenlijst (4DKL) voor het detecteren van depressieve stoornissen. HUWE 2007 Jul;50(7):494-501. [doi: 10.1007/bf03085226]

30. Terluin B, Rhenen WV, Schaufeli WB, De Haan M. The four-dimensional symptom questionnaire (4DSQ): measuring distress and other mental health problems in a working population. Work & Stress 2004 Jul;18(3):187-207. [doi: 10.1080/0267837042000297535]

31. Borghouts J, Eikey E, Mark G, De Leon C, Schueller SM, Schneider M, et al. Barriers to and facilitators of user engagement with digital mental health interventions: systematic review. J Med Internet Res 2021 Mar 24;23(3):e24387 [FREE Full text] [doi: 10.2196/24387] [Medline: 33759801]

32. Sommers-Spijkerman M, Austin J, Bohlmeijer E, Pots W. New evidence in the booming field of online mindfulness: an updated meta-analysis of randomized controlled trials. JMIR Ment Health 2021 Jul 19;8(7):e28168 [FREE Full text] [doi: 10.2196/28168] [Medline: 34279240]

33. Baumel A, Edan S, Kane JM. Is there a trial bias impacting user engagement with unguided e-mental health interventions? A systematic comparison of published reports and real-world usage of the same programs. Transl Behav Med 2019 Nov 25;9(6):1020-1033. [doi: 10.1093/tbm/ibz147] [Medline: 31689344]

34. Baumel A, Muench F, Edan S, Kane JM. Objective user engagement with mental health apps: systematic search and panel-based usage analysis. J Med Internet Res 2019 Sep 25;21(9):e14567 [FREE Full text] [doi: 10.2196/14567] [Medline: 31573916]

35. Bakker AB, Demerouti E, Schaufeli WB. Validation of the Maslach Burnout Inventory - General Survey: An internet Study. Anxiety, Stress & Coping 2002 Jan;15(3):245-260. [doi: 10.1080/1061580021000020716]

36.   Maslach C, Jackson SE. The measurement of experienced burnout. J Organiz Behav 1981 Apr;2(2):99-113. [doi: 10.1002/job.4030020205]

37.   Van AM, Oeij S, Seeleman J, Starmans R, Terluin B, Wewerinke A. Overspanning en burn-out. Nederlands Huisartsen Genootschap Richtlijnen (Guidelines of the Dutch academy for General Practicioners). 2018. URL: https://richtlijnen.nhg.org/standaarden/overspanning-en-burn-out [accessed 2022-12-15]

38.   Schaufeli WB, Desart S, De Witte H. Burnout Assessment Tool (BAT)-development, validity, and reliability. Int J Environ Res Public Health 2020 Dec 18;17(24):9495 [FREE Full text] [doi: 10.3390/ijerph17249495] [Medline: 33352940]

39.   Leiter MP, Maslach C. The impact of interpersonal environment on burnout and organizational commitment. J Organiz Behav 1988 Oct;9(4):297-308. [doi: 10.1002/job.4030090402]

40.   Baumeister RF, Bratslavsky E, Muraven M, Tice DM. Ego depletion: is the active self a limited resource? J Pers Soc Psychol 1998 May;74(5):1252-1265. [doi: 10.1037//0022-3514.74.5.1252] [Medline: 9599441]

41.   Jonsdottir IH, Nordlund A, Ellbin S, Ljung T, Glise K, Währborg P, et al. Cognitive impairment in patients with stress-related exhaustion. Stress 2013 Mar;16(2):181-190. [doi: 10.3109/10253890.2012.708950] [Medline: 22746338]

42.   Weisberg J, Sagie A. Teachers' physical, mental, and emotional burnout: impact on intention to quit. J Psychol 2010 Apr 02;133(3):333-339. [doi: 10.1080/00223989909599746]

43.   Brown KW, Ryan RM. The benefits of being present: mindfulness and its role in psychological well-being. J Pers Soc Psychol 2003 Apr;84(4):822-848. [doi: 10.1037/0022-3514.84.4.822] [Medline: 12703651]

44.   Ryan RM, Deci EL. From ego depletion to vitality: Theory and findings concerning the facilitation of energy available to the self. Soc Personal Psychol Compass 2008;2(2):702-717. [doi: 10.1111/j.1751-9004.2008.00098.x]

45.   Jiménez-Picón N, Romero-Martín M, Ponce-Blandón JA, Ramirez-Baena L, Palomo-Lara JC, Gómez-Salgado J. The relationship between mindfulness and emotional intelligence as a protective factor for healthcare professionals: systematic review. Int J Environ Res Public Health 2021 May 20;18(10):5491 [FREE Full text] [doi: 10.3390/ijerph18105491] [Medline: 34065519]

46.   Suleiman-Martos N, Gomez-Urquiza JL, Aguayo-Estremera R, Cañadas-De La Fuente GA, De La Fuente-Solana EI, Albendín-García L. The effect of mindfulness training on burnout syndrome in nursing: A systematic review and meta-analysis. J Adv Nurs 2020 May;76(5):1124-1140. [doi: 10.1111/jan.14318] [Medline: 32026484]

47.   Janssen M, Heerkens Y, Kuijer W, van der Heijden B, Engels J. Effects of Mindfulness-Based Stress Reduction on employees' mental health: A systematic review. PLoS One 2018;13(1):e0191332 [FREE Full text] [doi: 10.1371/journal.pone.0191332] [Medline: 29364935]

48.   Möltner H, Leve J, Esch T. [Burnout prevention and mobile mindfulness: evaluation of an app-based health training program for employees]. Gesundheitswesen 2018 Mar;80(3):295-300 [FREE Full text] [doi: 10.1055/s-0043-114004] [Medline: 29017191]

49.   van Os J, Verhagen S, Marsman A, Peeters F, Bak M, Marcelis M, ESM-MERGE Investigators PhD, et al. The experience sampling method as an mHealth tool to support self-monitoring, self-insight, and personalized health care in clinical practice. Depress Anxiety 2017 Jun;34(6):481-493. [doi: 10.1002/da.22647] [Medline: 28544391]

50.   Borsboom D. A network theory of mental disorders. World Psychiatry 2017 Feb;16(1):5-13 [FREE Full text] [doi: 10.1002/wps.20375] [Medline: 28127906]

Abbreviations

4DSQ: Four-Dimensional Symptom Questionnaire
MBI: mindfulness-based interventions
mHealth: mobile health
PSS: perceived stress scale
TV: television
VAS: visual analogue scale

XSL•FO

RenderX